Other book by the same author under publication:

**Tenders and Works contracts:** Preparation of SORs, Tender conditions, Inviting tenders, Evaluation of tenders, Award of contract, Concerned directives from Railway Board and vigilance angles thereupon related to Signal & Telecommunication Engineering System. Arbitration.

**Electronic Interlocking**

*By:*  
S.C. Mishra  
And  
Pramod P. Goel

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Dedicated to my parents
PREFACE

I joined railway in September 1964 and retired having put in 40 years of service. While working in different capacities, experience has been snowballing around me. The idea of sharing my experiences with all those who are in the beginning of their career has always been inspiring me. I made frequent attempts to put all that on record, which I gathered as knowledge with the passage of time. However now that it is available in your hands a feedback shall be of great help in improving the write-up.

Railway Signal Engineering is not taught formally in colleges except by The Institution of Railway Signal & Telecommunication Engineers although idea of introducing Railway Engineering as a subject by Engineering college has been in news recently. However at present the institute placed at Secunderabad is the only temple of Railway Signal Engineering.

Complete Signalling system may be put in six major groups viz. operating devices; such as levers, operating cum indication panel or key board with a VDU; operated equipment such as points, signals, facing point locks etc; transmission media between operated equipment and the operating devices such as rod run, wire run and cable; interlocking; power supply system viz. batteries/IPS and the monitoring devices viz. track circuits, electric point detectors, lock/fouling bars etc.

There were two choices, first, the entire work could be put in one bound book form and second, to put different topics in the form of divided volumes covering specific subject. I decided to go in for the second choice with the reason that every one might not be interested in all the topics and also that a book with every thing together may become unwieldy. The Book 'Indian Railway Signal Engineering’ is presented in volumes named as the ‘Indian Railway Signal Engineering, Volume-I, Volume-II, Volume-III & Volume-IV out of which each volume contains a major topic with a few topics common to signal and interlocking without which it would have been difficult to explain the topic covered in the book in hand.

The Volume–I which is basically an introduction to Signal Engineering was published in June 2008, while volume four of the book with electrical signalling system is in your hands which shall be followed by ensuing volumes. The book is in nine chapters covering all the six groups of electrical portion of the signal & Interlocking. First chapter basically frames the genesis of other chapters while SSI and block working has been covered under independent chapters (vi) & (ix) respectively. Help of circuits and other explanatory diagrams has been taken to explain the system. Extracts from various rule books have liberally been taken in presentation of facts to enable the reader locate these rules for associated topic details as well as to enable to get major portion of the rules and regulations at one place. This book basically deals with broad gauge railways which covers the major portion of Indian Railways.

I am hopeful that this book shall be useful to the signal engineers as ready reference as well as for preparation of departmental examinations.

Any suggestions for its improvement shall be of great help to me.
ACKNOWLEDGEMENTS

This book is the result of persistent encouragement of Shri Madan Mohan Agarwal, Ex Chief Engineer Northern Railway and author of many books on Track Engineering. I am not hesitant to record that this book might not have seen the light of the day without his inspiration. I express my sincere thanks to him.

Debts of gratitude are owed to Shri S.C. Mishra CSTE (projects) Bilaspur for sparing his valuable time and extending vital technological support in general as well giving valuable suggestions for the chapter of SSI.

I am indebted to Shri V.K. Goel Sr. Professor (Tele) IRISET, Shri Alok Chaturvedi CSTE (P&D) NCR, Shri Himanshu Mohan CSTE (Tele) NCR, Shri D.K. Singh DYCSTE/Con. NCR and Shri A.K. Saxena Director Research (S&T) RDSO for extending latest information and support but for which the book would have been deficient.

I am deeply indebted to Shri Siddhu Yadav SSTE (P&D) NCR has been continuously supporting with his rich experience of signalling system by going through written material and providing with his valuable suggestions.

I am also indebted to Shri P.L. Srivastava Ex SSTE, CORE who, having gone through entire text of the book painstakingly has not only screened out many typographical mistakes but also has been instrumental in modification of text, to Shri Amit Kesarwani, an CAD expert with fair knowledge of signalling system, who has prepared most of the complicated drawings and to Mohammad Afaq retired SI, Allahabad for helping me with technical literature in his possession and rich experience at his command.

Lastly, I thank my family members, my wife Pratibha Goel without whose support it would not have been possible to devote time in writing the book, and to my children Vaibhava, Doctor of Speech recognition by computers, who took pains out of his tight schedule to go through contents of chapter relevant to higher electronics, Chhavi and Vipul and their spouses, my son in law Amitabh, and daughters in laws Sumedha and Nimita, who have always been there for me and have been giving help and advice on different aspects of the book and moral support, to enable me to reach this point.

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CHAPTER – I

ELECTRICAL SIGNALLING SYSTEM

1 Evolution of electrical signalling system:
1.1 First mechanical interlocking was installed at Bricklayers arms Junction in England by C.H. Georgy with levers for points and stirrups for signals, in 1843, which was improvised by Stevens in 1847. Double wire signalling was developed around 1920 in Germany. Colour light signals with two coloured lamps were introduced in 1921. A.F. Bound introduced speed signalling at Mir field in England. Automatic signalling with semaphore signals was developed by A.H. Johnson in England in 1926. LMG Ferreia & R.J. Insell of Great Western Railway introduced route working with miniature levers.
1.2 First electromechanical signal - interlocking was installed by Sykes in 1883 at Victoria Terminal, England.
1.3 First power interlocking was installed in U.S. in 1876 under patent of Pratt & Burr, Tylor’s electric interlocking in 1889, and Ramsey & Weir’s in 1888. In 1876, Sykes introduced lock and block system at St. Pauls station in London. In 1878 Edward Tyer introduced tablet apparatus.
1.4 Colour light signals were first used in United States in 1904. The visibility of these signals was 150 metres only. These signals were initially meant for tunnels, first having been installed in East Boston tunnel of Boston Elevated Railway. The visibility of these signals was improved to 450 metres in 1912 and to 1050 metres range in 1914. Position light signals were developed in 1915. First colour light signal were used in Britain at Liverpool cross Road Railway in 1920 while first search light signals of 1350 metres visibility range were developed in the same year. In India first colour light signal was introduced in 1925 with the start of suburb route in erstwhile Bombay now Mumbai.
1.5 George Boole developed algebra of logics named after him as Boolean’s algebra, in 1847, which was widely used to design electrical interlocking circuits.
1.6 Block System based on space interval was developed in England.
1.7 The basics thus installed have continued to march forward thereafter changing shape in the form of Relay interlocking, Route relay interlocking, Block Proving by Axle Counters, change of analogue axle counters to digital axle counters, DC track circuits to multi section digital axle counters, Audio Frequency track circuits etcetera. The conventional signals erected by the side of track have also gone into the cab of locomotives. The signalling has passed through phase from semaphore via colour light to cab signalling & the points in the yard operated by solid rod switching over to operation by electric point machines.
1.8 With the inception of electrical signalling system operation became faster thereby increasing section capacity.

2 Signalling system: Signalling system is put in six groups. The arrangement of Signalling system with Electrical system of Interlocking shall be as shown in fig 2. The operating device shall be a computer with a key board, mouse & monitor in place of the panel, if Electronic system of interlocking is used. These groups are:
2.1 Operating devices,
2.2 Operated equipment,
2.3 Transmission media between operating devices and operated equipments,
2.4 Interlocking
2.5 Monitoring devices,
2.6 Power supply, and
2.7 Other safety devices.

Figure 2
Electrical Signalling system

3. Operating devices: Operating devices are mechanical and electrical.
3.1 Mechanical operating devices: Mechanical operating devices are levers which are for operation, for lower quadrant, semaphore signals, through single wire operating system or for double wire operating system for upper quadrant semaphore signalling. These levers are in straight alignment in case of single wire system of signalling and attached to a drum in case of double wire signalling system.

These levers are also used for operation of colour light signals and electric point machines using circuit controllers which work as electric switches corresponding to normal and reverse position of signals, in hybrid type of signalling system.

Miniaturised levers housed in a miniature lever frame are also used for electrical operation of signals and points.

Refer Indian Railway Signal Engineering, volume –III, by the same author for mechanical signal engineering.

3.2 Electrical operating devices are:
   i) Rotary switches,
   ii) Push buttons and
   iii) Mouse, key board and VDU in case of computer aided operating device.
Rotary switches and push buttons on the face of the Control cum Indication Panel are used to store the intention of the Operator for train operation, which, in turn initiate a process of checks and operation through logic circuits.

One of the important difference between mechanical and electrical operating devices is that in case of mechanical system of interlocking it shall not be possible to move the lever at fist stage if the interlocking does not permit its operation while in case of electrical and electronic system of interlocking, switches, push buttons or mouse & key board can be operated with liberty while the system takes care of the interlocking and action or no action shall occur depending upon fulfilment of conditions under the requirements of interlocking.

4. **Operated equipments:** Main operated equipments are points, locks, lock bars, signals, level crossing gates and lock on level crossing gates.
   4.1 **In case of mechanical signalling system:** Operated equipments viz. points, facing point locks, lock bars and level crossing gate boom locks are operated through rod and semaphore lower quadrant and upper quadrant signals though wires. Operation of level crossing gate equipped with lifting barriers is through a winch.
   4.2 **In hybrid type of signalling system:** Operated equipments viz. electrical motor driven points, electrical motor driven semaphore signals and colour light signals are electrically operated by levers connected through cables.
   4.3 **In electrically operated signalling system:** Operated equipments viz. colour light signals and electric motor operated points and are controlled by Rotary switches, push buttons or mouse & key board. Operation of level crossing gate equipped with power operated lifting barriers is through a push button provided on an independent panel dedicated for control of the gate.

5. **Transmission media between operating device and operated equipment:** On a station interlocked to standard–I, where points and signals are interlocked through key and lock arrangement under which transmission of keys between points and signals is done manually. On stations interlocked to standard-II and above with direct interlocking arrangement centralizes at one place, the media of transmission between operating devises and the operated equipments is wire for signals and rod for points on single wire signalling scheme, wire for signals as well as wire or rod for operation of points on double line scheme and copper or Optical fibre cable on electrical scheme of signalling.

   5.1 **Transmission in case of mechanical system of signalling:** Under single wire and double wire systems of semaphore signalling medium of transmission have to be compatible to each, accordingly signals are operated through single wire and double wire respectively. However points are operated through double wire or rod in case of double wire system of signalling and through rod in case of single wire systems of signalling.
   5.1.1 **Transmission media under single wire system of signalling:** In single wire signalling system, the transmission media for operation of signals is 6/8 Standard Wire Gauge (SWG), Galvanised Iron (GI) wire, carried on pulley stakes wire, is connected at one end with lever tail and other end with counter weight arm at the signal. Wherever wire is required to take turn, wire rope constituting seven wire ropes twisted, each rope having seven wire strands of twenty
two gauge, is joined with GI wire, using thimbles and disconnecting link in between to move along with the pulley on turns in the alignment. A single wire run can not be provided with compensators to accommodate variations in length of the wire due to ambient temperature variations as such wire adjuster is provided in the cabin near the lever frame to adjust the sag by pulling the wire to avoid drooping of the signal arm.

Points are operated using rod attached to lever tail at lever end and to the arm of adjustable crank at point end, through vertical crank to convert vertical movement to horizontal, attached to accommodating crank at the lead-out, running through right angle cranks at each right angle turn with rod compensators in between to compensate variations in the length of the rod due to ambient temperature variations.

5.1.2 Transmission media under double wire system of signalling: In double wire system of signalling two wires run forming a closed loop wrapped around the lever drum at the operating end and around the signal machine drum or point machine drum at the operated equipment end. Wire rope is used where ever wire is to move over pulleys and is wrapped around lever or signal drum. In case of double wire system of signalling the wire rope consists of six wire ropes of nineteen strands each, making it more flexible. Double wire compensators are used to keep the wires taught for complete transmission of stroke at the signal, point or detectors. The wires are carried on pulleys and through horizontal and vertical wheels wherever the alignment is required to take turn.

The points are also operated though 32mm diameter steel rod operated by rack and pinion double wire levers.

For details refer to Indian Railway Signal Engineering volume–III of the book by the same author.

5.2 Transmission in case of electrical and electronic system of Interlocking: In case of electrical and electronic system of Interlocking the transmission media is cable in case of electrical and electronic system of Interlocking. For signalling purposes these cables shall be i) Signalling cable, ii) Quad cable, iii) Power cable and iv) Optical Fibre Cable.

The cables are usually laid underground but some times may also be carried along with messenger wires or carried on stakes.

6. Interlocking: In a complex network where the traffic is heavy, it is important that the signal is taken ‘Off’ only after ensuring that the track is clear, points are set and secured for the scheduled route on which train is to traverse, interlocked level crossing gates falling in the route of train including the overlap, are closed and locked against road traffic. This eventually means that a desired sequence of operation of points and signals is required to be ensured before the signal can be taken ‘Off’. This desired sequence of operation is achieved through interlocking of these equipments with each other through mechanical, electrical or electronics means. As per Indian Government Railways General Rules 2006, clause 30, chapter- I, the interlocking is defined as “an arrangement of signals, points and other appliances, operated from a panel or
lever frame, so interconnected by mechanical locking or electrical locking or both that their
operation must take place in proper sequence to ensure safety”. The interlocking is defined in
Railway Signalling published by B.S.I as number 719/1936 as “an electrical or mechanical
means of making the operation of one piece of apparatus is dependent upon the operation of
certain predetermined conditions being fulfilled by other apparatus”. With the advent of Solid
State Interlocking, this stands modified to add ‘electronic’ to ‘electrical or mechanical’ in the
above definition. The interlocking can therefore be understood as ‘an arrangement through
which operation of points and signals in a pre determined sequence is ensured’.

6.1 The basic rules to be observed while designing interlocking which are predetermining
sequence of operation of points, locks, closing of level crossing gates etcetera, have been given
as essentials of interlocking in Signal Engineering Manual 1988 part-I paragraph 7.82, as
reproduced in following paragraph:

6.1.2 Essentials of interlocking: Lever frames and other apparatus provided for the
operation and control of signals, points, etc., shall be so arranged as to comply with the
following essentials (SEM part-1, 1988, paragraph 7.82) :

i) **It shall not be possible to take Off a running signal, unless all points including isolation
are correctly set, all facing points are locked and all interlocked level crossings closed
and locked against public road for the line on which the train will travel, including the
overlap.**

ii) **After the signal has been taken Off it shall not be possible to move any points or lock
on the route, including overlap and isolation, nor to release any interlocked gates until
the signal is replaced to the On position.**

iii) **It shall not be possible to take Off at the same time, any two fixed signals which can
lead to any conflicting movements.**

iv) **Where feasible, points shall be so interlocked as to avoid any conflicting movement.**

It is very important to understand that it is the signal, which is taken Off last, after ensuring
essentials of interlocking, be it operated by a lever or taken Off electrically/electronically, only
when all points en-route have been set for the route on which train is intended to move, this
should include overlap, all points falling in facing direction of the train are locked including
points falling in overlap as if the train was to pass over these points as well, all level crossing
gates which are interlocked with the signals and fall not only within the route but also in the
overlap, have been closed to road traffic and locked, while at the same time no two signals
should come ‘OFF’ simultaneously which may conflict route of the train. The signal being
operated last, it should always be possible to put it back to On in case of emergency, without
any hindrance, by lever in lever frame, by push button on panel or by click of a mouse.

6.2 Correspondence between operating and operated units:
6.2.1 All signals, points, Locks on points, Level crossing gates, inter-cabin slots and any
other equipment involved with the train movement are operated by levers in case of mechanical
system, switches or buttons if it is electro mechanical or electrical system and buttons or a
Visual Display Unit (VDU) with a key board and mouse, similar to that of computer, if it is
electronic system of operation and interlocking. These devices are operating devices.

6.2.2 On station interlocked to standard – III and above, the operating devices are required to be grouped together in one place and interlocked. These operating devices transfer command to operate the signals, points, Locks on points, Level crossing gates, inter-cabin slots, Block working system and any other equipment involved with the train movement. These are operated equipments, medium to carry commands to which is wire run for signals and rod run for points in mechanical signalling system and a cable and/or optical fibre in case of electrical or electronic signalling system.

The interlocking is in midst of operating devices and the medium to carry commands.

6.2.3 Although all measures are taken to ensure that there is no failure of correspondence between a command given through operating unit and the operation of the equipment but in case of such a failure the outcome could be disastrous, as interlocking shall permit taking ‘Off’ of the concerned signal while at site the conditions shall not be conducive for passage of train. As such a process of correspondence check is inculcated in the system without which any amount of interlocking shall be of no avail. The devices for checking correspondence are Circuit Breakers (CB) attached to signal arms to check that the signal is Off or On in correspondence with the signal lever, a point detector is used to check if the point is set to normal or reverse and the lock plunger on the point has moved its full travel in correspondence to the lever operating it, in mechanical arrangement. In electrically operated equipment the signal aspect is checked for signal being lighted On or Off through lamp checking devices/relays similarly the setting of point operated by electric point machines to be normal or reverse and locked properly, is checked by electric detector inbuilt in the point machines, or in older version, associated with point machines.

7. Monitoring devices: Monitoring devices are used for two basic purposes one being to monitor correspondence between operating devices and the operated equipment and secondly to monitor status of the yard such as clearance or occupation of tracks, status of level crossing gates, closed or open, under the control of the Satiation Master, flank protection ( fouling of adjoining track by a train standing within fouling mark) and alertness of Loco Pilot checked through Automatic Warning System (AWS).

7.1 Devices to monitor correspondence between operating devices and operated equipment: The correspondence between the operating units which are levers, switches, buttons or the key board of operating system of Solid State Interlocking and the operated equipment which are points, point locks and signals is established by:

7.1.1 Point and lock detectors are used to monitor setting of points for its correct housing with the stock rail, setting for normal or reverse as the case may be and locking of the point with full travel of the lock plunger.

7.1.2 To monitor the status of signals, the status of signal arm is checked by a circuit breaker attached to the arm in case of semaphore signals and by lamp checking relays in case of colour light signals.

7.2 Devices to monitor status of the yard & systems: The interlocking between the signals and points is established once correspondence between the operating devices such as
levers and buttons and operated equipment such as points and signals is also established. However safe movement of the train can take place only when the line on which the train is to be received is also checked for clearance and not fouling with any other train standing on adjoining line, level crossing gates falling in the route of the train which are interlocked are closed and locked against road traffic etcetera. It is also important to monitor the integrity of the cable which is the media for transfer of commands from the operating levers or panels and transferring status of the field such as correct setting of points, aspect correspondence of signals, closure of level crossing gates etcetera.

7.2.1 Monitoring track vacancy/occupancy: The devices used for checking clearance of track are:

i) **Track Circuits:** Different type of track circuits are used out of which most commonly used are a) Direct Current (DC) Track circuit, b) Alternating Current (AC) track circuits, c) High voltage uneven Impulse track circuit (Jeumont), d) Audio Frequency Track Circuit (AFTC).

ii) **Axle counters (A/C):** These devices are used depending upon specific requirement. Track circuits shall be discussed in ensuing chapter-VI of the book.

7.3 Flank Protection: The other area of safety which is required to be monitored by the system is protection against side collisions. Two railway lines running parallel to each other are kept at a specified minimum distance between them. If the given distance between the two tracks is reduced, the trains running on such tracks shall infringe with each other and shall result in side collision. Whenever two tracks join each other through a turnout or crossover, these infringe with each other till the distance between the two is arrived at safe range. The spot at which the two tracks become unsafe is known as fouling mark. The protection for trains on account of the infringement of tracks is called flank protection. When the flank protection is achieved through track circuits, the track circuits are so designed that unless the train stands clear of the track circuit, it shall not be possible to permit the train movement on such track [Fig 7.3(B-I)]. In yard where point zone is not track circuited the flank protection is achieved by using fouling or clearance bars. A, 42 feet uneven angled MS bar known as fouling bar or clearance bar depending its place of usage, is coupled with point in such a way that it shall not be possible to operate the point till the Fouling or the Clearance bar is kept pressed under the wheel. The point for the adjoining line can be set only when the fouling or clearance bar is cleared by the train entering the berthing part of the track [Fig 7.3(B-II)].

The fouling bar is linked with the trailing point in such a way that the point can not be operated from its last operated position unless the last train received on main line clears it. Similarly the clearance bar is attached to the trailing point in such a way that it shall not be possible to operate the point unless the last train received on loop line clears the bar.
8. **Power supply**: Performance of an electrical signalling system is dependent on efficient and reliable power supply. The efficiency of the power supply is dependent on accurate assessment and planning of the power supply system while reliability is the element of source of supply. In areas provided with 25 KV AC electrification reliable power supply is available. However in areas where civil supply is the main source of power supply, the reliability is not so efficient and as such alternative source of power supply has to be managed, which usually is a diesel generator and some times a solar power panel.

The Power supply for electrical system of signalling is required based upon operating voltages of different equipment such as some relays operate at 60Volt DC some at 24volts DC, point machines operate at 110 Volt DC as well as three phase 400 Volt AC, signals illuminated through incandescent lamps are lighted at 12V AC, transformed from 110V AC to 12 AC while LED signals are illuminated through 110 Volt DC as well as 110 V AC. Similarly power supplies vary for different type of Block Instruments, AFTC, Axle counters, Data Loggers, SSIs etcetera.

Accordingly a set of battery bank with corresponding battery charger to provide power to the equipment is provided, making the entire arrangement a huge set of battery banks and battery chargers. The conversion of the entire arrangement into and Integrated Power Supply (IPS) system comprising of a single battery bank, has made:

i) All requirements of different voltages through DC to DC converters packed in one cabinet,

ii) Uninterrupted power supply to signals, thereby ensuring that signals do not go blank in case of failure of main source of power supply,

iii) Making maintenance easy there being one single bank of battery as well as entire power supply system for one station housed at one location. However battery chargers and batteries are provided at site for track circuit’s feed.

iv) Uninterrupted source of power supply to panel and other indications.

9. **Safety devices other than signalling system**: Besides interlocking the points, signals and monitoring devices to ensure correspondence between the operating devices and operated equipments, some additional safety devices are required to be used to cater for the situations not covered so far. Such devices are:

i) **Automatic Warning system**: All efforts in making perfect and safe interlocked system shall fail if a Loco Pilot disregards the signal. Since there is no direct technically controlled link
between the Loco pilot and the signal except the visibility of the signal, a link is created between the signal by providing a track device communicating with device provided in the Loco through electromagnetic coupling. Action is taken by the device in conformity to the signal aspect, to control the Loco if needed and if timely action is not taken by the Loco pilot.

ii) **Anti collision devise**: Accidents in block section are most hazardous as the train moves in the section at maximum permissible speed and any obstruction encountered there is totally unawares to the Loco pilot. To safeguard against such situation where another train enters into the block section, the Loco pilot shall get intimation of such situation and suitable action shall be taken by the system through Global Positioning System (GPS) to protect the trains from colliding. Indian railway has named the device as Raksha Kavatch (Safety Shield).

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CHAPTER –II
OPERATING DEVICES

1. **Lever:** Lever is a tool to gain mechanical advantage about fulcrum. In semaphore system of signalling, operation of signals, points, locks and lock bars which require high force are operated by using levers through wire run in case of operation of signals and rod run in case of points, locks and lock bars under single or double wire semaphore signalling systems.

For details refer Indian Railway Signal Engineering Vol-III by the same author.

In some cases levers are used to operate hybrid system of signalling where points are operated by levers directly through rod transmission and semaphore signals are replaced by colour light signals. In another lever operated hybrid arrangement, the semaphore signals are operated by signal motors and points are operated through electric point machines. In both the arrangements Circuit Controllers are attached to the levers to work as switches to make and break the desired circuit. Push button operated control cum indication panels also control semaphore signals operated by signal motors and points with electric point machines.

2. **Control cum Indication panel:** Control cum Indication panel top is i) printed with geographical replica of the yard layout depicting all important features of signal & Interlocking plan depicting profile of signals, track circuits level crossing gates, point and trap indicators stop boards etcetera, ii) provided with push buttons & switches to operate the system and iii) also provided with indications of the status of signals, points, level crossing gate, power supply, flasher relay etcetera, to keep the Station Master informed of the status of yard, health of the system and guide him through operation. A typical panel diagram is placed as figure 2 amongst last pages of the book.

2.1 **Structural features of panel:** It is a box divided into two parts. The station yard plan is depicted on the top of the box, which is usually inclined towards chair of the Station master for convenience of operation. Signal, route, point and other buttons are provided geographically on the yard plan, see figure 2, placed at the end of the book. The lower part of the box is provided with terminals to connect interface wiring between relay room and the panel buttons, switches, bells, buzzers, counters and indications such as signal aspect, track vacancy, point setting status, power supply and flasher relay etcetera.

A panel diagram is prepared in conformity to the Signal & Interlocking plan and given to the company for manufacturing the panel. The panel diagram depicts complete yard layout, position of signal & route buttons, track circuits and other indications, colours of the buttons used and all other buttons and indications that may be required by the Station Master for efficient operation.

The Panel top is modular by design. Each module is a rectangular metal box of 54mmx34mm top with an arrangement for housing buttons and indication lamps in conformity to the signalling scheme and yard plan printed on the face of modules. These modules are grouped to
form top of the panel and accommodate complete yard plan. The buttons and the indication lamps are wired and connected to the terminals provided on the lower part of the panel box.

2.2 **Systems of operation from panel:** The system of giving command for operation by the Station Master by pressing two buttons simultaneously is called as Entrance - exit principle [SEM 1988 para7.108] and is symbolised by ‘NX’ system. This is done to avoid any operation due to inadvertent pressing of any one button on the panel.

There are two arrangements for electrical operation of signalling system from Control cum Indication panel. In one arrangement the Station Master has to set the desired route by setting points normal or reverse, independently & individually if free for operation, using two position rotary switches and then take the signals Off which shall simultaneously check compliance of essential of interlocking and lock the route. This arrangement is known as **‘non-route setting type’** and is being phased out gradually. *Accordingly use of rotary switches is not resorted to in future installations.*

The other arrangement is **‘route setting type’** in which pressing of signal and route buttons shall check interlocking, set the route automatically if found permissible, and take signals Off simultaneously locking the route. Two buttons are pressed simultaneously for about 2 to 5 seconds.

For bigger yards, some times, the indication panel is split from operating panel and is placed vertical opposite the operation panel to facilitate the view of the entire yard to the operator.

The buttons are depicted on panel diagram by single circle and indications by double circle with the indication inscribed within. The track circuits are depicted by rectangular strips along the track circuited portion of the track.

These route strips, remain blank till no movement is initiated. As and when a signalled movement is initiated by pressing the signal and route buttons simultaneously, and the route is set and locked, conditions having been fulfilled for such a movement, the route strips along with corresponding overlap glow with white light on the panel and yellow light on VDU. These route lights of the corresponding track circuits on being occupied by the train turn red as the train traverses the route and turn white instantaneously and then extinguish as the train occupies the destination/berthing track circuit except the berthing track which shows red till occupied by the train. The strips corresponding to the track circuit which gets occupied or fails, show red light irrespective of whether a movement has been initiated for this or any other portion of the yard.

2.2.1 **Buttons and indications provided on the panel:** In view that the Control cum indication panel is the only means of interaction between Station Master and the signalling system, buttons, indications, buzzer and counters are provided on the panel in such a way that the Station Master, i) is able to control of all activities in the yard and is ii) fully apprised of the yard status and ii) health of the system.

i) **Push buttons:** The buttons provided on the panel top are spring loaded which return back to its normal position when released. A buzzer makes a sound along with illuminated visual indication if the button is kept pressed or remains pressed inadvertently or for any reason
such as placement of a book or damaged spring for more than 10 seconds. No further command should be attempted till the button concerned is identified and put back to normal as pressing of another button may be read by the system along with the other pressed button and undesired action may be initiated. Main push buttons are designated as ‘Signal button’ and ‘Route button’. Signal button is provided near the foot of the signal and route button is provided on the track profile on which the train is to be brought. This arrangement is same for Shunt signals also. Pressing of signal button and route button communicates the intention of the Station Master to the interlocking system, for moving the train from the desired signal up to the next stop signal on the selected route. The system translates the command into desired action. As and when a point fails to operate or to set to desired position within prescribed time or a signal fails to take Off due to fusing of lamp, a buzzer shall ring along with an illuminated indication. The buzzer can be silenced by pressing acknowledgement button while the indication shall continue to glow till the cause of failure is rectified. For the purpose of quick identification, all buttons on the panel are coloured distinctively [Table 2.2.1(i)].

<table>
<thead>
<tr>
<th>SN</th>
<th>Button type</th>
<th>Colour &amp; placement on the panel</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>A)</td>
<td>Main buttons for operation of signals, points &amp; release or locking of crank handles as mentioned at SN 1 to 11 below are with reference to clause 21.2.11 of SEM Part II, September, 2001 and balance are as adopted by different railways:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Main running signal</td>
<td>Red: in between route strip profile</td>
<td>GN</td>
</tr>
<tr>
<td>2.</td>
<td>Calling on signal</td>
<td>Red with white dot: On top row of the panel</td>
<td>COGN</td>
</tr>
<tr>
<td>3.</td>
<td>Shunt signal on the same post as that of main signal</td>
<td>Yellow: by the side of route strip profile near the shunt signal profile.</td>
<td>SHGN</td>
</tr>
<tr>
<td>4.</td>
<td>Shunt signal Independent</td>
<td>Yellow: in between route strip profile.</td>
<td>SHGN</td>
</tr>
<tr>
<td>5.</td>
<td>Individual point operation</td>
<td>Black: placed near each point profile.</td>
<td>WN</td>
</tr>
<tr>
<td>6.</td>
<td>Exit (Route button)</td>
<td>White: with route name printed by its side.</td>
<td>UN</td>
</tr>
<tr>
<td>7.</td>
<td>Alternative route</td>
<td>Grey: with route name printed by its side.</td>
<td>UN</td>
</tr>
<tr>
<td>8.</td>
<td>Alternative overlap</td>
<td>White with black dot.</td>
<td>OYN</td>
</tr>
<tr>
<td>9.</td>
<td>Slot (Individual)</td>
<td>Green.</td>
<td>YN</td>
</tr>
<tr>
<td>10.</td>
<td>Crank handle (Individual)</td>
<td>Blue: placed near the point profile for release or withdrawal of control of crank handle operated with group button.</td>
<td>CHYN</td>
</tr>
<tr>
<td>11.</td>
<td>Point group</td>
<td>Black with red dot.</td>
<td>WWN</td>
</tr>
<tr>
<td>12.</td>
<td>Level Crossing (individual)</td>
<td>Grey.</td>
<td>XN</td>
</tr>
<tr>
<td>13.</td>
<td>Release of control over ground Frame lever operated point</td>
<td>Green.</td>
<td>YN</td>
</tr>
<tr>
<td>B)</td>
<td>Following group and other purpose buttons are placed on the top row of the panel:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Calling-on group.</td>
<td>Red COGGN</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Overlap release group.</td>
<td>Grey OYN</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Emergency route release group.</td>
<td>Grey EUUYN</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Emergency sectional route release group.</td>
<td>Grey EUYN</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Emergency signal cancellation group.</td>
<td>Red EGRN/ERN</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Emergency point operation group.</td>
<td>Blue EWN</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Common Group release button for Slot, Crank handle, and Level crossing gate.</td>
<td>Grey GBRN</td>
<td></td>
</tr>
</tbody>
</table>
Table 2.2.1(i)
Push buttons and their distinctive colours

<table>
<thead>
<tr>
<th>SN</th>
<th>Indication</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Signal</td>
<td>Signal aspects repeated on respective signal profile in a circle</td>
</tr>
<tr>
<td>2</td>
<td>Signal route indicator</td>
<td>A white inclined/vertical slit at the top of the signal profile when signal is taken Off with route.</td>
</tr>
<tr>
<td>3</td>
<td>Calling on</td>
<td>A white inclined slit when Calling on signal is lit.</td>
</tr>
<tr>
<td>4</td>
<td>Shunt signal Independent</td>
<td>When On- white horizontal strip, Off- a white inclined strip</td>
</tr>
<tr>
<td>5</td>
<td>Shunt signal dependent</td>
<td>When On- No light, Off- a white inclined strip</td>
</tr>
<tr>
<td>6</td>
<td>Point</td>
<td>Two route strips one straight and other inclined to the main alignment out of which one steadily illuminated strip straight to alignment indicates point set for straight and otherwise reverse respectively. Both the strips flash simultaneously for 10 seconds, while point is moving from normal to reverse or reverse to normal or when permanently failed to set in either position.</td>
</tr>
<tr>
<td>7</td>
<td>Point locked in route</td>
<td>A white circular indication on the junction of two route strips show point locked when illuminated.</td>
</tr>
<tr>
<td>8</td>
<td>Route section</td>
<td>A set of minimum two strips for each track circuit depict white light in the route section, only when route is set which turn red when the concerned track circuit is occupied or failed.</td>
</tr>
<tr>
<td>9</td>
<td>Route locked</td>
<td>A circular white indication by the side of the signal which illuminates when emergent route release is initiated and continues glowing during only the locked route is being released.</td>
</tr>
<tr>
<td>10</td>
<td>Crank handle</td>
<td>Out of the two circular indications near the individual crank handle button, one white light illuminates when the concerned group of crank handle is locked and the other red light illuminates when the crank handle is released.</td>
</tr>
<tr>
<td>11</td>
<td>Flasher</td>
<td>A circular flashing indication on panel top to show that the flasher is working properly.</td>
</tr>
<tr>
<td>12</td>
<td>Time element</td>
<td>A common circular indication on panel illuminates to show release of any route in progress for 120 seconds.</td>
</tr>
<tr>
<td>13</td>
<td>Power supply</td>
<td>White circular indication for each system i.e. 12VDC, 110 V AC &amp; other important power supply health status.</td>
</tr>
</tbody>
</table>

ii) **Indications:** Indications on the panels are, status of i) track circuits, ii) setting of points normal or reverse or failed, iii) route set, iv) route locked, v) point locked in any of the route, vi) level crossing gate controlled by the Station Master through panel locked or free, vii) crank handle locked or free, viii) health of power supply, ix) health of time element relay, x) health of flasher relay, xi) signal lamp fusing indication, xii) health of SSI system, xiii) signal passing at On indication when Intermediate Block signal is provided in adjoining block section xiv) train entering block section indication and xv) train entering into station section indication and many more indications are also provided onto panel face.
A circular white indication illuminates to indicate train passing IBS signal at On.

A circular indication illuminates in case of SSI system fails.

Red circular indication illuminates when any of the signal lamp in the group fuses.

The switch with white circular illuminated indication to show operating device in use being Panel or VDU.

<table>
<thead>
<tr>
<th>SN</th>
<th>Button with counter</th>
<th>Action</th>
<th>Counter abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EGNR</td>
<td>Emergent signal replacement</td>
<td>EGGZ</td>
</tr>
<tr>
<td>2</td>
<td>EUYN</td>
<td>Emergency Section route release</td>
<td>EUYZ</td>
</tr>
<tr>
<td>3</td>
<td>EUUYN</td>
<td>Route release (complete)</td>
<td>EUUYZ</td>
</tr>
<tr>
<td>4</td>
<td>COGGN</td>
<td>Taking Off of Calling on signal.</td>
<td>COZ</td>
</tr>
<tr>
<td>5</td>
<td>EWN</td>
<td>Emergency release of point</td>
<td>EWWZ</td>
</tr>
<tr>
<td>6</td>
<td>OYN</td>
<td>Emergent release of overlap</td>
<td>OYZ</td>
</tr>
<tr>
<td>7</td>
<td>IBS passed at On</td>
<td>IBS passed at On, advise next station.</td>
<td>- -</td>
</tr>
</tbody>
</table>

Some of these visual indications needing immediate attention of the Station Master are associated with the audio indications. These indications on panel face help the Station Master in maintaining a close watch on the activities in the station yard and thereby operating and controlling train movement inside the station section and block section [Table 2.2.1(ii)].

**Counters:** Some of the operations such as emergent release of route, route section, overlap or emergent operation of point, which are related with safe running of train are counted automatically with the release operation taking place, for the purpose of maintaining record of such a situation having arisen. Besides in case any unsafe incidence occurs while making such an operation the counter record shall be able to establish that it happened during such an operation. Actions counted are provided in table 2.2.1(iii):

<table>
<thead>
<tr>
<th>SN</th>
<th>Button with counter</th>
<th>Action</th>
<th>Counter abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EGNR</td>
<td>Emergent signal replacement</td>
<td>EGGZ</td>
</tr>
<tr>
<td>2</td>
<td>EUYN</td>
<td>Emergency Section route release</td>
<td>EUYZ</td>
</tr>
<tr>
<td>3</td>
<td>EUUYN</td>
<td>Route release (complete)</td>
<td>EUUYZ</td>
</tr>
<tr>
<td>4</td>
<td>COGGN</td>
<td>Taking Off of Calling on signal.</td>
<td>COZ</td>
</tr>
<tr>
<td>5</td>
<td>EWN</td>
<td>Emergency release of point</td>
<td>EWWZ</td>
</tr>
<tr>
<td>6</td>
<td>OYN</td>
<td>Emergent release of overlap</td>
<td>OYZ</td>
</tr>
<tr>
<td>7</td>
<td>IBS passed at On</td>
<td>IBS passed at On, advise next station.</td>
<td>- -</td>
</tr>
</tbody>
</table>

**Buzzers:** Buzzers are provided with the panel for the incidence needing immediate attention of the Station Master. The buzzer is associated with an acknowledgement button and one indication which illuminates with a white or red light. Each time the buzzer sounds, the Station Master shall acknowledge by pressing an associated acknowledgement button which shall shun the buzzer while the indication shall continue to be illuminated till the action to be taken is completed such as if the buzzer sounds along with illuminated indication, for arrival of the train in the station section, the buzzer shall be shunned by pressing acknowledgement button but the corresponding indication shall continue to be illuminated till the block section closing process is completed.

Similarly in case when the train passes the Advanced starter signal, Train Entering Section (TES) message is to be given to the Station Master of the adjoining station, the delay of which may result in delayed operation of the block instrument which consequently may result in
failure of the Block instrument causing detention to the following train. Delayed reaction to all such incidences sounding buzzer shall have cascading effect on the system. Different buzzers and the incidences when it sounds, is tabulated in table 2.2.1(iv):

<table>
<thead>
<tr>
<th>SN</th>
<th>When the buzzer sounds</th>
<th>Acknowledgement button</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Panel button pressed for more than 10 seconds</td>
<td>White</td>
</tr>
<tr>
<td>2.</td>
<td>Block release buzzer sounds when the block overlap is cleared by the train.</td>
<td>Block clearance acknowledgement</td>
</tr>
<tr>
<td>3.</td>
<td>Train entry into block section</td>
<td>Train entry acknowledgement</td>
</tr>
<tr>
<td>4.</td>
<td>Signal lamp failure</td>
<td>Signal lamp acknowledgement</td>
</tr>
<tr>
<td>5.</td>
<td>Power failure</td>
<td>Power failure acknowledgement</td>
</tr>
</tbody>
</table>

Table 2.2.1(iv)

Buzzers on the panel

3. Operation of solid state interlocking (SSI): Solid state interlocking is software based and can be operated through a Control cum Indication panel or through a visual display unit (VDU), akin to monitor of computer, aided by a key board and a mouse or a combination of both i.e. VDU and Control cum Indication panel. However to facilitate easy transition from Control cum Indication panel with push buttons to a key board, mouse and VDU, the conventional Control cum Indication panel is provided with a changeover switch to transfer operation from panel to VDU and vice-versa.

Few examples of operation through key board, mouse and VDU are given as follows:

3.1 Operation of signalling gears through computer: A typical mode of operation curtsy Westinghouse Rail Systems, British supplier’s trade name for SSI as Westrace, is given here for example:

3.1.1 Interlocking system configuration: When it is decided to control the yard through computer system, a set of operator console (VDU), which is a high-resolution colour monitor, keyboard and mouse is provided with a computer to control the signalling gears. This computer is connected to the central SSI unit, through Input/output interface unit for exchange of control and indication messages. VDU software is provided to display track mimic diagram of the station on the VDU, which is exact replica of Control cum indication panel in conformity to the yard plan, to control the signalling gears through menu driven functions. When a function is selected, an appropriate menu driven guide format is displayed along with guiding prompts, to enter the commands such as route request, point normal or reverse request etcetera.

Out of the computer or panel only one of the two shall be on-line as selected by the operator. However, panel is also dynamically updated on real time basis to facilitate instantaneous switching over to the panel from the computer.

3.1.2 Operation of SSI: The VDU software is as per Windows Graphical User Interface (GUI) design standards, with multiple window capability.

On start-up, network communication between SSI unit and VDU PC is established. VDU software starts automatically and a mimic diagram depicting the yard layout is displayed. This software, along with the keyboard or mouse, provides the Graphic User Interface (GUI), which
is an important functional feature of VDU. Menu functions are provided for selecting the VDU display and control functions. Description of the GUI is provided in ensuing paragraphs.

3.1.3 Changeover from panel working to PC: The Control cum Indication Panel is provided with a key named as PANEL / PC KEY. Panel/PC Key symbol on the VDU is clicked using mouse and the menu will be displayed as shown in figure 3.1.3a. Clicking the ‘REQUEST PC’ menu, the ‘PC’ indication will start flashing on the Panel. The Panel/PC switch shall be turned to PC mode which shall make the PC indication steady, which indicates that the mode of working is now changed to PC.

When it is decided to change from PC to panel, the switch on the panel shall be turned to Panel which shall make the panel indication to flash on the VDU. When the mouse is clicked on panel/PC key symbol on VDU, the indication on the VDU shall become steady as shown in

3.1.4 SM’s key control: Akin to operation by panel, an electronic key control is provided on the PC also, to avoid unauthorised operation of the operating system when the Station Master is away. The SM’s key shown on the VDU panel is activated by clicking on the ‘SM key’ menu. The window shall be as shown in figure 3.1.4.

To disable SM Key in VDU, ‘SMKey’ ‘out’ as shown in the figure shall be selected. This will disable all pop-up menus. It shall not be possible to make commands for signalling system operation thereupon. To enable the system again, ‘SMKey’ ‘in’ menu shall be selected.
3.1.5 **Operating signals - clearing and cancelling:**

a) **Clearing:** taking signal Off:

i) **Advanced starter signal:** To clear or cancel an Advanced starter signal say S19, must shall be clicked near the signal, a pop-up menu ‘SIGNAL 19’ with sub menus ‘Clear’ and ‘Cancel’, will appear as given in figure 3.1.5a. Once Line clear is obtained and the ‘Clear’ option on the popup menu is clicked, the signal Off aspect indication will appear while at the same time signal at site shall be taken Off. The signal can be cancelled by selecting the ‘Cancel’ pop-up menu and clicking it.

ii) **Home signal:** Signal number S18 and Calling on Signal C18 are taken for example. When clicked on or near signal S18/C18 a popup menu shall appear with options ‘HOME’, ‘CALLING ON’, ‘Cancel Signal’, ‘Emergency Route Release’ and ‘Emergency Route Cancellation’. With selection of option ‘HOME’, submenus ‘Clear For Route C’ and ‘Clear for Route B’ shall appear. When Home signal is to be taken Off for route C the submenu ‘Clear For Route C’ shall be clicked (Figure 3.1.5b). The desired route for Main Signal S18 shall be displayed on the VDU as yellow strip between the Home signal and overlap beyond starter signal on the route selected and the signal shall display Off aspect at site as well on the VDU, on signal profile.

If the signal lamp at site fails and does not illuminate for any reason the signal aspect indication on VDU shall flash.

iii) **Calling-on signal:** Calling-on signal is taken Off to receive the train on occupied line. This rule is utilised to receive a train when the Home signal on the post of which the Calling-on signal is placed, fails to come Off due to the reason other than point failure In the route selected. In such a situation, since the train is made to stop at the signal first, on the post of which the Calling-on signal is provided, clear availability of overlap beyond the next signal is not required. First, the Home signal on the post of which the Calling-on signal is provided, in this example, and when the Home signal fails to come Off, the menu ‘CALLING ON’ is selected which pops up a submenu after the Calling-on track circuit is occupied by the train, to ensure that the train comes to a stop before the signal is taken Off. During this period of 120 seconds the Calling-on signal indication flashes on the VDU (Figure 3.1.5b).

As a signal is taken Off, the route onto which the signal leads is displayed up to the next signal including overlap beyond, through yellow illuminated strips. See figure 3.1.5 a (i) for display of route for Home signal number 18.
b) **Cancellation of signal:** Cancellation of a signal is done by selecting the option ‘Cancel Signal’ on the same popup menu as for taking the signal Off [(Fig 3.1.5a) and (Fig 3.1.5c(i))]. All other signals such as starter & shunt signals are taken Off and cancelled similarly. When a signal is cancelled it is put back to On immediately of command. *It is pertinent to note that cancellation of signal shall not cancel the route.*

![Figure 3.1.5a(i)](image)
*Display of route by yellow strip*

c) **Cancellation of route:** [(Fig 3.1.5a) and (Fig 3.1.5c(i))] Cancellation or release of route is invariably termed as emergent. The route is cancelled when the train has not occupied the approach track, while release of route is applicable when the train has occupied the approach track or the back lock track or when the signal is dead approach locked. In case of cancellation of route, the route including the overlap shall be released immediately. For approach locked signal it shall take 120 seconds to release the route, from the time the cancellation command is given.

In the present example, the popup menu shows ‘STARTER’ and ‘SHUNT’, when menu ‘STARTER’ is selected, submenus ‘Clear’, ‘Cancel’, ‘Emergency Route Release’, Emergency Route Cancellation’ and ‘Release Overlap’

![Figure 3.1.5c(i)](image)
*Emergency Route Release/Cancellation*
The menu for the desired operation shall be clicked and the route shall be cancelled along with the overlap.

However under normal circumstances some times when Overlap does not release automatically after arrival of the train on berthing track the overlap may be released by selecting the popup menu ‘Release Overlap’. In each case of release of the route another ‘Confirmation’ popup menu ‘Are you sure want to perform Emergency Operation?’ shall appear on the VDU to ascertain this to be a deliberate action, which can be confirmed by clicking option ‘YES’ or aborted by clicking Option ‘No’.

[Figure 3.1.5c (iii)]

**d) Point operation and crank handle release:**
(Figure 3.1.5d) When a point is clicked on VDU, a menu mentioning the point number shall appear with the options ‘Normal operation’, ‘Emergency operation’ and ‘Crank handle’. For Normal operation of point, which means that the point is to be operated under normal conditions and the point is not locked in any route, the ‘Normal operation’ option shall be selected by clicking on VDU which shall move the point from its present position to the other position. If the point is lying reversed and the option is clicked the point shall move to normal. Each such clicking shall move the point to the position other than present.

Emergent operation of point is done when the point is locked in any route and is undertaken under extreme emergency situations as the point gets operated bypassing track locking. To safeguard against inadvertent command given a dialog box will popup to reconfirm the operation similar to emergent route cancellation process.

For release of crank handle, when selected the ‘Crank Handle’ option on the popup menu when point is clicked on VDU, submenu ‘LOCK’ and ‘RELEASE’ shall appear. To release the crank handle for the point number 55, option ‘RELEASE’ shall be clicked which shall release the key for the crank handle, for the concerned point. Similar action is taken when the crank handle is to be locked by selecting and clicking ‘LOCK’ option of the same menu.
Till the crank handle key is locked with the relay at site, the indication above ‘LOCKED’ caption shall glow on VDU, marked as ‘RELEASE’, when key is taken out of the relay with clicking of ‘Release’ option on the VDU.

The ‘LOCK’ option of the submenu shall flash on the VDU until the key is taken out in the field and will disappear when key is taken out. Veeder counter when operation is through panel. However soft version of counters is also available on VDU which can be popped when required. This is with disadvantages i) soft version does not give the desired level of confidence to the user and ii) these counters are not visible to the operator all the time but have to be popped up. As an amiable alternative when the panel and the computer are used in tandem the veeder counters provided on the panel are used for operation by computer and panel.

c) **Locking and releasing of level crossing gate, controlled from panel:** [Fig 3.1.5f] With the clicking of level crossing gate profile on the VDU a popup menu shall appear on the VDU with options ‘LOCK’, ‘RELEASE’ & ‘CANCEL’.

For allowing the gate to be opened ‘RELEAE’ option shall be selected & clicked which shall permit the key for operation of the winch to be released in the gate lodge, when the gate is winch operated. If it is power operated with the release indication shall glow on the VDU, it shall enable opening of the gate and the Gate man shall open the gate.

When the Gateman closes the gate and puts back the key of the winch in the lock, or closes the power operated lifting barrier, on instructions of the Station Master, the ‘LOCK’ option of the popup menu shall start flashing. The flashing of ‘LOCK’ option shall stop with the Station Master clicking on the option.

Once train is passed and the gate man wants to open the gate, SM shall click LX Release menu. Now lock indication will flash till the gate man has taken the key.

Some more features: When MECR fails, to stop the buzzer, click ‘Failure Acknowledge’ When failure is rectified, again buzzer comes and to acknowledge that ‘Rectified’ menu is provided as shown in figure 3.1.6a & 3.1.6b.
1. **Multiple choice questions**

1. Control cum indication panel is:
   (a) Operating device.*
   (b) Operated device
   (c) Indication panel only
   (d) None of them.

2. Signal button on the panel are coloured:
   (a) Red.*
   (b) Grey.
   (c) White.
   (d) Blue.

3. Control of SSI can be done through:
   (a) Control cum indication panel.
   (b) VDU & mouse.
   (c) Either of the two.*
   (d) Both of the two at one time.

4. Electrical signalling system can be operated by:
   (a) Levers.
   (b) Control cum indication panel.
   (c) VDU & mouse.
   (d) Any of them.*

5. Buzzer shall sound on panel if:
   (a) Any of the buttons is kept pressed for 10 seconds or more.*
   (b) All the buttons are pressed simultaneously.
   (c) Signal & Route buttons are pressed for 5 seconds.
   (d) Two signal buttons are pressed simultaneously.

2. **Select the right answer (True/ False):**

1. Counters on control cum indication panel count cancellation of signal – True*/False
2. When a train enters the block section a buzzer rings on the panel- True*/False
3. Track circuit clear indication is shown on the panel as white strips always - True/False*
4. Point set to normal is indicated on the panel by letter N/R - True/False*
5. In route setting type of control panel points are set automatically be pressing signal and route buttons - True*/False.
3. **Answer the following question:**

1. Write short notes on:
   (a) Control cum Indication panel.
   (b) Electrical system of signalling controlled by levers.

2. Comment & describe: Interlocking system is in between operating device & operated equipment but before transmission media.

3. Write short notes on:
   a) Indications on the Control cum Indication panel.
   b) Control of SSI by VDU.

*****
CHAPTER – III

OPERATED EQUIPMENTS

1. Operated Equipments: The equipments which are operated by the Station Master for movement of trains are:
   i) Points - crossovers and turnouts by means of rod or point machines,
   ii) Facing point locks with or without lock bars,
   iii) Lock bars and Holding bars,
   iv) Signals - Colour light & Semaphore,
   v) Auxiliary signals - Colour light and semaphore,
   vi) Level crossing gates & lock on the gates.

Before going ahead on to operated equipment for points it is necessary to understand points and their structure on which the point machine is fitted to be operated.

2. Points & crossings, crossovers and turnouts: A set of points and crossings is a means to transfer railway vehicles from one track to another. The wheels of the vehicle are provided with inside flanges which negotiate the rail of the track guided by the switch rail through crossing, on to the track to which it is intended to move the vehicle on. (Subject of points is courtesy “Indian Railway Track 2008, by M. M. Agarwal”)

A pair of tongue rails with their stock rails is termed as points. A set of points and crossing leading from one line directly on to another line is a turnout [Figure 2 (a)], while two sets of points and crossings, i.e. turnouts, which lead from one track to another and vice versa is a crossover [Figure 2 (b)].

2.1 Components of the turnouts: [Figure 2 c]
   i) Tongue rail: a tapered movable rail made of high carbon or manganese steel to withstand wear. This is also called switch rail.
   ii) Stretcher bar: Stretcher bar is provided to maintain desired fixed opening at the toe of the tongue rail.
   iii) Stock rail: the running rail against which the tongue rail operates and houses at the toe.
   iv) Outer straight lead rail: Outer rail connecting stock rail to the rail of straight track,
   v) Inner straight lead rail: Inner rail connecting stock rail to the rail of straight track,
   vi) Outer curve lead rail: Curved rail connecting tongue rail on outer side to the crossing through a heel block.
   vii) Inner curve lead rail: Curved rail connecting tongue rail on inner side to the crossing through a heel block.
viii) Heel block: A specially designed block to connect the tong rail to the lead rails.
ix) Check rail: to guard the wheel flange against leaving head of the rail.
x) Crossing: it is a structure at the junction of intersection of two rails for smooth transition of wheel flange from one rail to the other.
xi) Gauge tie plates: on sleepers other than steel trough, a gauge tie plate is essentially required to keep the gauge maintained, where any signalled movement is to take place.

**Figure 2c**
Structure of a turnout

2.2 **Direction of turnout:** A turnout is designed as right hand or left hand turnout depending upon side if diversion of the traffic.

The direction of the point is called facing when the train or vehicle approaches it to face the thin end of the tongue rail. The direction of the point is trailing when the train or vehicle approaches to negotiate first the crossing before passing through the tongue rail.

2.3 **Tongue rails:** Are either straight or curved. Straight tongue rails while being easy to manufacture, can be fitted on left as well as right hand 1 in 8 ½ and 1 in 12 turnouts. However only limited speed can be permitted on such turnouts. The length of the tongue rails is measured from heel to toe, which vary depending upon gauge and the angle of the switch as given in table 2.3.

<table>
<thead>
<tr>
<th>Gauge &amp; Its Type</th>
<th>Length of the Tongue Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 in 8 ½ Straight</td>
</tr>
<tr>
<td>BG (90R)</td>
<td>4725 mm</td>
</tr>
<tr>
<td>MG (75R)</td>
<td>4116 mm</td>
</tr>
</tbody>
</table>

Minimum and maximum throw of switch in mm & in inches:

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Minimum &amp; Maximum Throw</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>95 – 115 mm, 3¾ - 4¾ inch.</td>
</tr>
<tr>
<td>MG</td>
<td>89 – 100 mm, 3¾ - 4 inch.</td>
</tr>
</tbody>
</table>
Permissible speed on turnouts: When a train is scheduled to stop at a station the approximate time lost in deceleration and acceleration combined together is six minutes, besides time of stoppage. Similarly there is loss of time when the train is required to negotiate through a turnout or crossover because of speed restrictions imposed, for safety reasons, for negotiating the crossover. Indian railway continues endeavouring reduction in negotiating time by modifying design of these turnouts.

The existing speed restrictions on different turnouts are tabulated below:

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Type of turnout</th>
<th>Switch angle</th>
<th>Permissible speed in kmph</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>1 in 8 ½</td>
<td>1º 34' 27''</td>
<td>10 for straight switch (speed reduced from earlier 15)</td>
</tr>
<tr>
<td>BG</td>
<td>1 in 8 ½</td>
<td>1º 47' 27''</td>
<td>15 for curved switch (of 52/60 KG rails on PSC sleepers)</td>
</tr>
<tr>
<td>BG</td>
<td>1 in 8 ½</td>
<td>Symmetrical split (S.S.)</td>
<td>30 for curved switch as well as for S.S. with 52/60 kg on PSC sleepers.</td>
</tr>
<tr>
<td>BG</td>
<td>1 in 12</td>
<td>1º 8' 0</td>
<td>15 for straight.</td>
</tr>
<tr>
<td>BG</td>
<td>1 in 12</td>
<td>1º 27' 35''</td>
<td>30 for curved switch (for 52/60kg on PSC sleepers (permitted if all turnouts on which running train may pass throughout the section and the loco is provided with speedometer.)</td>
</tr>
<tr>
<td>BG</td>
<td>1 in 16</td>
<td>0º 24' 35''</td>
<td>50 or 60+ (60+kmph permitted only for high speed turnout to drawing No. RDST/T-403.</td>
</tr>
<tr>
<td>MG</td>
<td>1 in 8 ½</td>
<td>1º 35' 30''</td>
<td>10 for straight.</td>
</tr>
<tr>
<td>MG</td>
<td>1 in 8 ½</td>
<td>0º 29' 14''</td>
<td>10 for curved switch.</td>
</tr>
<tr>
<td>MG</td>
<td>1 in 12</td>
<td>1º 0' 38''</td>
<td>15 for straight.</td>
</tr>
<tr>
<td>MG</td>
<td>1 in 16</td>
<td>0º 24' 27''</td>
<td>15 for partly curved switch.</td>
</tr>
<tr>
<td>MG</td>
<td>1 in 16</td>
<td>0º 24' 27''</td>
<td>30.</td>
</tr>
</tbody>
</table>

3 Minimum Equipments of points with respect to standard of interlocking: In terms of clause 7.131 chapter VII of SEM 1988 correction slip number 6 dated 26.03.2004, the minimum compliments for points vis-à-vis maximum permissible speed for all future works with effect of issue of the correction slip have been prescribed as:
<table>
<thead>
<tr>
<th>Requirement of points</th>
<th>Standards of interlocking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable speed</td>
<td>Standard - I -</td>
</tr>
<tr>
<td></td>
<td>Standard -II -</td>
</tr>
<tr>
<td></td>
<td>Standard - III -</td>
</tr>
<tr>
<td></td>
<td>Standard - IV -</td>
</tr>
<tr>
<td>Operation</td>
<td>Mechanical</td>
</tr>
<tr>
<td></td>
<td>Mech / Elec</td>
</tr>
<tr>
<td></td>
<td>Mech / Elec</td>
</tr>
<tr>
<td></td>
<td>Mech / Elec</td>
</tr>
<tr>
<td>Locking</td>
<td>Key/FPL/HPL</td>
</tr>
<tr>
<td></td>
<td>FPL /Point M/c</td>
</tr>
<tr>
<td></td>
<td>FPL/Point M/c</td>
</tr>
<tr>
<td></td>
<td>Clamp type direct*</td>
</tr>
<tr>
<td>Switch detection</td>
<td>Mech / Elec</td>
</tr>
<tr>
<td></td>
<td>Mech / Elec</td>
</tr>
<tr>
<td></td>
<td>Mech / Elec</td>
</tr>
<tr>
<td></td>
<td>Electrical</td>
</tr>
<tr>
<td>Lock detection</td>
<td>Not required</td>
</tr>
<tr>
<td></td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>Required</td>
</tr>
<tr>
<td>Interlocking</td>
<td>Key / Mech</td>
</tr>
<tr>
<td></td>
<td>Mech/Elec/ Electronic</td>
</tr>
<tr>
<td></td>
<td>Mech/Elec/ Electronic</td>
</tr>
<tr>
<td></td>
<td>Mech/Elec/ Electronic</td>
</tr>
</tbody>
</table>

Abbreviations: Mech- Mechanical; Elec- Electrical; FPL- Facing Point Lock; HPL- Hand Plunger Lock; Point M/c- Point Machine; * - Desirable.

**In terms of SEM 1984**, which was in vogue till the introduction of SEM 1988, and provision of which have been allowed to be continued in existing installations, the minimum requirements of points for permitting given speed have been prescribed as:

<table>
<thead>
<tr>
<th>Maximum permissible speed over the points</th>
<th>Minimum requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common to speeds above 15 Kmph</td>
<td>i) means for locking each switch independently, ii) a means for detecting each switch independently by the relative signals, iii) a gauge tie plate where steel sleepers are not provided.</td>
</tr>
<tr>
<td>Specific to speed up to 15 Kmph</td>
<td>i) A bolt and a cotter individually fitted to each switch rail and padlock or a clamp and a padlock for locking switch rail to stock rail, ii) A gauge tie plate where steel sleepers are not provided.</td>
</tr>
<tr>
<td>Specific to speed up to 50 Kmph</td>
<td>i) A key lock of approved type, ii) A means for preventing the points from being unlocked during the passage of train, unless arrangement is such that a key is used to release the signals and cannot be brought back to the points until such signals have been put back to On position.</td>
</tr>
<tr>
<td>Specific to speed up to 75 Kmph</td>
<td>i) A plunger type facing point lock, ii) A means for preventing the points from being unlocked during the passage of train, unless arrangement is such that a key is used to release the signals and cannot be brought back to the points until such signals have been put back to On position.</td>
</tr>
<tr>
<td>Specific to speed exceeding 75 Kmph</td>
<td>i) A plunger type facing point lock, ii) A means for detecting full travel of the lock plunger by relative signals, iii) a means for preventing the point from being unlocked during the passage of train.</td>
</tr>
</tbody>
</table>

4. **Equipment for operating point**: The operation of points may be either by mechanical means or electrical means, in any case it has to be in compliance to the provisions of Signal Engineering Manual 1988 for all new works and in compliance to the provisions of SEM 1984 for all existing installations.
Under system of mechanical signalling points are operated by a lever through a steel rod of 32 mm diameter run between lever tail and arm of the adjustable crank. Under double wire system of mechanical signalling rotary point machines are used to drive FPL and throw the switches. For detailed system of mechanical operation of point, Indian Railway Signal Engineering Volume III may be referred to. However in a system of electrical signalling, points are operated by electric point machines.

5. **Electric and pneumatic point machines**: Machine powered electrically or pneumatically to unlock the point, throw the switches form one setting to another i.e. normal to reverse or reverse to normal and lock both the switches of the point open and closed, in last operated position.

Variety of point machines have been in use by Indian railways over the period as detailed below:

5.1 **Electric Point machines based on style**: Based on style and technique of operation & locking the tongue rails, point machines are of type where the arrangement for locking the points is outside the point machine casing, i) Out type and where the arrangement of locking is inside point machine casing, ii) Internal type.

These machines are again classified based on arrangements as:

i) In & out type also known as FPL type - 5A (GRS) with single field and 5E (Nippon) point machines.

ii) Straight throw also known as (Switch & Lock Movement) SLM type– M-63 manufactured in India by M/s Westing House Saxby & Farma, with split field motor.

iii) Rotary type –Siemn’s and Crompton & Grieves make with split field motor.

In, *out type Electric Point Machine* the arrangement to lock the point is similar to mechanical Facing Point Lock which is outside point machine. The movement of point motor is imparted in parts i) a plunger moves linearly to unlock the point, during this period there is no movement to the point operating crank, ii) while the plunger continues moving in the same direction idle, the point operating crank imparts movement to throw rod connected to leading stretcher bar to set the point. Once the tongue rails have moved to the desired position iii) the plunger re-locks the point split stretcher bar in the last operated position. Same sequence of operation takes place to set the point in opposite direction.

a) **Style ‘M’ point machine**: Series commutator type motor is designed to work on 20-30 volt DC, 110V DC or 110 V single phase AC. The minimum stalling thrust of the DC point machine is for 1500 lbs. The motor imparts drive to the crank arm connected to point throw rod and to lock bar through gear train and a friction clutch. Locking of tongue rails and detection of point setting is inside point machine. The detection is completed only when the lock engages the extended lock slides beyond 1¾" with the completion of lock bar stroke. The circuit controller, facing point lock and the point and lock detector is housed in third compartment out of three compartments of the point machine, each compartment of which has its independent cover. The arrangement in the point machine is to extend the throw to an out side lock-bar also. The machine can be operated manually by a crank handle.
AC operated point machine is controlled by a polarised relay placed near the point machine which is used to interchange the phase and neutral for the purpose of reversing the direction of motor rotation.

b) **Type ‘HA’ (SGE) point machine**: series wound split field motor works on 110 V DC with nominal 4-5A current for single ended point and 6-7 A for double slip points. One winding is used for normal operation and the other for reverse operation. The machine is out type which throws the point to either side and gives drive to outside lock bar. The gear wheel driven by the motor through a friction clutch drives the escapement crank and the lock bar. The escapement crank moves about the fulcrum in between its ends, on the machine base. A roller pin is provided at one end of the escapement crank which moves along a cam-path cut into the gear wheel. The other end of the escapement crank is connected to the throw rod and gives drive to throw rod to set the point to normal or reverse in either end of the gearwheel movement. The gear wheel gives drive to lock bar through a crank and link arrangement which is designed such that the lock bar moves in one direction first to unlock the point then to hold it till the points are moving and then to relock the point with complete rotation of the gear wheel.

The motor is connected with snubbing relay to avoid jerks at the completion of the movement.

c) **Style 5A (GRS) point machine**: Style 5A (GRS) point machine is combined type in which unlocking, throwing of points, relocking detection is combined. The lock is in and out type. The motor is 110 V DC operated, four poles series wound. The field coils are wired in two pairs in series. It takes 5 A to operate single ended point. The stalling force is 4000 lbs. The motor gives drive to point operation gear through a clutch. The throw of the machine is six inches as such to accommodate the 4½" stroke required for the point operation the stroke is adjusted so as to provide an idle stroke of 1½". The power to the motor is supplied through a relay with heavy duty contacts.

The points can be operated manually by hand cranking.

The friction clutch comprises of about six steel friction discs. Half the discs of 3/16 " thickness are keyed to the friction clutch case and half of 1/8" thickness are fixed with driving shaft. In between these discs moulded feredo friction disks are placed and the entire system is adjusted to required friction force by spring loaded bolts.

d) **Model 5E switch point machine**: Model 5E switch point machine is manufactured in India by M/s Westing House Saxby Farma Company, Kolkata (erstwhile Calcutta). The machine works with series split field 110 V DC motor. The friction clutch having two steel discs with cork disks with creel is fitted on the motor shaft along with a creel. The cork disks provide friction grip. The friction is adjustable by nuts provided on friction clutch casing.

This is an in type point machine. The drive is given to locking bar housed inside point machine casing through a specially made fibre glass reinforced belt. The belt couples with the creel on the shaft of the motor and a gear assembly fixed on the slide. With the movement of the locking bar the escapement crank is driven about its fulcrum provided on the body of the machine, by a roller pin fixed on the locking bar. The locking bar first unlocks the point slides and continues to move forward engaging the escapement crank which in turn gives 125mm movement to the throw rod to one side setting of the point. The locking bar locks the point slides and keeps the
escapement crank in last operated position. Same action is repeated while reverse rotation of the motor. Total movement of the locking bar is 200mm. The machine has inbuilt point and lock detection.

The Machines where the locking of points is out side the point machine, are being phased out gradually and are more or less of historical importance.

5.2 Electric point machines based on power supply:
   i) Direct Current (DC) - 110V DC, 36 V DC, 24 V DC
   ii) Three phase Alternating Current (AC) – 400V three phase AC.
   iii) Electro-Pneumatic.

5.3 Electric point machines based on field arrangement:
   i) Single field GRS 5A Nippon make.
   ii) Split field GRS 5E, IRS type M-63, Siemens and Crompton & Grieves.

5.4 Electric point machines based on usage:
   i) Trailable, used generally in hump yards where lose shunting may cause trailing through of points thereby breaking the point machine.
   ii) Non-trailable all point machines under general usage for running of trains.

5.5 New generation point machines: Design factor - The machine should be designed such that:
   i) The body and parts of the machine should be sturdy enough to withstand heavy jerks imparted by train passing over the point on which the machine is fixed as well as it should be possible to fix it ensuring no inter stock rail and point machine movement. This is done by providing extended gauge tie plate placed on the sleepers and fixing on longer sleepers with four bolts.
   ii) The machine should be secured against out side interference.
   iii) It should be possible to operate points mechanically in absence of failure of electrical or pneumatic operation.
   iv) When being operated locally without electric operation, the electric power supply to the machine should be cut off to safe guard against inadvertent extension of power supply resulting in operation of point machine may not cause injury to the persons working.
   iii) It should be possible to reverse movement of switches midway at any stage of operation.
   iv) The operation of points, locking and detection of each switch is housed within the point machine housing.
   v) Power supply to the point machine shall be i) 110V DC, ii) 110V single phase AC, iii) three phase 400 V AC or, iv) Electro Pneumatic.

5.5.1 110V DC fed 143 mm or 220mm stroke point machines & its operation: 143 mm stroke 110 V DC point machines are widely used on Indian railways except for considerations of high speed turnouts, thick web switches or AC immunity in area electrified on 25 KV AC traction, where specific designed machines are chosen for use [Figure 5.5.1].

The machine with twin series wound DC motor, gives high initial torque. The direction of spindle of the motor gets reversed with the 110V DC fed through one winding is changed to the second winding. The machine’s armature is extended to spindle which gives drive to a rotary
pinion wheel. The pinion wheel is connected to a gear drum through a clutch, which gives to & fro drive to a slide through rack and pinion arrangement. The slide, in turn is connected to the throw rod. The throw rod is connected to the lug fixed with the leading stretcher bar of the point, moving point from normal to reverse or reverse to normal depending upon rotation of the spindle of the point machine.

The clutch is provided to allow slippage to the armature movement in case of there being an obstruction between switch and stock rails of the point as well as in order to absorb shock when the point is set. This is to avoid heating and consequent damage to the armature winding.

A set of two slides is housed in the point machine, each of which is attached with the rod connected to the ‘D’ bracket fastened to each switch with bolts and nuts for locking of the tongue rails. A rotary lock is attached with the worm wheel spindle through clutch which locks the slide in the point machine in normal or reverse position. These slides are in two pieces fastened to each other through intermeshing teeth tightened together with bolts, making the assembly adjustable so as to ensure for point switches that it is not possible to lock the switch rails in their last operated condition unless the gap of closed switch and the stock rail is less than 5 mm. Whenever there is improper setting of switch rail with the stock rail due to any reason the rotary lock shall not be able to move inside the curved notch of the switch rail slide while the armature of the motor of the point machine shall continue moving. To avoid damage to the motor and machine the rotating time of the motor is restricted to 10 seconds after which the heavy duty WCR (Siemens) or QBCA (Q series) contactor relay gets de-energised and cuts the point operation circuit.

Figure 5.5.1
Point operation circuit and NC/RC contacts

5.5.2 One of the manufacturer’s of in type point machines are M/s Siemens, point machines which are being used on Indian Railways. The Assembly arrangement of a typical point machine manufactured by M/s Siemens is shown in figure 5.5.2. The Split field DC Electric Motor marked as ‘3’ is housed into a cast iron base ‘1’. The pinion of this motor gives rotary drive through reduction gears to toothed circular assembly with a clutch ‘5’. This circular
assembly makes a rack and pinion assembly and further transmits linear motion to rack slide ‘7b’. This rack slide connected to throw rod further imparts motion to throw rod which is connected to the lug fastened with leading stretcher bar of the points. One bracket is fastened with each switch rail to which one rod each is connected with the slides ‘6a’ & ‘6b’ provided in point machine cast iron housing.

![Figure 5.5.2](image)

**Assembly arrangement of the siemens point machine (courtesy M/s Siemens)**

Just above the two detector slides, Switch Pedestal with contact device is housed for point setting detection. The assembly contains detector contacts and NC/RC contacts. The detection rods are connected with the bracket fixed on switch rails, through eye joint and cotter bolts at one end and to the detector slides housed in the point machine through an extension piece and nuts.

5.5.3 **Adjustment of detector contacts and obstruction test:** Detector slides of closed switch are adjusted with reference to the detection rods using nuts in such a way that the detection contacts shall just make when an test piece of 1.6mm is placed between tongue and stock rails of closed switch at a distance of 150 mm from the toe of the switch and is just disconnected when the test piece of 3.25 mm is placed at the same position.

5.5.4 **Obstruction test** shall be carried out with an obstruction piece of 5mm thickness placed in between stock rail and switch rail at a position of 150mm from the toe of the switch. As the switch rail is butted against stock rail with the obstruction piece in between, i) the point
shall not be locked, ii) point detector contacts should not assume the position indicating point closure and iii) friction clutch should slip.

5.5.5 Normal /Reverse contacts (NC/RC): [Figure 5.5.1] In consideration of basic requirement that it should always be possible to through back the point to either way in case the point does not move to the position desired other than its setting from it was initiated to be thrown, or it is decided to put back the point to its original position while the point had already moved and is midway, NC & RC contacts are provided. When the point is set and locked in normal position, RC contact is made to enable point to be operated for reverse setting and NC contact is disconnected and vice versa when the point is set and locked in reverse position, NC contact is made and RC contact is disconnected. When the point is moving NC & RC both contacts are made to facilitate midway reversal.

One rod is fastened with brackets fixed on each tongue rail using eye joints and cotter bolts there by connecting both tongue rails. One rod is connected between lug, provided in middle of the rod joining both the brackets and Lock slide ‘7a’ and is adjusted in such a way that the locking slide and gear rack get locked at the end of its stroke by a segment engaging in their locking curves to hold the point in last operated position. An additional arrangement is provided in the lock slide such that a gap of more than 5mm is never possible to be created between stock rail and the tongue rail when the train is moving over the points.

5.5.6 Reduction gears: For operation of switch & lock the gear ratio of the motor straighter & worm wheel is such that the motor needs less power to transmit desired stalling force on to the point switches. The worm wheel which drives clutch wheel revolves less than one turn.

5.5.7 Friction clutch: the point motor & driving gear assembly are connected through the friction clutch. Whenever the load on the motor shaft increases beyond a limit, the friction clutch slips & allows the motor to move on without transmitting movement to the driven assembly.

The friction clutch declutches:

i) To accommodate momentum after the point has been set and locked

ii) When there is obstruction in between switch and stock rail due to which indication circuit is not getting completed to disconnect the point operation circuit.

(iii) During mid stroke reversal.

5.5.8 Adjustment of friction clutch: In terms of paragraph 19.37 of SEM Part II, September 2001, ‘Friction clutch should be so adjusted that slipping current is between one and half times to twice the normal operating current or as specified by the manufacturer. For rotary type point machines no attempt should be made to adjust the friction clutch at site. Friction clutch can only be adjusted in authorised workshop. When difference between normal operating current and operating current under obstruction is less than 0.5A, the clutch requires adjustment. Such machine should be replaced.

5.5.9 Snubbing: In context to pint machine, snubbing is stopping the motor of the machine from continuing its rotation after the feed is disconnected. It is to safeguard the entire system against severe jerk due to uncontrolled over run of the motor. Clutch is provided in point machine to retard onwards movement of the motor after the power supply, to give drive to the motor, has been switched off. In machines where clutch is not provided field of the motor is short circuited which generates an electro motive force which is reverse to power supply.
polarity which caused rotation of the stator, thereby it opposes the very cause due to which it was created. This generated Electro Motive Force (e.m.f.) thereby retards the movement of the stator. This is done through i) Snubbing relay, ii) Directional contacts, iii) rectifiers.

5.5.10 Manual operation of electric point machine: when the point machine fails to operate electrically, a crank handle is used to operate the points manually to set it to either way. The crank handle provided with point machine by the manufacturer, is universal as such any crank handle can be used with any point machine. This may lead to liberal use of the crank handles endangering train movement. To safeguard against this undesirable situation, all crank handles so procured with the point machines are confiscated and put in safe custody.

Given number of Crank Handles is interlocked with the signals in such a manner that release of any crank handle shall stop signalled movement over the affected point. For this, crank handle groups are created to cover all electrically operated points in the yard. One or more points are created in each crank handle group.

The groups are made in such a way that failure of one point machine requiring manual operation does not affect movement over the routes other than the affected point. As and when any point fails needing manual operation by crank handle, a key is released from a Key Lock Control Relay (KLCR) (Siemens group of relays), which is used to open the flap of the corresponding point machine cover [marker ‘2’ of figure 5.5.2]. A 2 ½ inch stroke lever lock connected to the plunger of ‘E’ type lock is also used in lieu of the KLCR. The crank handle is attacked with the key of the ‘E’ type lock using a chain to keep the crank handle attached with the key inseparably. As the crank handle is released from the panel a indication is illuminated near the lever lock. The key can be operated allowing its full rotation to enable it to be extracted from the ‘E’ type lock. After operation of the point machine the key is put
back into the ‘E’ type lock and rotated to be locked with the lever-lock.

Either a crank handle is chained with each group KLCR or one crank handle is kept in a box locked by the Station Master and sealed by one of the responsible S&T staff, kept in Station Master’s room. In any case the key released from KLCR corresponding to a specific ward when inserted into the point machine cover, the crank handle either chained with the key or brought after opening the lock & break opening the seal from the Station Master’s office is inserted into the opening created into the cover of the point machine by the key released from KLCR.

Insertion of the crank handle operates the switch [marker ‘8’ of figure 5.5.2] fixed with point machine cast iron casing, which in turn breaks power supply contact to the point machine for the safety of men crank-handling it. This is to ensure that while crank handle is being used, electrical operation of point machine should not take place for safety of the persons crank-handling the point machine.

5.5.11 Crank handles Grouping: In the given example, crank handles have been grouped as CH: GR.1 (CH-crank handle; GR-group) covering point number 59, CH: GR.2 covers point number 54, CH: GR3 covers point numbers 52 & 56 and CH: GR.4 covers point number 55. If point number 59 & 55 are put in one crank handle group, failure of point number 55 which if required to be operated by crank handle shall also stop signalled movement over the up main line along with down main line, both points being in the same group, it is therefore essential that point number 59 is not put in any other group. However when point number 56 and 52 are put in the same group failure of any of the two points shall stop movement on up loop line only without affecting any other movement in the yard. For similar reasons point number 54 & 52 if put in one crank handle group, failure of point number 52 shall stop signalled movement on up main line also (Figure 5.5.11).

5.5.12 Features of the point machine:

<table>
<thead>
<tr>
<th>SN</th>
<th>Features of machine</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motor</td>
<td>110V DC operated split field, series wound with Minimum operating voltage 60 V</td>
</tr>
<tr>
<td>2</td>
<td>Normal operating current</td>
<td>2.5 to 3 Amp.</td>
</tr>
<tr>
<td>3</td>
<td>Operating current</td>
<td>3.6 to 3.8 Amps.</td>
</tr>
<tr>
<td>4</td>
<td>RPM</td>
<td>1700</td>
</tr>
<tr>
<td>5</td>
<td>Stroke</td>
<td>94mm (minimum) &amp; 143 mm (maximum)</td>
</tr>
<tr>
<td>6</td>
<td>Operating time</td>
<td>3 to 4 seconds</td>
</tr>
<tr>
<td>7</td>
<td>Stalling thrust</td>
<td>200 Kg.</td>
</tr>
<tr>
<td>8</td>
<td>Range of operation with 1.5 sq mm Cu signalling cable.</td>
<td>820 mts.</td>
</tr>
</tbody>
</table>

5.6 Fixing of point machine: In case of points operated by rods, the Adjustable Crank is fixed on a cast iron foundation which intern is concreted to make a monolithic mass with the ground. The stretcher bar of the point is connected with the adjustable crank through a throw rod. Usually the point assembly moves laterally, where the traffic is unidirectional, termed as
creep, the throw rod connected between adjustable crank and the leading stretcher bar does not continue to be at right angle to the track alignment thereby the angular component of the power transmitted to the point does not continue be full and gets reduced depending on angle of alignment with reference to a line right angle to the rail. To overcome this, the point machine is installed on the same sleepers on which point assembly is fixed thereby eliminating the condition of angular throw to points.

The fixing arrangement of 143 mm stroke point machines on PSC sleepers to operate 1 in 12 turnout with curved switches is provided under RDSO drawing number RDSO/S 3361-62 (Figure 5.6).

Machine is installed on 3750 mm long sleeper numbers 3 & 4. Gauge tie plate is provided to full length on sleeper number 3 and an extension piece of MS plate is provided on sleeper
number 4 to maintain the machine placed levelled. Distance of leading stretcher bar from the
toe of the switch is kept 685 mm. The distance of machine centre from the inner gauge face is
kept 950mm and for point machines raised by 150mm above sleeper as 1050mm. The space
between other sleepers is modified as given in the point machine layout in Figure 5.6.
Dimensions mentioned in the drawing are in mm.

5.7 **Thick web switches and Clamp lock:** In terms of Standards of Interlocking, provided
in Signal Engineering manual 1988 paragraph 7.131 read with correction slip number 6, the
speed of the train is prescribed to be 160 Kmph under standard of interlocking number IV.

*Figure 5.7*

*Thick web switch with clamp lock point layout*
Under the minimum equipment of points on such station, point machine should preferably be provided with a clamp lock (paragraph 3 as above). Electric point machines have to be used under IRS specification number IRS-S 24. The fixing arrangement of point machines of 220mm stroke with clamp lock arrangement on PSC sleepers is given in drawing number RDSO/S 3454-55 for 60 & 52 Kg rails respectively. Clamp lock is subassembly of the point machine (RDSO/S 3455) under drawing number RDSO/S 3376 for 52 Kg rails. (Figure 5.7)

5.7.1 **Thick web switches:** for the purpose of high speed of trains on turnouts, 20 sets each of three types of high-speed BG turnouts were imported from BBRE/UK, COGIFER/France and VOEST-ALPINE/Austria and put on trial on Indian Railways, in early 1990’s. All of these turnouts were 60 Kg Thick Web Switches (TWS) with clamp locks. The switch opening at toe was 160 mm for British and Austrian designs and 140 mm for French design. Based on the studies of these imported thick web switches layouts, Railway Board placed an order of 400 sets of 10125mm ZU-1-60 thick web curved switches for use on fan shaped PSC sleepers in 1995. These thick web switches were provided through six Indian firms with their own designs on five Railways namely erstwhile Central, Eastern, Northern, and Western & South Eastern Railways.

Only 35 - 40 mm flange way clearance could be available at Junction of Rail Head (JOH) of open switch rail on these turnouts with 115mm switch opening as against 60mm required. This resulted in hitting by each passing wheel at JOH causing severe fatigue, wear & tear of tongue rail, stresses on point machine, locking/detecting mechanism & connection with tongue rail. To overcome this, direct locking of closed tongue rail with stock rail through clamp point lock to enhance safety and 160 mm opening at toe of open tongue rail along with use of spring setting device (SSD) to improve track clearance at JOH are adopted as standard requirements of thick web switches.

As operation of thick web switch is not possible with 143mm throw point machines not being enough to operate clamp lock as well as to have 160mm opening to achieve adequate flange way clearance at JOH, 220mm throw IRS type electric point machine and clamp lock were developed by RDSO and 75th SSC’s recommendations approved by Board. 220mm IRS type electric point machine and clamp lock were included in revised specification of electric point machine i.e. IRS: S 24/2002 issued on 5.9.2002.

Electric Point Machine with clamp lock, besides being operated by 110V DC power supply and internal interlocking has additional features as:

<table>
<thead>
<tr>
<th>SN</th>
<th>Features of machine</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motor</td>
<td>110V DC operated split field, series wound 0.44 KW</td>
</tr>
<tr>
<td>2</td>
<td>Maximum operating current</td>
<td>5.5 Amps.</td>
</tr>
<tr>
<td>3</td>
<td>Maximum stroke</td>
<td>220 mm</td>
</tr>
<tr>
<td>4</td>
<td>Maximum stalling thrust</td>
<td>450Kg</td>
</tr>
<tr>
<td>5</td>
<td>Maximum operating time</td>
<td>5 seconds</td>
</tr>
<tr>
<td>6</td>
<td>Range of operation with 1.5 sq mm Cu signalling cable</td>
<td>820 mts.</td>
</tr>
</tbody>
</table>
i) 220mm throw instead of 143 mm to accommodate 160 mm opening (for adequate clearance at JOH) and 60 mm for clamp lock.

ii) 700 kg slipping load.

iii) 1000 kg Minimum Stalling load.

5.7.2 Clamp Point Lock: Drawings showing for 52 Kg & 60 Kg thick web switches turnouts of 160mm opening ground connection and clamp point lock have been issued vide Drawing numbers RDSO/S 3455 and RDSO/S 3454 respectively. After successful trial, these were incorporated in specification number IRS: S 24/2002 of electric point machine vide clause No. 20.3 with following salient features:

i) Tongue rail and stock rail in closed position are directly locked.

ii) Open tongue rail is firmly held in open position.

iii) Relative movement between tongue and stock rail is checked.

The ground connection and clamp point lock of 52 kg & 60 kg turnouts have been made as a part of specification of these point machines to be supplied along with point machine if asked by the purchaser which is recommended for better compatibility.

a) Operation of Clamp point lock: Before installing clamp lock i) all Permanent Way leading and following stretcher bars are required to be removed from the turnout as during operation both the switch rails move separately and ii) Switch rails are set to house against stock rail up to JOH as far as possible maintaining a minimum gap of 57mm at JOH for adequate flange way clearance. Total throw of the point driving bar is 220mm [Figure 5.7.2].

Especially designed point driving bar is attached with the throw rod of the point machine which can be attached on either side. The lock lever is swivelled to switch rail and swings about its fulcrum. The clamp is rigidly attached with the stock rail. Both the switch rails move independent of each other.

On closed switch side, the point driving bar is so designed that when the point is set on either side, the lock lever gets out of the notch of the point driving bar and gets sandwiched between point driving bar and the shoulder of the clamp making the assembly a monolithic block holding the switch rail rigidly with the clamp-stock rail through lock lever in its closed position.

On open switch side, at the same time, the lock lever engages itself with the notch in point operating bar getting sandwiched between inner wall of the clamp and the notch of the point operating bar thereby rigidly holding the open switch also in its opened condition.

At the closed switch rail end, as the point driving bar moves towards left to change the setting of point from the given position to other position, the notch in the point driving bar gradually aligns itself to the head of the lock lever as the point driving bar moves further the head of the lock lever moves inside clamp getting sandwiched between the clamp wall and the notch in the point driving bar. This is first 60mm move of the point operating bar during which there is no movement to the closed switch rail except that the closed switch rail is released and gets ready to move having been engaged to the point driving bar, while the open switch rail moves by 60mm towards stock rail.
During next 100 mm throw, both tongue rails move by 100 mm thereby completing 160 mm throw.

As the point driving bar moves further during the last 60 mm throw of the point driving bar, the lock lever head starts getting out of the notch of the point driving bar, on open switch rail end which is in the process of closing, and is sandwiched between the point driving bar and the shoulder of the clamp making the lock lever and the clamp assembly a monolithic body thereby holding the closed switch tightly with the stock rail.

After adjusting the clamp lock the detector slides, lock slides and drive rod shall be adjusted such that with 5 mm thick obstruction test piece placed between the switch and gauge face of stock rail at 150 mm from the actual toe of the point, the point does not get locked either by clamp lock, inside lock or in the point machine and detection contacts are not made.

![Diagram of clamp lock locking sequence of the point](image_url)

**Figure: 5.7.2**

*Clamp lock locking sequence of the point*
b) **Installation:** Instructions for installation have been covered under report No.SS-85 on installation and maintenance of clamp point lock and 220mm throw Electric Point Machine on 60 Kg TWS turnouts on PSC Sleepers (Ref: Drg. No. RDSO/S 3454) released by RDSO in February, 2000).

5.8 **Electric point machine provided in area electrified with AC traction:** The distance between switching relay and the point machine is an important factor for point operation for the reasons of, i) voltage drop and ii) development of induced voltage, across the conductors when provided in area electrified with AC traction.

So far as voltage drop is concerned the same is partially made good by adding conductors of the cable in parallel to the main conductor thereby reducing the voltage drop. However electric motor of the point machine shall be required to be immunised to AC developed proportionate to the length of parallelism. Maximum permissible length of parallelism for various type of commonly used point machines have been prescribed under paragraph number 22.8.22 of SEM Part-II, September 2001 as shown in the table 5.8

<table>
<thead>
<tr>
<th>Type of Machine</th>
<th>AC immunity level in volts</th>
<th>Maximum permissible parallelism in meters between point contactor &amp; point motor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Single line</td>
</tr>
<tr>
<td>IRS-24</td>
<td>160</td>
<td>910</td>
</tr>
<tr>
<td>SGE 110V</td>
<td>250</td>
<td>1435</td>
</tr>
<tr>
<td>GRS 5E</td>
<td>90</td>
<td>515</td>
</tr>
<tr>
<td>Style 63</td>
<td>130</td>
<td>745</td>
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<td>M3</td>
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<td>160</td>
<td>910</td>
</tr>
<tr>
<td>Siemens IB</td>
<td>300</td>
<td>1650</td>
</tr>
<tr>
<td>Siemens IC</td>
<td>400</td>
<td>2200</td>
</tr>
<tr>
<td>LM-55</td>
<td>160</td>
<td>910</td>
</tr>
</tbody>
</table>

*Table 5.8*

*Maximum permissible length of parallelism up to which the point machines may be provided in area electrified with AC traction*

The Distances are worked out with a factor of safety of 1.5.

5.9 **Electro Pneumatic Point machines:** Once the water enters the electrically operated point machine its motor stops working immobilizing yard moments. These point machines are used by placing them on a raised platform and giving drive to the stretcher bar through offset brackets. As it can be visualised the arrangement is not very satisfactory. In such area pneumatic point machines work satisfactory with specific reference to Mumbai suburban area.

An electric motor operated compressor is connected to a storage reservoir at a place convenient to group of point machines. The drum is filled with compressed air at a pressure of 40 to 80 pounds per square inch and is connected to point machines through dedicated galvanised steel
pipelines. These pipe lines are provided with stop cocks in such a way that defective pipeline may be isolated and air supply may be regulated through a parallel loop. The compressor system is provided with cut-in and cut-out switches to start and stop the motor when the air pressure inside reservoir reaches to maximum and minimum level respectively. As and when the point is required to be thrown from normal to reverse or vice versa the command is given electrically to control magnet which in turn controls the desired valve to release the air pressure to the Operating cylinder and thereafter discharge the air there from and throw the point to set it and lock it in last operated position.

*Fig 5.9*

*A typical pneumatic point machine.*
In order to have reliable supply of the compressed air two compressor units are used with two reservoirs. The compressor of one reservoir works at one time.

The operation of point takes place as switch and lock movement (SLM) in one direction. Accordingly the movement of point unlocks the points, operates and locks it in one straight move in either direction. A photographic picture of pneumatic point machine is placed as figure 5.9 (courtesy manufacturer of the pneumatic point machine).

Valves used are cut-off type of style ‘C’ or continuous air feed type of style ‘CP’. The cut-off type valve applies pressure for a short time and stops while continuous feed type continues to maintain pressure. Continuous air feed type valves are used in hump yards.

The point motor cylinder has a piston. The valve is so designed that it compresses air from one side and releases from the other side of the motor to exhaust the air out of piston trapped in cavity other side of the piston. The motion of piston moves the point.

Electro pneumatic point operation machine control valve style ‘CP’: Instead of using slide valves as in case of valve type ‘C’, two separate poppet valves N1 & N2 are used. Under normal conditions valves are closed under spring pressure. As the point is desired to be set from reverse to normal, the electric coil NW is energised due to which exhaust ports are closed, pin valves are opened allowing compressed air to flow from main chamber to the normal intermediate cylinder. Piston is pushed and the poppet valve N1 is opened. Consequently the air enters into normal side of the double acting motor, throwing the points to normal. As the point is detected normal the supply to the valve coil is cut off, pin valve is released cutting off further supply of compressed air to cylinder ‘N’ and the air inside is allowed to escape to atmosphere.

Electro pneumatic operation of points has definite advantages over electric point machine except that the point cannot be operated manually in case of failure of pneumatic system of operation:

i) The point can be operated under water.

ii) Operation of point is almost instantaneous.

iii) Apparatus used is simple and requires low maintenance.

iv) Electric consumption for point operation is low.

The detection arrangement is housed within point machine.

5.10 **Trailable point machines**: Under normal circumstances whenever a point worked by an electric point machine is trailed through, which could be through un-signalled move only, the machine is usually damaged, point being locked and wheel flange force making space between stock and tongue rail to accommodate its thickness. These machines are termed as non-trailable point machines.

In marshalling yards if points are electrically operated the marshalling movement may result in trailing through of points. Trailable point machines are found useful in such yards as the trailing through by the wheel does not damage the point machine.
5.11 **Three phase 400V AC point machines**: Distances between heavy duty contactor unit and the DC point machine, being large, in bigger yards and owing to the limit of distance, in area electrified with AC traction the heavy duty contactor unit is required to be shifted within limiting distance from the point machine complicating the arrangement. To mitigate such a situation three phase 400 V AC point machines are provided. The machine is by and large the same as a DC point machine except that the motor provided is synchronous operated by three phase.

The characteristics of a typical three phase point machine are provided in the table marked as figure 5.11.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>400 V AC 3 phase</td>
</tr>
<tr>
<td>Throw</td>
<td>143 mm</td>
</tr>
<tr>
<td>Rated current</td>
<td>≤ 2.5 A</td>
</tr>
<tr>
<td>Starting current</td>
<td>≤ 10 A</td>
</tr>
<tr>
<td>Operating time</td>
<td>&lt; 6 seconds</td>
</tr>
<tr>
<td>Stalling force</td>
<td>3500 N</td>
</tr>
</tbody>
</table>

Figure 5.11: Features of three phase 400V AC point machine

6. **Level crossings**: Level crossings are unmanned and manned. Roads which are unimportant with scanty traffic and with equally less frequency of trains on the track are left unmanned in view of economics of chances of accident being rare versus the cost of manning the gate. Crossing of such railway track is the responsibility of individual person who is supposed to verify the approaching train before moving across the road taking care of his own safety.

Comparatively busier roads crossing the railway track are provided with gates on each side of the railway track in such a manner that when closed, it shall not be possible for the road user to cross the road. This gate is ‘Level Crossing gate’. Such gates are manned by a Gateman who is posted by railways to protect road users from getting hurt by train. Such manned level crossing gates are **non-interlocked** or **interlocked**.

The gateman posted on a non-interlocked level crossing gate, if connected with the Station Master of adjoining station through a telephone, gets instructions from the Station Master and closes and opens the gate on requirement.

A gate to be interlocked or not interlocked and the conditions for keeping the gate closed or opened against road traffic, under normal conditions is based on the classification of the gate as well as its placement i.e. the gate falls in station section, Absolute block section or Automatic block section. For details Indian Railway Signal Engineering Volume-I by the author may be referred to.

6.1 **Classification based on TVUs**: The gates are classified as ‘Special ‘class’, ‘A’ class, ‘B’ class and ‘C’ class. The classification of the gates is done in consultation with road authorities, on the basis of class of the road, visibility conditions, volume of road traffic across the gate and number of trains passing over the level crossing. These details are prepared based on census done for one week. The census is done at least once in five years and the classification of the gate is revised based on such census, if required. All such criteria are converted into ‘Train Vehicle Unit’ (TVU) taking train, motor vehicles, bullock carts and tongas as one unit and cycle-rikshaw/auto rikshaw as ½ unit. Number of these units for the
gates decides the classification of the gate [IR P Way Manual Para 919]. For details Indian Railway Signal Engineering Volume-I by same author may be referred to.

6.2 **Interlocked Level Crossing gates**: Interlocking of the gate means protecting it by providing signals on either side of the gate along the track, section being single line or double line. In colour light signalling territory one gate signal at a distance of 180 meters from the edge of the road of the level crossing gate is placed preceded by one or two Distant signals depending upon the section to which the gate pertains. A circular plate painted yellow with letter ‘G’ painted black, is clamped on the post of the gate-signal provided in the station limits or in the Absolute Block section territory. The gate provided in the station section is protected by the main running signals. In case of gate signal provided in Automatic block section, letter A painted in black on the face of LED signal or on face of the unit box glass, illuminated by incandescent lamp, is provided on the gate signal post in addition to the G marker plate to make the signal automatic when A marker is illuminated. Such markers are required to guide the Loco Pilot for observance of the rules to pass the gate signal which is different than for the signals designated otherwise.

6.3 **Gate signal and rules for passing it**: When the signal provided with a ‘G’ marker is Off it is treated as any other stop signal but when the gate signal is On and it does not come Off after waiting for one minute during day and two minutes during night it is treated as Gate signal having been failed to come Off. Within station section as the gate is secured by the stop signals, an authority to pass the signal at On is issued by the Station Master. However the Gate Man operating the level crossing gate in the section other than Station section is not authorised to issue authority to pass the signal at On.

The gate signal may fail of itself for any circuitry failure, signal not being taken Off due to an obstruction at the gate or the gate becomes defective or damaged due to getting hit by a road vehicle or mechanism failure. However when the gate signal is not Off for any reason what so ever, the instruction as given in the Paragraph 3.73 (2) of Indian Government Railways General Rules 2006 shall be followed which provides as:

(a) If the gate stop signal is provided with a ‘G’ marker, the Loco Pilot shall wait at the signal for one minute by day and two minutes by night, and if the signal is not taken Off within this period, he may draw his train ahead cautiously up to the level crossing, and

(b) If the Gate man is available and exhibiting hand signals, proceed further past the gate cautiously, or

(c) If the Gate man is not available, or if available but not exhibiting hand signals, the Loco pilot shall stop short of the level crossing, where he shall then be hand signalled past the gate by the Gate man, if there is one, or in the absence of Gate man, by one of the members of the engine crew of the train after ascertaining that the gate is closed against road traffic.

6.4 **Construction details of Level crossing gates**: Each manned level crossing provided with a gate has to follow basic norms as:

a) A compacted road in between two gates preferably metalled to ensure speedy clearance of the road and to prevent road users from falling on to the ballast by the side of road.
b) Rumble strips on both the approaching end of the gate to discourage road user from speed passing the gates.

c) A gate sign provided at the approach road at a distance adequate enough to enable a speeding vehicle to control it self.

d) A wicket gate by the side of each gate, swing or lifting barrier, duly fenced by its side with wire or a brick wall to prevent tress passing by road users crisscrossing the unusable path.

e) Road signals with a hooter on busy gates as and when specified by railways to sound when the gate is being closed to avoid it getting hit by an ignorant road user vehicle driver.

f) A height gauge in section provided with Over head electric traction to prevent road user getting entangled damaging the traction system or getting electrocuted.

6.4.1 **Level crossing gate types:** Construction based level crossing gates are -

a) Swing /leaf gates.

b) Lifting barriers mechanically operated.

c) Lifting barriers power operated.

i) **Swing /Leaf gates:** These gates are provided by Civil Engineering department of railways and are fabricated by steel angles hinged on rail-posts. The gate may be of single leaf or double leaves depending upon width of the road, on both sides of the track. Each set of gate on either side of the track is provided with a wicket gate to facilitate pedestrians to move. The Gate leaves have provision of pad locking the gate in case of non interlocked gate. In case of interlocked gates, an ‘E’ type lock assembly is mounted on each side leaves of the gate. The key is released after locking one side leaves and is used to lock other side leaves, which in turn releases a key for releasing the signal lever. The lever is pulled to take the gate signal Off thereby holding the gate in locked position.

An arrangement is also there to link closing and opening of one side of leaves moving simultaneously other side leaves having been linked to each other mechanically.

ii) **Lifting barriers mechanically operated:** Swing gates are opened across the approach road forcing the road traffic waiting for opening of the gate to go back to make way for the leaves to open. The lifting barrier moves vertically, thereby making way instantly for the road traffic by lifting the boom upwards. The gate consists of:

**Boom:** Boom is made of GI or aluminium tubular pipe. It is in pieces coupled with each other by end plates or threaded sockets. The end piece of the boom is joined to a tubular pipe of diameter larger than that of the rest of it. This larger diameter part of the boom is clamped in between two parts of the ‘Trunnion bracket’ made of cast iron. The Trunnion bracket rotates about the axis rod which passes through brackets fastened with gate standards, on either side of the Trunnion bracket. These Standards are rigidly fastened to a cement concrete foundation on to the ground.

The Trunnion bracket has inbuilt cam path to accommodate roller pin of the drum wheel which is mounted on a pin fixed on the ‘Standards’. The Trunnion Bracket also bears the extra cast iron weight plates to be fastened onto it for counterbalancing the weight of different lengths of
the boom extended beyond axle about which the Trunnion bracket moves holding the entire boom clamped to it. In addition, cylindrical cast iron weights can also be filled into the end part of the boom clamped in between Trunnion bracket, threaded through a mild steel rod anchored to the axle rod at one end and a cap at the end of the boom. These smaller size weights are used for fine counter balancing the boom. The counter balancing of the boom is required for its smooth up and down movement.

The drum wheel fastened with the standard converts its rotary movement to linear, driving lifting barrier up or down through cam path of the Trunnion bracket. The drum wheel is also provided with inbuilt caste tooth equidistantly placed along its periphery which imparts up and down movement to a rod connected with a gong, at regular interval to bell the gong which is also fastened with the standard, to warn the approaching road traffic about the gate being closed. The bell does not sound while the boom is opening. The drum wheel continues moving even after the boom comes to vertical position and the roller pin gets out of the cam path of the Trunnion bracket and rests against it in such a way that the boom is held vertical by the roller pin.

A geared drum wheel with wire rope wrapped around it is mounted on a stand of steel channel. A crank handle with a gear wheel and a small drum with a notch are also mounted on to the same channel in such a way that the gears of both the wheels are intermeshed with each other, to make a ‘winch’. The gear ratio of two wheels is such that adequate lever advantage is available to the winch operator. The winch is fixed on to a foundation firmly with the ground. The other end of the wire rope is wrapped around the drum wheel mounted onto the standards to give drive to the boom through Trunnion bracket. The wire run in between the two is run on pulleys mounted on pulley stakes and horizontal and vertical wheels connected to make a taught loop. The clock wise rotation of crank handle of the winch imparts clock wise movement to the wheel drum on standards and vice versa. Accordingly the boom is lifted up or down.

Barriers rest on stands provided at loose end of the boom when gate is closed. The stand is provided with i) a boom guide to guide the falling boom if out of alignment into the resting cavity of the stand, and ii) boom lock to hold the booms while it is resting on the standards.

The boom lock is operated by a lever provided on the ground lever frame using wire run or rod run between the lever and the lever lock. Two more levers are provided on the same ground lever frame, to which the lock lever is provided to take the gate signals, provided at both the ends of the gate, Off and are interlocked in such a way that locking the boom releases the signal levers.

An ‘E’ type key lock is also fastened with the winch in such a way that the key of the lock can be extracted only when the notch cut in a smaller drum attached to the crank handle of the winch gets in alignment to the plunger of the lock only when the booms rest on the stand. The key so released from the winch is inserted into the lock provided on the lock lever to release it to be pulled. The boom lock is operated by pulling of the lever. The signal controlling levers are attached with Circuit Controllers which switch on signal circuit when the lever is pulled having been released by the lock lever.
iii) **Lifting barriers power operated:** power operated lifting barriers are Manufactured and procured under specification IRS S-41-70. The lifting barrier is operated by an electric AC motor controlled by an operating panel. The torque of the motor is transmitted to the boom through a train of gears in four steps. A friction clutch is mounted subsequent to first gear train to safeguard against overload on the motor. The torque continues to be transmitted from first to second and to last gear train and finally to the boom shaft by a link connection.

The boom is usually rectangular in shape made of aluminium sheet with the arrangement for provision of counter weight to ensure operation of a balanced boom. The boom is locked in open as well as closed position. Vertical and closed position of the boom can be fine tuned by an adjustment bolt mounted on the lower hinge of the lever gear.

While the boom is closing it is likely experience a shock. To avoid this, friction break is applied when the boom is nearing boom stand behind the fourth gear. The boom is held in closed position by a DC electromagnet.

An electric hooter is also fitted over the road signal post of the level crossing gate to warn approaching road vehicle of gate being closed. The gate signals for rail traffic are operated from another operation cum indication panel provided inside gate lodge. These signals can be taken Off only when the gate is closed and locked against road traffic.

In case of failure of the booms the gate can be closed or opened by using crank handle manually. The crank handle is kept in a sealed box making a contact for logic circuit proving crank handle. As and when crank handle is taken out of its position the logic circuit is disconnected and it shall not be possible to operate the gate signals till the crank handle is replaced back. As the crank handle is inserted into the drive shaft the electric connection to the gate gets disconnected and it shall not be possible to operate the gate from operating panel.

The gate man is warned of a train approaching the gate. A track circuit is provided at a distance of two kilometres from the gate on either side of the gate. The gateman gets a bell warning of the approaching train on which the gateman closes the gate promptly. The track circuit also back locks the gate once closed. In automatic signalling territory all gates are required to be interlocked.

The power operated gates are designed by the manufacturers and may differ in design from one vendor to another.

Power operated gates are also used for automatic closure by an approaching train. However the system does not work well on section with heavy rush.

7. **Signals:** Under the signalling system ‘Signal’ is the last operated equipment to be operated for taking it Off after setting and locking the points, closing all level crossing gates falling in its route and ensuring all other safety requirements having been fulfilled and is first to be put back to On at its back, after passage of the train.
Signals are i) main and ii) subsidiary. Main signals are meant for running of the trains while subsidiary signals are used for purpose other than running of trains. Refer to ‘Indian Railway Signal Engineering’, Volume-I Chapter –II by the same author, for classification of signals.

7.1 Main Colour Light Signal: The fundamental difference between the semaphore and the colour light signals is that the lamp which could be kerosene oil based or an electric lamp, is fixed on to the semaphore signal post, the spectacle unit moves to place red, green or yellow colour roundel opposite the lamp while in case of colour light signal each unit provided with a red, yellow or green coloured lens has an electric lamp of its own.

The semaphore signal lamp is provided with a stepped clear lens to emit a clear focussed light through the coloured roundel (glass) fixed on to the spectacle. With the movement of the spectacle, the desired coloured roundel is placed in front of the lamp and the Loco Pilot sees the signal light during night time depending upon the colour of the roundel placed in front of the signal lamp. The colour of the roundel shall be red, yellow or green; However in case of colour light signal, which is required to display its aspects through coloured light during day as well as night, having no moving parts, consists of units to house an electric lamp placed at the focal point of a couplet of stepped lenses out of which the inner lens first to face the lamp is of the desired colour and the outer is clear. Each unit is exactly similar in size and construction arrangement except that the inner lens is of the required colour. These units may be one, two, three or four depending upon different aspects required to be displayed by the given signal and are placed one over the other arranged from bottom to top in sequence red, yellow and green for a stop signal and yellow, green and yellow for a permissive signal. Some times when the stop signal is provided with red and double yellow indications without green in between, the position of green is provided with a blind unit in between two yellow indication units, since red is kept at the bottom most position, the two yellow colour light units are separated to avoid appearance of two yellow lights merging with each other viewed from a distance. A variation to the arrangement in such a situation is some times done by putting red in between two yellow colour signal units, however this arrangement is not considered as good. Multi unit Colour Light signal Pole assembly with signal unit and ladder is designed in conformity to IRS specification S26-64. [Figure 7].

The lens couplet emits a focused beam parallel to the track so as to enable the Loco Pilot to see the signal light from a distance as far as possible from the signal. This is to facilitate the Loco pilot to keep the train under control in conformity to the signal indication. When the train is required to be brought to stop near the foot of the signal, Loco pilot my not be able to see the signal light as the beam is focussed parallel to track, especially if the unit is higher than the loco pilot’s eye level. To mitigate such a situation the outer i.e. coloured lens is provided with a fresenel strip conventionally called as ‘Hot Strip’, designed such that a part of the parallel beam disperses the light such that the Loco Pilot is able to see the signal light through the ‘Hot Strip’.

The signal is erected on a i) Cement Concrete foundation cast in-situ (at the same position where the signal ladder is to be erected), with which four bolts are grouted to hold the ii) cast iron base secured by washers, nuts and check nuts; iii) A steel tubular pole is hoisted inside the cast iron base over which the, iv) signal base is capped and secured by collar bolts to hold the
junction box and signal units; v) The junction box accommodates terminals on which, the cable between the nearest apparatus case controlling signal aspects, and the signal pole, is terminated. The junction box also has inbuilt two eye pieces to align the signal unit in such a way that all of multi units emit light beam parallel to the track [Figure 7a]; it is mounted on the base with nuts and bolts; vi) The signal units are mounted over the junction box and then one over the other depending upon number of aspects to be displayed by the said signal, secured with the nuts and bolts.

The top of the cement concrete foundation of the signal is kept at rail level to ensure that the most restrictive aspect indication of the signal remains at the eye level of the loco pilot. Accordingly the length of signal post for a signal without a junction or any other type route indicator is kept 3.5 meters. This height is 12 feet (3.65 m).

When a route indicator, junction or any other type is used along with the signal, the route indicator is placed on the top of the signal pole. The signal unit in such a situation is mounted on an offset bracket, which is clamped with the signal pole in such a way that the Red indication is placed at the height of eye level of the Loco Pilot sitting in the Loco. In such a case a 4.5 metre signal pole is used. In situation when the signal unit is required to be mounted on the offset bracket without a route indicator for shifting unit’s alignment from the signal pole for reasons of improving visibility due to obstructing OHE mast, non availability of adequate space for casting foundation at the desired place or any other reason. The signal pole top is caped by putting Pinnacle at the opening of the pole to prevent rain water from pouring into foundation base through hole for cable inlet into signal pole. Drainage of water inside foundation base through signal

![Figure 7](image-url)
pole shall result in loosening of ground’s hold on the foundation and subsequent falling of the signal resulting in serious consequences. To enable maintenance and inspections, a Ladder Foundation is grouted with, inside ground, preferably with cement concrete block cast in-situ. The ladder is fastened with the end of the Ladder Foundation projected beyond concrete cement casting using nuts and bolts while the other end, with the platform. The platform is provided with a guard rail.

The number plate is clamped with the post on which signal number is to be painted for identification by the Loco Pilot.

Finally the signal post is vertically aligned using plumb bob and wood wedges are forced between the space in-between outer side of the signal post and inner side of the signal base holding the signal pole vertically aligned in place and then sealed using bitumen and fine finished to hold the signal post absolutely vertical. The signal unit is aligned using both the eye pieces such that the signal light beam travels through in between both the rails of the track maintaining horizontal parallelism with the track so that the light beam does not get invisible due to loss of alignment but is visible till the lumens are lost to be visible which shall be farthest visibility of the signal to the incoming Loco pilot (Figure 7a).

If the light beam of the signal unit is not a bunch of parallel rays they shall intersect each other and destroy them selves at a short distance as well as less number of rays going parallel shall be available to the loco pilot. The signal lamp holder is provided with an arrangement for adjusting the lamp filament in such a way that it is placed at the focal point of the lens couplet. After the post and the signal unit [all single signal lamp units provided on the post joined together make the signal unit] have been aligned, the signal lamp is adjusted by cooperation between one person on the signal platform and the other person at the farthest distance from the signal post.

A black screen is provided around the signal unit to avoid glare to the Loco Pilot from opposite direction, for improved visibility. A hood is provided to obstruct incident sun light rays striking the signal lens face which if are able to reach the face of the signal lamp shall get reflected giving a ghost indication, when the sun is at the back of the loco Pilot at an compromising angle. Inside of each signal unit is painted black to avoid ghost indication from the approaching locomotive’s light or sun light when sun is at a compromising angle and is able to reach inside unit.

Each unit is provided with a locking arrangement in such a way to enable all provision of locking all units with a single lock to avoid out side interference.

**To align signal unit:** Two projected pieces are provided on the side of the junction box of the signal. Each piece has a hole in between placed in such a way that the ray of light passing through both gives the view of the object towards which the signal unit is pointing. If the signal unit is leaning forward the rails shall be visible very near to the signal post. The bolts provided
at the collar of the junction box are loosened, the unit is tilted such that the rail is visible at
farthest possible distance and then the bolts and check nuts tightened at such position.

7.2 **Calling on signal:** In big yards where the distance between place of sitting of the
Station Master and the reception signals is large enough to cause appreciable time loss in
serving paper authority to the loco pilot through porter, when the main signal fails, a calling–on
signal is provided on the post same for which the paper authority was supposed to be issued.

Indian Government Railways General Rules clause 3.13 (2) provides that a calling-on signal
shall be fixed below a stop signal governing the approach of a train. Under approved special
instructions, a calling-on signal may be provided below any other stop signal except the last
stop signal.

Calling-on signal is a miniaturised unit with a ‘C’ marker, clamped on the main signal post
below the main signal unit. It remains blank when On and displays white light when Off,
delayed by 120 seconds after occupation of the track circuit provided specially for the purpose
in rear of the main signal, only when main signal on the post of which it is provided is On. LED
signal units for calling-on signal are also available and can be clamped with the main signal
post. Calling–on signal is illuminated by 12 V AC powered incandescent lamp or 110V AC or
110V DC powered LED signals.

When the reception signal fails to come Off, the calling-on signal is taken Off taken Off calls
on the loco pilot to draw his train ahead with caution. This avoids issue of paper authority to the
loco pilot saving time.

Calling-on signal can only be taken Off after the main signal fails to come Off but route lights
are displayed, if controlled by panel, proving all points en-route up to the destination are set and
locked, while one or more track circuits en-route might have failed.

7.3 **Shunt signal:** Shunting is an activity essential for running of trains carried out for i)
organising a train arrangement to specific orientation, ii) detaching and attaching of wagons,
coaches or loco, iii) placement of train racks on line for departure, iv) detaching defective
wagons in siding at road side stations etcetera.

Shunt signals are provided in the station section.

Shunt signals may be provided on a post by itself or on the same post that of main signal below
the main signal unit. When provided on a post by itself it displays On as well as Off aspect for
which it has three lamps, two lamps placed to represent a horizontal line and one to form a line
inclined at 45° to horizontal line with one lamp working as common pilot lamp. [Figure 7.3].
When the shunt signal is provided on the post of a main signal it remains blank when On. When taken Off it displays two white lights such as to represent an inclined line at 45° to the horizontal line. Both of the main signal and the shunt signal on the same post can not be taken Off one and the same time.

Shunt signal lamp two pin clear single filament 60V, 25 watts conform to IS 418 are placed at the focal point of lunar white lens.

The cast iron unit of the shunt signal is partitioned to hold lamp holder in each portioned hosing. A lunar white lens is provided on the facing side for each lamp. The tubular post is fixed into a shunt signal base which is fixed on the cement concrete foundation caste in-se-to. Unit is fixed on the top of tubular post when the signal is placed on a post by itself. The unit is otherwise clamped on the main signal post.

7.4 **Route indicators:** The loco pilot is essentially required be informed of the track on which his train is being received or despatched. Accordingly each signal placed at track converging while being received on and diverging while being despatched to, is provided with one of i) Junction type, ii) stencil type and iii) theatre type route indicators.

7.4.1 **Junction type route indicator:** Octagonal shaped cast iron unit is mounted on the top of signal pole through a bracket such as to be clearly visible above signal unit mounted on the elbow on the same pole. A 25 watt 110V AC powered incandescent lamp or LED signal is fixed at the centre of the octagonal unit. A cast iron arm, partitioned into four units each to house a 25 watt 110V powered incandescent lamp or LED signal, is fastened with one of the octagonal face of the unit at required position. Each such unit in the arm is provided with white lunar lens to transmit parallel beam from the incandescent lamp filament placed at the focal point of the lens. In this way the route indicator arm displays five illuminated lamps in a row including the pilot lamp placed in the centre of the octagonal unit, to indicate direction of the track on which the loco is being received. Accordingly the pilot lamp is common to all the arms. All these lamps are connected in parallel to each other and the route lamp checking relay continues to be energised till at least three lamps continue to glow. Each of the unit is protected from ghost indication by providing hoods. Visibility of route indicators is prescribed to be 200 meters minimum.

Maximum of six such route indicator arms can be fixed upon the octagonal unit, thereby maximum seven routes can be indicated by the junction type route indicator, as no route is indicated for main

![Figure 7.4.1 junction type route indicator](image)
line (without a turnout or crossover) for which the space on the octagonal unit is kept unused. As and when more than seven routes are required to be indicated to the loco pilot, either an intermediate signal is provided ahead of the signal in question if the signalling scheme so warrants or a theatre type of route indicator is used instead of junction type.

First route indicator placed at left of the central blank position shall indicate for first track on the left of main line, so on and so forth. Similar shall be the arrangement for right hand side indicators.

In case an intermediate signal is provided which shall be required only if more than one route is required to be indicated to the loco pilot by the signal, the route indicator on the main signal shall be placed after counting the tracks in between blank position on the octagonal unit and the intermediate signal concerned. For example if the intermediate signal is provided at a position after two destination tracks on the left from main line, the position of the arm shall be third leaving the blank space.

7.4.2 **Stencil type route indicator:** for signals when the number of routes is limited to two or three for departure/starter signals usually where comparatively lesser visibility of the route indicator shall not be of serious consequence, stencil type route indicators are used.

Two or three units similar to colour light signal unit with the letter designating the departure time is stencilled on the face plate/glass sheet of the unit is fixed over the main signal unit. An incandescent lamp is provided in the unit to illuminate the route indicator. As incandescent lamp is provided to illuminate the visibility of the route indicator is poor.

For example if the train is to be despatched from starter signal where to tracks branch Off one for main line and other for branch line the letter ‘M’ for main line and letter ‘B’ for branch line shall be stencilled [Figure 7.4.2].

7.4.3 **Theatre type route indicator:** Under the situation where more than seven routes are required to be indicated at the reception signal line number on which the train is being received is displayed by the indicator designed by an array of 7x5 dot-matrix electric lamp assembly which form the desired numerals based upon the route controlling relay (UPR) for the given route is energised. The lamp checking relay is common making it difficult to maintain nearly fixed current to flow with five to double the number of lamps illuminated. This type of route indicator is rarely used.

7.5 **Signal lamp:** The electric lamps for colour light signals are designed, manufactured and procured under specification number IRS S 57-2005. Lamps used for main signal are i) incandescent, two pole, twin filament, 12V AC powered, 25Watt and 33Watt, ii) incandescent three pole twin filament, 12V AC powered, 25Watt and 33Watt and iii) LED signals powered by 110 V AC or 110V DC. Lamps for shunt signal and junction type route indicator are single filament two pole 25Watt, powered by 110 V AC as well as LED signals powered by 110 V AC or 110 V DC. 12V, 16Watt, main filament of 25watt lamps with twin filament with specific
number SL17 is placed horizontal at focal point of the lens couplet while 16V, 12watt auxiliary filament is placed vertically and is slightly out of focal point. The main filament of 33 watt signal lamp specific number SL21, is 12V, 24Watt and auxiliary filament is 16V, 12 watt placed in the manner same as 25Watt signal lamp.

The base of the incandescent lamp has three pins to ensure that lamp can be placed in the lamp holder in a position such that the filament of the lamp and the poles are positioned to be i) stable, ii) make proper contact with the holder springs extending power to the lamp and iii) the main and auxiliary filaments do not interchange their positions. The holder is mounted on a bracket and can be moved to and fro for placement of main signal filament at the focal point of lens couplet.

7.5.1 **Two pole twin filament incandescent signal lamp:** The 25 & 33 watt electric signal incandescent lamp, with two poles and double filament. Both filaments are fed in parallel through two poles. With the fusing of any one of the filament total current across lamp checking relay (ECR) drops thereby de-energising it, consequently creating conditions of fused lamp except that the signal does not go blank because of one illuminating filament, resulting in creation of conflicting aspect type conditions for the loco pilot, during night when the visibility of colour light signal increased many fold. This required fast replacement of the lamp as the trains get delayed due to the signals preceding, showing less restrictive aspect.

Life of these lamps was enhanced to 5000 hours from 1000 hours and subsequently improvised by providing **three pole lamps**.

7.5.2 **Three pole double filament incandescent lamp:** Procurement of three pole double filament incandescent lamp is done under specification SL-35. The power supply is given to the main filament through two poles normally connected to the 33 watt signal lamp. As one of the filament fuses the power supply is extended to the third pole through a switching relay (MECR), thereby keeping the signal lighted by second filament, without de-energising the ECR, consequently not affecting aspects of signals preceding, thereby not effecting the train movement while at the same time intimating the Station Master that main filament was fused. One MECR is provided with each signal lamp in the signal unit. MECRs of each lamp of each signal are connected in parallel and the set of parallel connection of all signals is connected in series forming an omnibus circuit terminating in Station Master’s and the Maintainer’s room connected to a bell and illuminated light indication on the Control cum Indication panel. While the audible indication can be muted by pressing a button, the visual indication continues to glow till the lamp is replaced. The extent of urgency however reduces considerably and the lamp could be replaced at convenience. The arrangement has proved to be costly due to requirement of additional cable cores as well as the possibility of signal going blank is not completely ruled out if the signal lamp’s second filament also fuses by the time the defective lamp is replaced.

*This necessitated use of LED signals.*
7.5.3 **LED signals:** The blanking off of the signal could be i) due to fusing of the lamp or due to ii) power supply failure.

While the power supply failure has bee taken care by provision of Integrated Power Supply system (IPS), the lamp failure has almost been eliminated with the advent of the LED signals.

7.5.3.1 **Design and RDSO specifications:** RDSO issued specification for LED signals as RDSO/SPN/153/99 (covering only AC version) of LED working on 110V AC. In the Year 2002, a new specification RDSO/SPN/153/2002 followed by 204 was issued. This specification covers both DC and AC fed LED light units. Latest specification is improvised version of previous specifications in respect of ‘Current Regulator’ that its life has been defined to be 60 months. Only one current regulator has been designed for use with conventional ECR/ECR for LED signals/AC-DC supply. Life of LED signal unit has been specified to be 120 months. Individual LED parameters, lumen output, average driving current of main, calling-on, route and shunt signals have been defined in the specifications.

A Light Emitting Diode (LED) is a solid state ‘p-n’ junction semiconductor device developed by doping a substrate material with different materials. The dopant in the ‘n’ region provides mobile negative charge carriers (electrons), while the dopant in the ‘p’ region provides mobile positive charge carriers also known as ‘holes’. Within a semiconductor crystal, when a forward voltage is applied to the ‘p-n’ junction from the ‘p’ region to the ‘n’ region, the charge carriers inject across the junction into a zone where they recombine and convert their excess energy into light. The materials used at the junction determine the wavelength of the emitted light i.e. the colour displayed by the diode. A clear or diffused epoxy lens covers the semiconductor chip and seals the LED. It also provides some optical control to the emitted light.

The relatively small lumen packet that is emitted by a single LED, requires a bunch of LEDs to be used clustered together to emit light such that the lumen efficacy i.e. Lumen per watt, of the bunch of LEDs is better than that of incandescent lamp, which is being replaced by the LED signal. For LED signals, about 50 to 60 LEDs are packaged normally to create the high-luminance signal face as required under specifications.

LED signal which is the ‘Signal lighting unit’ is supported by ‘Current regulator unit’ and ‘Health monitoring unit’.

i) **Signal lighting unit:** Signal lighting unit comprise of arrays of LEDs in series and parallel combinations. LEDs in a Main signal aspect unit are arranged in more than one array so that in the event of failure of one array, whole unit does not become blank. LEDs in the arrays are inter connected in such a manner that affect of failure of an array is spread out equally to maintain uniform visibility. Design is such that failure of an LED does not seriously affect illumination of the LED signal. Signal Unit housing is made of industrial grade plastic or rust proof metallic body and is hermetically sealed. LED Signal Unit can be fitted on the existing signal assemblies, without any modification on them, while at the same time Combination of lenses is no more required with the use of LED signal.

ii) **Current regulator unit:** LED’s performance is dependent on constant current. Therefore LED arrays of the signal lighting unit are fed constant current through current
regulator irrespective of input supply voltage fluctuations. Current regulator is so designed that normally LEDs of an array are driven within average drive current range recommended by the LED manufacturer and under no circumstances LEDs of an array are driven by current more than the maximum current recommended.

Current regulator of Main signal aspect is an independent unit which is universal and can be configured for AC or DC, conventional ECR i.e. the ECR used with incandescent lamps or LED ECR i.e. the ECR used with LED signal, blanking or non blanking options by shifting jumpers provided on exterior of body of current regulator. LED Signal lighting units are normally to be used with ECRs especially designed for LED signals. However it is possible to use LED Signal lighting Units with conventional ‘On’ indication ECRs (In case of Siemens make ECRs, Off ECRs are to be used).

In non-blanking option Main signal lighting unit remains lit even if illumination value falls below a minimum prescribed value of illumination but in such case the input current of Current Regulator is restricted to a predefined low value to ensure dropping of ECR.

For signals other than main signals, current regulator is in-built with signal lighting unit. Such signal lighting unit extinguishes when illumination falls below a minimum prescribed level of illumination.

iii) Health Monitoring Unit (HMU): (Figure 7.5.3.1) is provided with Main signals for predictive maintenance. ECR de-energises as illumination falls below 50% extending alarm. Audio and visual alarms are provided at central place, preferably with Station Master’s room or where ESM is posted in Electrical Signal Maintainer’s (ESM’s) room. These alarms are designed to indicate the status of input current.

The alarm is switched on when the current through Current Regulator falls below 50% or illumination of LED signal lighting unit falls below prescribed level, or when Health monitoring unit or the current regulator becomes faulty. Audio alarm can be silenced by pressing ‘Acknowledge’ button but visual ‘failure’ indication, continues to be illuminated till the fault is rectified. Monitoring is done on same pair of conductors, which are used for lighting of signal light units. In case health monitor unit becomes faulty, signal at site does not go blank.

7.5.3.2 Operating and other important parameters: LED signals are capable of working at both 110V AC as well as 110VDC. Some of the parameters, when the LED signal is used with ECR, specific to LED signal, are given in table number 7.5.3.2 (Specification number RDSO/SPN/153):
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Main signal</th>
<th>Calling-on signal</th>
<th>Route indicator</th>
<th>Position light shunt signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>110 V ± 20%</td>
<td>125ma ± 5% (rms)</td>
<td>125ma ± 5% (rms)</td>
<td>25ma ± 5% (rms)</td>
</tr>
<tr>
<td>Current per unit at input terminals of current regulator</td>
<td>A C</td>
<td>125ma ± 5% (rms)</td>
<td>125ma ± 5% (rms)</td>
<td>25ma ± 5% (rms)</td>
</tr>
<tr>
<td>D C</td>
<td>105ma ± 5% (rms)</td>
<td>105ma ± 5% (rms)</td>
<td>23ma ± 5% (rms)</td>
<td>50ma ± 5% (rms)</td>
</tr>
<tr>
<td>Illumination measured at 1.5m from signal lighting unit, axially</td>
<td>120 LX (-15+25%)</td>
<td>110 LX (-15+25%)</td>
<td>110 LX (-15+25%)</td>
<td>50 LX (-15+25%)</td>
</tr>
<tr>
<td></td>
<td>50 LX (-15+25%)</td>
<td>50 LX (-15+25%)</td>
<td>30 LX (-15+25%)</td>
<td></td>
</tr>
<tr>
<td>Threshold illumination measured at 1.5 meters from signal lighting unit, axially</td>
<td>20 LX (-15+25%)</td>
<td>20 LX (-15+25%)</td>
<td>20 LX (-15+25%)</td>
<td>10 LX (-15+25%)</td>
</tr>
<tr>
<td></td>
<td>10 LX (-15+25%)</td>
<td>10 LX (-15+25%)</td>
<td>10 LX (-15+25%)</td>
<td></td>
</tr>
<tr>
<td>Colour</td>
<td>Red</td>
<td>Yellow</td>
<td>Green</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>Lunar white</td>
<td>Lunar white</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table number 7.5.3.2**

*Important parameters of LED signals*

7.5.3.3 **Colour of LED signals:** Indian Railways follow the BS: 1376:1974 standards. Accordingly the colours are defined in X, Y, Z co-ordinates in terms of CIE Chromatic alb chart. X co-ordinate is analogous to red, Y to green and Z to blue. The other colours are defined in terms of X, Y and Z co-ordinates and represented by dominant wavelength on the periphery. The colours which do not lie on the periphery of the CIE chart have to be necessarily defined by co-ordinates and for the purpose of visual appearance to the eye are defined by dominant wavelength.

7.5.3.4 **Salient features of LED signals and comparison with incandescent lamps:**

i) The LED signals have been developed in such a way that the entire assembly can be housed in the same signal unit designed to house the incandescent lamps as well as the same ECR which are being used with filament lamps, can be used with these lamps.

Besides this, with the use of LED signal, few more important & definite advantages which out weight the use of incandescent lamps are:

ii) Life of LED signals is far more than incandescent lamps, about 10 years as compared to 5000 hours of incandescent lamp. None of the signal lamps light continuously for twenty four hours. The hours are counted for the period the lamp is lighted.

iii) These are brighter and do not need focussing once installed properly as these do not require set of lens combination.

iv) Not requiring frequent replacements hazards while signal lamps are being changed by maintenance staff is proportionally reduced to negligible extent, at the same time maintenance effort is reduced considerably on account of reduction in lamp replacement.

v) LED signals need about 60% lesser energy as compared to incandescent lamps.

vi) DC power LED signals being DC power fed eliminate requirement of transformer.
vii) With use of LED signals only one type of ECR has been designed to be used with main as well as subsidiary signals, thereby reducing inventory.

viii) AC powered LED signals can be lighted up to distance of 800 meters from the controlling relay using unscreened signalling cable as in this case threshold voltage being up to 88V as per one of the LED manufacturer’s catalogue, there by reducing use of cutting in relays is considerably.

ix) DC powered LED is immune to 300V AC. With the use of DC powered LED signal many accessories such as inverters and transformers in IPS get eliminated in addition to repeating relays.

x) LED signals are tolerant to wide voltage variation.

xi) The colour of LED is decided by the doping material at ‘p-n’ junction. However it has been tested and found that the colour of LED for all aspects is not affected due to Voltage variation in the specified range i.e. 90 to 130 V AC, with current regulator working, as well as due to current variation between cut-in current & burnout current. Excessive current leads to primarily heating in the LEDs causing ultimately reduction in light out put.

xii) There is one unified design for main, shunt & Calling on signal as well as for 110V AC/DC lamp proving relays as against different type of relays have to be used with each type of signal.

xiii) LED signals are designed such that with the failure of one LED due to open/short circuit, other LEDs in the array are not affected. Variation in the current beyond 50% of the specified constant current, decrease affected by open circuit and increase due to short circuit is monitored by an optical device which generates alarm when visibility goes down below prescribed limits and also switches off the unit.

xiv) The LED signals degenerate gradually giving alarm of its health through health monitoring unit while failure of an incandescent lamp is abrupt.

xv) Specified visibility of LED lamp during daytime is 600mts for all main signals as against 200mts specified for incandescent lamp during daytime as 400mts for first main signal and 200mts for pre-warned signals.

7.6 Lamp Checking relays (ECRs): Current sensitive relay with minimum possible contacts is provided in series of the power supply dedicated for an individual lamp, so that the relay causes minimum possible voltage drop across itself which shall compel availability of minimum flux to pick up the armature of the relay. As the power is switched on for illumination of a lamp or LED, the current flows through source of power to lamp/LED via ECR and energises the ECR while lighting the lamp/LED. A typical main signal ‘Q’ series ECR is provided with 2F & 2B contacts only.

There have been cases of lamp proving relay continuing energised even with fusing of 12 V incandescent signal lamp one filament, due to 110V/12V signal transformer drawing current more than specified (manufacturing defect). With the introduction of triple pole lamps provision of alarm has been made to indicate fusing of first filament. However there is no provision to detect poor visibility due to low voltage or focussing.
While existing ECRs may continue to be used with LED signals, ECRs for LED signals are specified to be used under specification numbers STS/E/Relays/DC lit LED Signal/03-2004 or STS/E/Relays/AC lit LED Signal/03-2004 for LEDs illuminated with DC or AC power supply respectively.

7.7 Electrical operation of semaphore signals: Operation of semaphore signals which are distantly placed from the point of operation either single wire or double wire always had been a difficult job with maintenance point of view. During the process of development, electrical operation of semaphore signals has been very use full saving long distance wire run and associated maintenance. Electric Signal machine is used for this purpose.


7.7.2 System of working of signal machine to IRS specifications:

7.7.2.1 The signal motor is designed for two aspect lower quadrant as well as three aspect upper quadrant working and works on 10V DC 3 amps, or when designed to be operated by hand generator, by 110V DC, 0.4 amp current.

7.7.2.2 Gear train: Gear train is in three sets of reduction gears to reduce the speed of semaphore arm. Pinions are fixed with corresponding shafts using keys. The shafts are mounted with the body of the signal machine on bearing. The signal spectacle is mounted on the shaft of the last pinion of the gear train.

7.7.2.3 Friction clutch: The motor shaft is coupled to the friction clutch, which consists of Ferodo lined disks loaded by springs. Friction clutch coupled to the motor shaft is provided to reduce the shock due to over run of the motor, to safeguard the hold off latch from getting damaged and as well as to safeguard the roundels from getting damaged provided on the signal arm.

7.7.2.4 Hold off device: Once the signal has been taken Off and the power supply to the electric motor is cut-off, the signal is required to be held in last operated position. The Hold Off device consisting of i) an electromagnet with one armature and two contacts, ii) latch arm with a latch piece and iii) clutch gear. The hold off coil has two windings one pick up coil winding and other Hold off Coil winding. As the arm is lifted up to 40° - 50° or 85° - 90° in upper quadrant system of working or lowered to 40° - 50° in lower quadrant system of working, the electromagnet energises and cuts off power supply to electric motor. With this the speed of signal arm decreases and finally the arm starts getting back after stopping due to its weight. At this juncture the latch detent locks with the clutch gear and holds the arm.

7.7.2.5 Circuit controller: Circuit controllers are coupled to the signal arm mounted above signal motor. These are used for controlling power supply to signal motor, Hold off coils and snubbing contact.

7.7.2.6 Snubbing contact: The contact is used to short circuit the motor coil when power supply to the motor is cut off to restrict the speed of the movement of the motor due to momentum.

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Chapter-III  Self assessment

1. Multiple choice questions:

1. Pair of tongue rails with stock rails is a:
   (a) Turnout (b) Crossover (c) point* (d) None of them
2. A crossover is a set of:
   (a) Turnouts* (b) points (c) Crossing (d) All of them
3. Permissible maximum speed over 1in16 turnout on BG track is:
   (a) 10Kmph (b) 30kmph (c) 50kmph* (d) 15kmph
4. 110V DC point machine with clamp lock provides stroke of:
   (a) 143 mm (b) 220mm* (c) 110mm (d) none of them.
5. Clamp lock is desirable on point for speed of train above:
   (a) 110Kmph (b) 120Kmph (c) 140Kmph* (d) 160Kmph.
6. WCR relay heavy duty contacts are to:
   (a) Carry heavy currant.*
   (b) Limit the operating time of point machine.
   (c) To maintain 10 second limit for point operation.
   (d) All of them.
7. Crank Handle is:
   (a) Inter locked with signalling system.*
   (b) Non interlocked and kept free to be used under emergency.
   (c) Kept under safe custody with Station Master.
   (d) All of them.
8. NC/RC controls in machine are for:
   (a) Normal to reverse setting of point. (b) Reverse of normal setting of point.
   (c) Midway operation of point* (d) All of them.
9. LED signals are provided with:
   (a) Lens couplet (b) fresenel strip (c) both of them (d) none of them*
10. Junction type route indicator can lead to maximum:
    (a) Seven routes* (b) Six routes (c) three routes (d) four routes
11. LED signals can be powered by: (Tick any two)
    (a) 110V DC* (b) 110V AC* (c) 12V AC (d) 12V DC
12. Role of friction clutch in point machine is to:
    (a) Slow down the movement (b) absorb shock* (c) reverse the movement (d) reduce power consumption.
2. Select the right answer (True/False):
1. Operation of stretcher bare of point with clamp lock is independent- True*/False.
2. Command to pneumatic point machine is electrical- True*/False.
3. Theatre type route indicator is an array of lamps to display the line number- True*/False.
4. Junction type route indicator has four lamps in its arm- True*/False.
5. Stencil type of route indicator displays route through alphabet stencilled and illuminated- True*/False.
6. Three phase AC operated point machine is designed to work on 300V AC- True/False*.
7. LED Signal is provided with one universal AC/DC HMU and one universal A/C- DC current regulator- True*/False.
8. Life of LED signals is more then in incandescent lamp- True*/False.
9. Shunt signal on the signal post has three indication lamps- True/False.*
10. Shunt signal on the post by itself has three indication lamps- True*/False.

3. Answer following questions:
1. Write short notes on:
   (a) Point clamp lock.
   (b) Lamp checking relays.
   (c) Special feature and advantage of LED signals.
   (d) Description friction clutch in print machines and its function.
   (e) Pneumatic point machine.
2. Describe electric point machine and write its basic requirements.
3. Describe role of crank handle in signalling system & its grouping.
4. Write short notes on:
   (a) Snubbing.
   (b) NC/RC controls.
   (c) 143mm stroke of point machine of is to keep margin for adjustment of point operation.
5. Write short notes on:
   (a) Adjustment & testing of point detection.
   (b) Adjustment of signal beam when incandescent lamp is used.
   (c) Electrical operation of Semaphore signal arm.

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CHAPTER – IV

TRANSMISSION MEDIA -CABLES

1. **Cables as media of transmission:** In electrical signalling system transmission of commands and yard status is through cables for which different type of cables used are i) Signalling Cable, ii) Quad Cable, iii) Power Cable and iv) Optical Fibre Cable.

2. **Signalling cables:** The conductors used for signalling system wiring and long range transmission are grouped into convenient configuration group to form the cable. Such cables used for signalling purposes are Signalling Cables.

The PVC insulated underground, unscreened cable for Indian Railway Signalling & power supply to signalling system are manufactured and procured in conformity to IRS specification Number S-63/2007. These Specifications have superseded earlier specifications 63/89 with amendment 6. The specification for signalling cable is read with other specifications viz. i) IRS23, for electrical signalling and interlocking Equipments, ii) IS723 steel counter sunk head wire nails, iii) IS3975, for mild steel wires, strips and tapes for armoured cable, iv) IS5831-84 PVC insulation and sheath of electrical cables, v) IS 6745/72, for determination of Mass of zinc coating on iron and steel articles used in the cable, vi) IS8130 Conductors for insulated electrical cables and flexible cords, vii) IS9938 recommended colours for PVC insulation for wires and cables, viii) IS10810-84 methods for test of cables. Any of these specifications whenever mentioned without reference to year, these shall be deemed to be read with latest amendments.

Signalling cable is used for transmission of all signalling commands from relay room to operated equipments, such as signals, points, level crossing gates, inter-cabin slotting etcetera and transmission of yard status such as that of signal aspects, points, gates, track occupancy, level crossing gates etcetera. The signalling cable is also used for short distance telephone communication between Station Master and the end cabins as well as Between Station Master and the level crossing gate within station section (figure 2).

2.1 **Structure & configuration:** Signalling cable is a bunch of single solid annealed copper conductors each conductor being of 1.5 square mm area of cross section, each conductor provided with PVC insulation coating. The conductors of the cable are called as 'cores'. The bunch of conductors is covered with a PVC jacket, which in turn is covered with a steel armouring for protection of cable from damage by outside interference such as pick axe etcetera while digging the trench along side the trench where such cable is already laid. The armouring is done by wrapping the steel strips or wires helically around the cable all along its length. The armouring is further covered with a PVC jacket. The cable is supplied by manufacturers in 500 metres length, wrapped on a drum. Cable conductors used for track circuits are of 2.5 square mm area of cross section.

The number of conductors in each cable has been standardised by Railway Board through their Circular number 2001/SfG/Specn./1, dated 23/24.12.2002. The cable core configuration accordingly has been rationalised as i) 2 core of each conductor of area of cross section as 2.5
Sq. mm, and ii) 12 core, iii) 19 core, iv) 24 core, & v) 30 core each of area of cross section as 1.5 sq. mm. With the issue of this letter all cables being used between 2 to 37 core other than specified have been put to be out of use.

Cable core insulation coating is coloured and the cores are arranged in a sequence for easier identification for the purpose of joining and termination. The principles being i) for a single central core of a multi-core cable red or black shall be used, ii) for the bunch of 2,3,4, or 5 cores in the centre, the colours shall correspond to different core cables as given below (IRS Specification paragraph 5.2.5):

- One core : Red, black, yellow blue or green.
- Two core : Red & black.
- Three core : Red, yellow and blue.
- Four core : Red, yellow, blue and black.
- Five core : Red, yellow, blue, black and grey.

2.1.1 Sheathed cables: The cable used in area provided with 25 KV AC traction was required to be screened with aluminium or lead sheathe to reduce induced e.m.f. on cable conductors. This cable sheath was required to be earthed and the earth in turn was required to be maintained to have resistance of less than 10 ohms. As all the signalling circuits were designed based on reduced induced e.m.f. it was almost not possible to maintain earth resistance to given standards, the scheme was changed from use of sheathed cable to unscreened cable, simultaneously changing signalling system power supply from earlier 110V AC to 300V AC. The system became unwieldy and unsafe for persons working on the signalling circuits at such high voltage and therefore was subsequently again reverted back from 300V AC with unscreened cable to 110V AC unscreened cable.

As such now only unscreened signalling cable is being used with 110 V AC power supply for signalling system.

2.2 Planning of signalling cable:
2.2.1 In each main cable adequate number of spare conductors to a minimum 20% of total conductors used shall be kept as spares up to the farthest point zone, beyond which only 10% conductors shall be kept as spare of the total conductors used. No spare conductors are required if the total conductors used in the cable are 3 or less. The spare conductors shall be provided out of outermost layer of the cable. [SEM part-II September, 2001 paragraph 15.3.2].

2.2.2 Where a number of cables are laid along a route, the circuits shall be so distributed that cables can be disconnected for maintenance with least possible dislocation to traffic. [SEM part-II September, 2001 paragraph 15.3.3].

2.2.3 Separate cable shall be used for Auxiliary signals and for point operation. [SEM part-II September, 2001 paragraph 15.3.3 & 1.3.8].

2.3 Standard Resistance of copper conductors:
2.3.1 Standard resistance of circular copper conductors of signalling cable is tabulated as table number 2.3.1 [clause 3.1.1 of specification number S-63/2007].
<table>
<thead>
<tr>
<th>Area of cross section In sq mm</th>
<th>Number of wires in each conductor</th>
<th>Diameter of wires In mm</th>
<th>Standard resistance of conductor per km at 20°C, in Ohms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>1</td>
<td>1.13</td>
<td>17.241</td>
</tr>
<tr>
<td>1.5</td>
<td>1</td>
<td>1.40</td>
<td>11.20</td>
</tr>
<tr>
<td>2.5</td>
<td>1</td>
<td>1.80</td>
<td>6.775</td>
</tr>
<tr>
<td>2.5</td>
<td>3</td>
<td>1.06</td>
<td>6.644</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>2.24</td>
<td>4.375</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>0.85</td>
<td>4.414</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>2.80</td>
<td>2.800</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>1.40</td>
<td>1.627</td>
</tr>
<tr>
<td>16</td>
<td>7</td>
<td>1.70</td>
<td>1.104</td>
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<td>25</td>
<td>7</td>
<td>2.24</td>
<td>0.6357</td>
</tr>
<tr>
<td>35</td>
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</tr>
<tr>
<td>50</td>
<td>19</td>
<td>1.80</td>
<td>0.3633</td>
</tr>
</tbody>
</table>

**Table 2.3.1  Standard resistance of circular copper conductors of signalling cable**

Temperature correction shall be required to be done to work out actual resistance for use of the cable in areas with a different temperature for example for a change of 5°C the correction factor shall be 1.0638 and so on. The variation shall be minimal and standard resistance may be taken into account for practical purposes.

2.3.2 **Current carrying capacity and associated voltage drops for twin and multi core armoured, PVC insulated cables with copper conductors laid underground** is tabulated as table number 2.3.2 when cable is placed when the cable is clipped to non-metallic wall or in open trays or embedded directly into concrete [Technical data compiled by the Electrical Contractors Association of Maharashtra, table 15].

<table>
<thead>
<tr>
<th>Area of cross section In sq mm</th>
<th>Twin core cable single phase AC or DC</th>
<th>Three or four (multi) core cable three phase AC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current carrying capacity (A)</td>
<td>Voltage drop per ampere per metre</td>
</tr>
<tr>
<td>1.5</td>
<td>20</td>
<td>29mv</td>
</tr>
<tr>
<td>2.5</td>
<td>29</td>
<td>18mv</td>
</tr>
<tr>
<td>25</td>
<td>115</td>
<td>1.8mv</td>
</tr>
</tbody>
</table>

**Table 2.3.2  current carrying capacity and voltage drop across copper conductors**

2.4 **Power cable:** Wherever power is required for signalling system, it is transmitted using cable especially designed for transmission of power, termed as Power cable. Any transmission for signalling system may also be used for transmission of power for the signalling system also while no transmission for signalling system is permitted on power cable except power supply.

Power cable is manufactured and procured under IRS specification Number S-63/2007. The specification S-63/2007 is for signalling cable and also includes specification for power cable
for signalling purposes. The specifications provide use of copper conductors for power cable under specification number S-63 and under the same specification, with the provision of aluminium conductors under specification number S-1554. The requirements for power cable under specification number S-63 are different than for signalling cables.

RDSO, as per their Circular number TI/PSI/PROTCT/CLS/03 Dated: 21.02.2003 have provided for use of aluminium conductor for power cable conforming to IS: 1554 Pt.1. The use of aluminium conductor power cable between AT/Local supply to CLS panel and from CLS power panel to Signalling equipment room is also specified under paragraph 1.2.2 with specific reference to the circular, in Railway Signalling Installation and Quality Handbook issued in 2006, by Railway Board. Aluminium conductor power cable is being used on Indian railways.

In area electrified with AC traction, power for signalling system is to be given by Electrical department of Railways up to the Station Master’s room. Thereafter the power supply for signalling system up to the Battery & Equipment room or up to the room where Integrated Power Supply (IPS) equipment is placed, is drawn by Signal & Telecommunication department of Railways. Aluminium conductors are not used for any other purpose in the signalling system. For more information Indian railway Signalling Engineering Volume I by the same author may be referred to.

2.4.1 **Size of conductors:** The size of the cable conductor shall be so selected as to suit the electrical load. [SEM part-II September, 2001 paragraph 15.2]. RDSO’s letter dated 21.02.2003, has also specified use of power cables vis-à-vis power supply source on principles tabled below:

<table>
<thead>
<tr>
<th>Source of Power supply (AT or local)</th>
<th>Type of cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>5KVA</td>
<td>2 x 25 sq mm aluminium conductor</td>
</tr>
<tr>
<td>10KVA</td>
<td>2 x 70 sq mm aluminium conductor</td>
</tr>
<tr>
<td>25KVA</td>
<td>2 x 150 sq mm aluminium conductor</td>
</tr>
<tr>
<td>50KVA</td>
<td>2 x 300 sq mm aluminium conductor</td>
</tr>
</tbody>
</table>

3. **Quad cable usage & configuration:** For signalling system quad cable is used for transmission of data or speech where electrical or electronic noise and cross talk may interfere with the data or a communication channel transmitted, for short distances. Such cable is used for i) Axle counters, ii) Audio Frequency Track Circuits (AFTC), iii) Block working between two stations, iv) connecting Station Master with telephone at Level crossing gates falling in block section and for v) connecting emergency sockets provided on emergency posts in block section, on omnibus circuit with emergency control room in area provided with AC traction.

3.1 **Connection to Axle Counters (A/C) and Audio Frequency Track Circuits (AFTC):** Axle counter system for track vacancy detection are i) single section analogue, ii) single section digital and iii) multi section digital. In case of single section analogue and multi section digital axle counters the evaluation unit is placed centrally and electronic junction box/electronic assembly is placed near the transducers/Axle detectors which are fixed with rails. In case of analogue axle counters an independent pair connects the electronic junction box with the evaluator unit while in case of multi section digital axle counters the central evaluator communicates with field units in star configuration using quad cable.
There are different methods of connecting AFTCs depending upon manufacturer’s design. Alcatel have designed the system such that the transmitters and receivers are placed inside relay room while Tuning Units are kept at site near the railway line. The transmitters and receivers are connected with tuning units on independent pairs of the quad cable with the restriction that transmitter or receiver of the same frequency shall not be kept in same cable.

3.2 Connection between two Block instruments: On double line section non cooperative SGE type double line lock and block instruments are used. The line circuit works on single conductor with earth return. Block working with Instrument is polarity sensitive as such any leakage with earth may result in unsafe conditions. For the reason of safety and stability of system only PE insulated conductors are used for line circuit of block instruments. In area electrified with 25 KV AC, telephone communication circuit and block bell circuits can not be worked on single conductor as such for the purpose of mitigating the high induced voltage on conductors isolation transformers are used to form a loop there by nullifying the affect of induced e.m.f. and also to isolate the cable conductor from local circuit.

One pair of quad cable is exclusively dedicated for telephone circuit. The system is for the purpose of abundant safety precaution to avoid any interference or cross talk with any other system of communication misleading to the Station Master resulting in action on wrong information. This is the specific reason to provide an independent battery for the block telephone as well. One pair is used for transmission of block bell codes on a given frequency and one pair is used for telegraph circuit. Accordingly 1½ quad is used for block working between two block stations while ½ quad is kept as spares, which make it 2 quads, leaving behind one quad for emergency sockets and three quads for gate telephone connections. However block instrument line circuits are used on single conductor with earth return which is the solitary case in itself.

For block working each of the four pairs of the quad cable is terminated on a transformer at both end stations, making closed loop. One of the block instrument line circuits is superimposed on the pair used for block bell circuit and other block line circuit on pair of telegraph circuit, as phantom circuits. Since block line circuit is not visible but still it functions through balanced current on each conductor of the pair diverging at the sending end and converging at the receiving end through centre tapings of the transformers, it is called as phantom.

As the block bell circuit works on a given frequency and the line circuit for block working works on direct current (DC), the two circuits do not interfere with each other while sharing both the conductors of the quad. At the time of introduction of RE the telegraph circuit for transmission of meal messages, commercial messages and other train operation were done through telegraph. Over the period with the introduction of better communication facilities the use of telegraph has been dispensed with while the pair is retained.

Besides, the transformer has to match the characteristic impedance of cable conductors as well as equipment used, also. The line matching is essential to enable transfer of input and output signals without loss. The typical characteristic impedance of the PE insulated quad cable is 470 ohms and the cable/equipment connected to the transformer’s secondary winding is 1120 ohms.
Emergency Control Phone (ECP) used in RE area is also of 1120 ohms impedance. Figure 3.2 depicts schematic diagram of one such transformer connection.

![Connection of transformer for block instrument circuit and phantom circuit](image)

**Figure 3.2**

3.3 **Connecting emergency sockets:** In the area provided with 25KV AC traction, overhead communication alignment is essentially required to be put on underground cable thereby switching over the arrangement of hooking the Portable Control Phone (PCP) to control communication carrying overhead conductors for emergency communication, to underground cables using Emergency Control Phone (ECP) by connecting to emergency sockets. Accordingly emergency sockets are provided throughout block section at an interval of one kilometre and near feeding, sectioning, sub-sectioning posts, OHE Depots and other strategic places in addition. Two pairs of the quads are designed to be used for emergency circuit out of which one pair is used for transmission and other for receive circuit. A phantom circuit is derived from centre tapping of primary winding of the transformer meant for calling attention of the OHE controller by pressing a button provided on the ECP. The system of calling attention never worked efficiently and the circuit was subsequently modified to be used to connect administrative telephone from emergency socket which turned out to be very useful in extending communication up to the site of accident. Transmission of voice in analogue form results in distortion of the waveform due to different impedance offered to different frequencies. For longer distance communication, waveform correction and amplification of amplitude is required to be done at suitable intervals. Equaliser and amplifier equipment are housed for the purpose in ‘Repeaters’ where the cable is terminated.

3.4 **Quad cable configuration:** Only jelly filled six quad cables have been standardised for use on Indian railways under specification number IRS: TC 30-05.

3.4.1 **Cable conductors:** The cable conductors are single solid annealed copper of 0.9mm diameter, provided with solid polythene insulation jacket and paired and twisted. Two such pairs are twisted to make a quad (quadruplet) to form a star configuration. Each quad is held together by means of open helical whipping of cotton or nylon thread or a coloured tape. A polyethylene string is used in the centre of quad to give the quad a solid circular shape and stability. Six such quads are placed together in such a way that they do not shift from their position during transport or laying.
All the six quads are put together and wrapped by a polyester tape. Jell is filled in between, under pressure, to ensure water resistance. The polyester tape wrapping is covered with poly-aluminium barrier. Over this polyethylene jacket is provided which is covered with aluminium screen of wire or strips. The cable is further covered with woven tape impregnated with Barium Chromate, PVC intermediate sheath, armouring made of galvanised steel tape and PVC outer sheath in given order of sequence [Figure 3.4].

The resistance of each conductor is 28 ohms per Km at 20° C. The colour sequence of the insulation of the conductors shall be as per Table 3.4.1.

<table>
<thead>
<tr>
<th>Quad number</th>
<th>Colour of the conductor insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wire-A</td>
</tr>
<tr>
<td>1.</td>
<td>White</td>
</tr>
<tr>
<td>2.</td>
<td>White</td>
</tr>
<tr>
<td>3.</td>
<td>White</td>
</tr>
<tr>
<td>4.</td>
<td>White</td>
</tr>
<tr>
<td>5.</td>
<td>White</td>
</tr>
<tr>
<td>6.</td>
<td>White</td>
</tr>
</tbody>
</table>

The colour sequence of the insulation of the conductors

It is pertinent to note that the dimension of the signalling cable copper conductors is normally referred in terms of area of cross-section while the dimension of the quad cable is normally referred in terms of diameter.

3.4.2 Cross talk and attenuation: Cross talk is, inducted power in cable conductors due to transmission of power in any other conductor which may be in the form of voice, data or AC power supply. If some speech communication travelling through one pair of cable creates slightest disturbance in adjoining pair, this cross talk becomes annoying for speech communication or creates disturbance to a data transmission distorting data being transmitted resulting in serious consequences.

Accordingly the quad cable is designed for eliminating cross talk, which is measured by injecting 150KHz, 5KHz and 0.8 KHz power into the cable pair and cross talk level measured on other pair. When measured at 150 KHz, the RMS and individual values of far end cross talk...
shall be better than 67.8dB/km and 55.0dB/km respectively. When measured at 5 KHz and 0.8 KHz, the RMS and individual values of far end cross talk shall be better than 60.0dB/km and 55.0dB/km respectively on both the frequencies. Near end cross talk between adjoining pairs when measured at 150 KHz shall be better than 55dB, at 5 KHz better than 60dB and at 0.8 KHz better than 65dB.

3.4.3 **Attenuation**: The cross talk shall be through alternating current which may be voice or data as such resistance becomes rather insignificant in comparison to attenuation to the signal. Attenuation is also measured by injecting 150KHz, 5KHz and 0.8 KHz power and measuring at the far end the losses. When measured at 150 KHz, average attenuation of the pair shall not exceed 4.4dB/km, at 5 KHz it shall not exceed 2.5dB/km and at 0.8 KHz it shall not exceed 1.2 dB/km, at 20°C.

4. **Optical Fibre Cable (OFC)**: With the advent of electronic system of interlocking, transmission of information can now take place accurately and reliably through Optical Fibre. This, besides increased speed of transmission, saves huge amount of costly copper. The usage of OFC in signalling system is increasing with each passing day which makes it essential for the Signal Engineers to understand OFC in right earnestness.

In a typical example where Solid State Interlocking is provided at a central place the points and signals are provided at both the ends of the yard the output digital commands from Solid State Interlocking (SSI) shall transmitted to mini SSI system placed at both the ends of the yard, through OFC. Thereafter feed to points and signals shall be extended from output commands of these end SSIs through signalling copper cable. The arrangement shall take care of ill effects of induced e.m.f. where the station falls on area electrified with 25 KV AC traction.

While transmission of information through copper cable takes place through conduction of electrons, in case of Optical Fibre Cable it takes place through light modulated to the desired frequency propagating through the optical fibre. Since the conductor is non-metallic there is no influence of electromagnetic induction on the functioning of the cable. Accordingly the communication is also free of cross talk or noise. OFC having no resale value is free of thefts as against in case of copper cables.

4.1 **Structure of Optical fibre**: The optical fibre is a thread made of silica glass with its central core covered with a cladding overall diameter being to the tune of 1/10 mm and is capable of transmitting 8000 telephone channels concurrently.

4.1.1 **Manufacture of the OFC**: To understand OFC the function of OFC and a glimpse of how the OFC is manufactured shall make it easier.

The fibre is manufactured in two steps. i) preparation of the ‘Preform’ and ii) drawl of the fibre.

The **Preform** is a solid glass rod. For preparation of Preform, out of many, one of the methods is known as Modified Chemical Vapour Deposition (MCVD) technique. A tube of quartz is mounted on lathe and allowed to rotate. A mixture of Oxygen and vapours of Silicon tetrachloride is led into the tube. A burner emitting heat to the tune of 2000°C is made to move
at a controlled speed along rotating tube. As the gases pass through inside of the tube they form small particles called 'Soot'. This soot converts to pure white glass on getting heated further. The index of the individual layers is controlled by adding small amounts of Phosphorous, Germanium, Boron or fluorine while preparing the Preform. After 60-70 layers the flow of gases is stopped, the speed of the burner is decreased and the temperature is increased which causes the entire material to take form of a solid glass rod. The Preform is separated out from rest of the material. The fibre so drawn remains the replica of the Preform.

The next process is to convert the Preform to the fibre of desired size. The process is known as ‘Fibre Draw’. The Preform is hung vertically in a draw tower heated at around 1900°C. The liquefied portion flows down because of gravity and then stretched into thin strand. The diameter of the fibre is monitored by a laser based diameter gauge. From one meter Preform, 15 Kilometres of fibre can be drawn. (Curtsy- The Fibre Optic Association.). The fibre is given a primary coating and thereupon a coloured plastic tube as a secondary coating to avoid damage to the fibre while further handling to be put into a cable form.

4.1.2 Optical Fibre cable structure: [Figure 4.1.2] In conformity to the latest specifications the fibre, cable is designed as ‘Loose Tube cable’. The fibre, after having being covered with primary coating is placed inside secondary coating loose tube, of diameter 2.4mm ± 0.1mm designated as ‘Loose Tube’. Four such primary coated fibres are put in one loose tube and the space inside is filled with a water blocking thixotropic jelly. Six such loose tubes are stranded around a central FRP strength member in case of an armoured cable. The strength member is to give mechanical strength to the cable. This assembly is called as cable core. The cable core is filled with a water blocking compound and covered with a continuous layer of non-hygrosopic dielectric material applied longitudinally or helically overlapped to provide moisture barrier to the core. The Core is covered with Heavy Duty Poly Ethylene (HDPE) tube to form inner sheath of the cable. The inner sheath is covered with corrugated stainless steel alloy of thickness not less than 0.05 mm to protect the cable from rodents and to certain extent from outside interference also. Having been armoured the cable is finished by providing outer HDPE jacket of not less than 2 mm thickness.

![Figure 4.1.2](image)

Structure of mono - mode 24 fibre OFC
4.1.3 **Type of OFC:** Based upon usage requirements three basic type of OFC is manufactured. Structurally these are, i) Multi mode step index, ii) Multi mode graded index and iii) Monomode step index.

a) **Multi mode step index fibre:** A fibre is multimode if more than one ray is able to traverse through it from one end to other. The boundary of core and cladding having two values of refractive indices, make the fibre step index. Such fibre is easy to splice and better coupling with light source is possible being thick in diameter i.e. 100 micrometer, but with the drawback of step index, resulting in large dispersion i.e. all the rays created by one pulse, travelling different length and so reaching at the end at different time thereby elongating the pulse, in turn causing lower band width i.e. coverage of shorter frequency band, with the increasing length of fibre. Accordingly such fibres are used for short distance communication.

b) **Multi mode graded index fibre:** In order to get an enhanced band width, two improvements over multimode step index fibre are made, first being the step index on the boundary of core and cladding is modified to be graded which means the refractive index changes gradually from largest at the centre and gradually decreasing on both sides thereby looking as the core of the fibre was made in layers the refractive index of which decrease from the centre of the core. With this the dispersion is reduced thereby increasing the bandwidth for longer length of fibre. Secondly the band width is further improved by reducing the diameter of the fibre at the cost of difficult splicing as well as coupling due to reduction in diameter of the fibre.

c) **Mono-mode step index fibre:** A fibre is mono-mode if only one ray can pass through the fibre. To achieve this, the diameter of the fibre is reduced to 09 micrometres and Numerical aperture being approximately 0.11. This makes dispersion minimum, with largest bandwidth but results in difficult splicing, difficult coupling and costly manufacturing.

Mono mode step index fibre is suitable for long distance and faster & larger bandwidth. RDSO has specified use of Mono-mode 24 fibre Optical Fibre Cable to be used by Indian Railway as per IRS specification number TC 55-2006. Nominal diameter of the mono-mode fibre has been given under the specifications as 8.8 micrometer – 9.8 micrometer for matched clad fibre.

4.2 **Principle of working:** Communication with OFC works on the principle of refraction of a light ray. Total internal reflection takes place at the boundary of two material when incident ray passing through a material with high refractive index shrikes against the boundary of the material of lower refractive index. Accordingly the core of the fibre is kept of refractive index higher than the cladding. The angle of reflection is same as that of incidence[Figure 4.2].
4.2.1 **Light source:** Light Emitting Diodes (LEDs) are one of the sources of light. LED has small output power to the tune of micro watt. Its spectral width is large to the tune of 40-50 nanometre. The coupling loss is high. In totality all of these factors contribute in use of LED as light source for shorter distance transmission. Another type of diode i.e. Edge Light emitting Diode (ELED) emits light from the edge giving better coupling. ELED emits high power to the tune of 300micro watt while still another version of ELED emits 1milliwatt.

The best source of light is the **Laser Diode**. Most commonly used laser Diodes are made of Gallium- Aluminium- Arsenide. The output power of laser is 1-2 milliwatt. The semiconductor laser diode can be switched on & off at the rate of 1000 megabits /second.

4.2.2 **Numerical Aperture of fibre:** Numerical Aperture (NA) is the angle ‘θ’ at which light remains within fibre without being lost through cladding [Figure 4.2.2]. The coupling of light source with optical fibre is the most important factor in deciding efficiency of the transmission.

It depends on the angle of emission of the light source and on ability of fibre to receive incident light, which is the critical angle ‘θ’ beyond which the incident ray is lost and does not find path to the end. It may be seen here that incident ray ‘a’ goes straight without any refraction, ray ‘b’ gets reflected in the fibre being within the angle of numerical aperture and ray ‘c’ gets lost as it is beyond the numerical aperture and does not find path further.

In case of LED light source, the light is emitted through its surface, causing it to diffuse. The emission of ELED is at 31⁰ giving better coupling as compared to LEDs. In case of laser Diodes the emission angle is 15⁰-20⁰ giving best coupling, resulting in about 70% efficiency of coupling with output power as 1-2 milliwatt.

4.2.3 **Receivers:** PIN or Avalanche Photo Diode (APD) is used as receiver at the exit end of the fibre. These are light sensors and their efficiency is measured in terms of minimum light required to work the system efficiently.

4.2.4 **Transmission made digital:** Whatever sound is created through voice or instruments of music it is a blend of different wave forms of different frequencies and amplitudes. Any alteration in wave form or amplitude shall result in distorted information reaching to the receiver in case of copper cable, since during transmission through conductor it offers different impedance to different frequencies which results in distorted waveform at the receiving end. This has to be set right by use of equaliser. However if any other wave form is added during transmission, the output may be different, added with noise. To avoid such a situation the analogue communication is digitised.

Any digital communication is transmitted in the form of a binary digit ‘Bit’. Each Bit has a value either zero (0) or one (1) and graphically represented as shown in the figure 4.2.4a. A set of 8 Bits is called a ‘Byte’.
A sound wave may look like as shown in the figure 4.2.4a, against X axis and Y axis. The wave form is sampled electronically on a fixed time interval @ of 8000 times per second. The sampling may be conceived in analogy to a movie picture film in which a set of still photographs are filmed on one reel which when viewed against a fixed window looks as if the characters were moving imbibing the hidden part to the viewer.

The samples of the wave form are shown in the figure by vertical lines touching the contour of the sound wave and the X axis. A few of these sample positions are randomly marked as a, b, c, & d in sequence. Each sampled position of the sound wave form is translated into 8 Bits i.e. a set of one Byte, by a coder. A set of one Byte is shown in the figure which may be assumed to be sample of position ‘a’. It is pertinent to note that each sampled position which is converted into a set of 8 Bits i.e. one Byte, while 8000 such samples are taken per second, as such the rate of transmission works out to be 64 Kilo bits/second. At the receiving end of the communication channel these Bytes are converted back into original shape of the sampled wave form where all such shapes joined together recreate analogue waves to be used as sound. The analogue input could be a sound, a picture or any other data.

One of the methods of propagation of more than one communication channels into one fibre is by insertion of other voice or data channels between sampling of the first channel, at a given rate. Each such voice or data channel is segregated out at the receiving end at the same rate and routed to the desired destination.

For example, assume three voice or data channels ‘A’, ‘B’ and ‘C’ in analogue form are to be transmitted across one communication channel. An electronic switching device, controlled by an electronic timer, switches over analogue communication channels ‘A’, ‘B’ & ‘C’ one by one in same sequence, to a common coder.
Each such piece of sample is converted into binary digits and sent in the form of a pulse train on to the optical fibre [figure 4.2.4b].

4.2.5 **Termination and joining of fibre:** Optical fibre of the cable is terminated on equipment at both ends of the cable wherefrom data is required to be transmitted, retrieved or propagated onwards through ‘Connectors’. These connectors are ‘Pigtail’ and ‘Patch Cord’. One end of the Pigtail is spliced with the fibre of the OFC and other end is terminated onto an socket. One end of the Patch cord is connected with the Pigtail through socket and other end is connected to the equipment. This way the Patch cord works as a link between Pigtail and the radio equipment to facilitate easy manipulation of the connections.

The equipment required to convert analogue input data meant for further transmission and to convert the digitised data received, into analogue form, light source, receivers, amplifiers, power supply and other associated equipment are mounted on a rack.

The socket is screwed to a light source for onwards transmission to be retrieved at other end of the main fibre, or on to a receiver, received from other end for onwards transmission through radio equipment. The transmission through a fibre accordingly is unidirectional.

Pig tails used on Indian railways shall conform to specification number RDSO/SPN/69/2007. Salient features provided for single mode fibre, in the specifications are given in table number 4.2.5:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal wavelength</td>
<td>1310 nm</td>
</tr>
<tr>
<td>Cut off wavelength</td>
<td>1240 nm</td>
</tr>
<tr>
<td>Length of the Pigtail</td>
<td>5 &amp; 10 meters or as specified by the purchaser</td>
</tr>
<tr>
<td>Connector type</td>
<td>PC-FC</td>
</tr>
<tr>
<td>Permissible insertion loss</td>
<td>0.1 dB maximum</td>
</tr>
<tr>
<td>Return loss</td>
<td>Better than 45 dB</td>
</tr>
</tbody>
</table>

Table 4.2.5
Salient features of single mode fibre

The quality of Optical fibre link termination affects the channel insertion loss.

i) **Pigtail:** The pigtail fibre of the same type and index as that of under use in the cable is inserted into a socket such as to protrude beyond the socket. The protruding part of the fibre is polished to give a semi spherical shape and sealed with the socket using epoxy. The socket is screwed to connect firmly with the light source or to the receiver such that the fibre’s protruded part makes a physical contact [PC] with the surface of patch chord of the transmitter or receiver for the purpose of coupling.
FC/PC, the most popularly used single mode connector is required to be keyed into the slot. It requires care full alignment of the socket into the slot properly before tightening. [Figure 4.2.5 (i)] As an improvement over PC –FC, the snap-in connector (SC) is widely used in single mode systems for its excellent performance. The connector latches with a simple push-pull motion. It is also available in a duplex configuration. [Figure 4.2.5(ii)]

ii) **Splicing**: ‘Splicing’ is joining of two Optical Fibres. The Optic fibre cable is delivered usually in three kilometre length drums. To maintain continuity of the fibre, the ends are spliced. Splicing may be i) mechanical or ii) fusion.

A **mechanical splice** is made as temporary arrangement at site. The ends of fibres are firmly held in a tray in alignment facing each other using alignment sleeve and the joint is filled with fibre index matching gel to avoid reflection loss. Splicing machines are used to make **fusion splice** into which ends of the fibre are placed facing each other after cleaving the cladding of the fibre. The faces of both the ends are cut sharp to be exactly vertical, cleaved portion is cleaned of dust with lint-free wipes moistened with isopropyl alcohol. As both the ends are placed duly cleaned and aligned facing each other without any air gap and dirt or dust a high electric arc causes the ends to fuse and weld with each other [Figure 4.2.5 (iii)]. The choice of type of splice is usually based on cost or location.

iii) **Splice Loss**: Since Optic Fibre technology was introduced in the late 70s, numerous connector styles have been developed. Each design is meant to offer less light loss, back reflection and easier termination at a lower cost. Accordingly splice loss result in i) loss of energy and ii) loss due to reflection.

Loss is minimised when the two Fibre cores are identical and perfectly aligned, the connectors or splices are properly finished and no dirt is present. Only the light that is coupled into the adjoining fibre's core will propagate, and the rest of it becomes the connector or splice loss.

Factors that cause transmission loss due to splicing are because of: [Figure 4.2.5(iv)]

a) **End gap**,  
b) **Non-Concentricity**,
c) **Angular cut or End angle,**
d) **Numerical Aperture (NA) mismatch,**
e) **Poor finish,**
f) **Improper Coaxial alignment,**
g) **Axial run-out,**
h) **Core mismatch.**

**End gap loss:** The emerging cone of light from the connector spills over the core of the receiving fibre and gets lost. In addition, the air gap between the fibres causes a reflection when the light encounters the change in refractive indices from the glass fibre to the air in the gap. This reflection (called ‘Fresnel’ reflection) amounts to about 5% in typical flat polished connectors, and means that no connector with an air gap can have less than 0.3 dB loss. This reflection is also referred to as back reflection or optical return loss, which can be a problem in laser based systems. Connectors use a number of polishing techniques to insure physical contact of the Fibre ends to minimise back reflection.

On mechanical splices, it is possible to reduce back reflection by using non-perpendicular cleaves, which cause back reflections to be absorbed in the cladding of the Fibre. The end finish of the Fibre must be properly polished to minimise loss. A rough surface scatters light while dirt scatters as well as absorbs light. Since the optical fibre is so small, airborne dirt may become a major source of loss. The connectors should be stored covered to protect the end of the ferrule from dirt. The end of the ferrule should never be touched, since the oils on the skin shall snowball dirt collection.

**b) Losses due to misalignment and mismatch in fibre dimensions:** Numerical aperture (NA) and core diameter differences of two fibres to be spliced will create connections that have different losses depending on the direction of light propagation.

Light from a Fibre with a larger NA will be more sensitive to angularity and end gap, so transmission from a Fibre of larger NA to one of smaller NA will result in higher loss than the reverse. Likewise, light from a larger diameter Fibre will have high loss coupled to a Fibre of smaller diameter, while one can couple a small diameter Fibre to a large diameter Fibre with minimal loss, since it is much less sensitive to end gap or lateral offset. These fibre mismatches occur for two reasons i) need to interconnect two dissimilar fibres and ii) difference of diameter during manufacturing in fibres of the same nominal dimensions. With two multimode fibres in usage, if a smaller diameter fibre is connected to a larger one, the coupling losses will be minimal causing only the Fresnel
loss (about 0.3 dB). But connecting larger fibres to smaller ones results in substantial losses, not only due to the smaller cores size, but also the smaller NA of most small core fibres.

After splicing, the joint is secured inside OFC joint closure. The sleeve is inserted onto the OFC and slipped on to cover the joined portion and heated. The sleeve is heat shrinkable to form a monolithic unit with the OFC.

4.2.6 **OFC Measurements:** Optical Time Domain Reflectometer (OTDR) measures and displays optical link attenuation as a function of time by converting the returned optical power from fibre length and components into a proportional electric current. As such the OTDR measures and displays link attenuation by directly measuring link return loss. A sample OTDR display is shown in figure 4.2.6. It may be seen through the diagram that losses at fusion splice are minimum, at mechanical splice these are more and maximum at fibre end. The graph line inclined towards far end shows the overall fibre loss.

5 **Laying of cables:** Cables may be laid underground, either in trench, in ducts, in cement troughs, in pipes or in any other approved manner. [SEM part-II September, 2001, paragraph 15.5].

5.1 **Laying of cable in ducts:** [SEM part-II, September 2001, paragraph 15.6] RCC, masonry or any other approved type of duct may be used for laying the cable.

5.1.1 The duct shall have suitable covers and designed such that water is not accumulated inside. In rocky area it is desirable to protect them with split RCC ducts of suitable design.

5.1.2 While taking cables under the track, it shall be carried in trucking kept sufficiently below the ballast level.

5.1.3 Where several cables of different categories have to be laid in the same trench, they shall be placed as far as possible in the following order starting from the main track side, so that in the event of failures, maintenance staff may easily recognise the damaged cables:

i) Telecommunication cable.

ii) Signalling cable.

iii) Power cable.

5.1.4 Cables belonging to Posts & Telegraph department or electrical department must not be laid in the same trench along with signal & telecommunication cables. A distance of minimum 10 cm must be maintained between telecommunication cable and signalling cables. The signalling cable shall be separated by a row of bricks between them.

![Figure 4.2.6- OTDR screen](image-url)
5.2 Signalling cable for outdoor circuits should normally not be laid above ground: In exceptional circumstances where it becomes unavoidable to lay the cable above ground, the following precautions should be taken: [SEM part-II September, 2001, paragraph 15.4]

5.2.1 The cable should be suspended in wooden cleats, from cable hangers or in any other approved manner so that no mechanical damage occurs to the cable even under exposed condition.

5.2.2 Cable supports shall be so spaced as to avoid sag.

5.2.3 In station yards cable shall be laid in ducts suitably protected.

5.2.4 Indoor signalling cable shall normally be laid on ladders, channels or any other approved manner. The cable should be neatly tied or laced.

5.2.5 In AC electrified areas cable shall be laid underground only.

5.2.6 Additional precautions shall be taken for laying signalling cable in section energised with 25 AC traction as follows:

i) The cable running parallel to the track shall be buried at a depth of 0.8 metres from the ground level and while crossing under the track shall be 1 metre below the bottom of the rail. In case of rocky soil the depth may be reduced to 0.5 metres.

ii) In case of tail cable the depth shall be not less than 0.5 metres.

iii) The distance between OHE mast and the cable trench shall be not less than 3 metres to maintain depth of the trench more than 0.5 metres.

iv) A distance of one metre shall be maintained between the cable and the OHE mast supporting Catenary or any structure that is likely to come in contact with high tension conductors. In this case depth of the cable shall not exceed 0.5 metres. The distance of the cable from OHE mast may be reduced to 0.5 metres by passing the cable through RCC pipes near the OHE mast.

v) In vicinity of the traction substation or switching station such as Feeding posts, sectioning posts and sub sectioning posts, the cable shall be laid one metre away from any metallic body of the substation which is fixed in the ground. The distance of one metre shall also be maintained from the substation earth.

vi) All the traction return current flows through substation earth as such a) the cable shall be laid on the side of track opposite to substation or, b) on the side of substation, it should be laid through RCC pipe or enclosed brick channels, for a length of not less than 300 metres on either side of the substation.

vii) The cable shall be laid at least 5 metres away from the switching station earthing, which can be reduced to one metre by passing the cable through RCC pipes near the earth.

viii) Signalling, telecomm and power cable can be laid in the same trench observing following precautions:

a) 100 mm distance between signalling and telecomm cable shall be maintained.

b) Signalling and power cable shall be separated by a row of bricks.

c) For recognising the cables in the same trench, the telecommunication cable shall be laid nearest to the track, signalling cable spaced by 100 mm next to telecommunication cable away from track and power cable separated by row of bricks outermost away from the track. If LT and HT both cables are laid in the same trench as signalling and telecom, the HT cable shall be put outermost and LT by the side of bricks.
d) A separation of 50 mm shall be maintained between the power cable and signalling cable when laid in separate trenches.

ix) Cables shall cross the track:
   a) Right angle to it.
   b) Shall not cross under the points and crossings.
   c) Pass through RCC or Double Walled Corrugated (DWC) PVC pipes at a depth of one meter below bottom of rails.
   d) Minimum distance of 0.2 metres shall be kept between signalling and power cable.
   e) When cable has to cross a metallic bridge it shall be placed inside GI pipe filled with sealing compound suitable to withstand 6000 V AC.
Chapter IV  
Self assessments

1. **Multiple choice question:**
   1. Media of communication between operating and operated unit is not:
      (a) OFC (b) Signalling copper cable (c) Quad copper cable (d) Power Aluminium cable*.
   2. Conductors of power cable used for signalling in general are:
      (a) Copper conductor (b) Aluminium conductor* (c) steel conductor (d) any of them.
   3. Quad cable is jelly filled for:
      (a) Lubrication between conductors (b) moisture resistance* (c) Identification of damage to cable (d) None of them.
   4. Optical fibre cable communicates through:
      (a) Copper conductors (b) Aluminium conductors, (c) Fibre drawn from silica glass.*
      (d) none of them.
   5. Media of communication through optical fibre is:
      (a) Electrons (b) protons (c) neutrons (d) photons.*

2. **Select right answer (True/false).**
   1. PVC sheath on cable is provided to reduce induced e.m.f.- True/false*.
   2. Signalling cable circular copper conductors are of 1.5 mm diameter.-True/false*
   3. Signalling cable can be laid along with power & telecommunication cable. True*/false.
   4. Transmission media between axel counter evaluator & electronic junction box can be signalling cable also- True/false*.

3. **Answer the following questions:**
   1. Describe:
      (a) Optical fibre.
      (b) Role of optical fibre in railway signalling system.
      (c) Multi mode graded index fibre.
      (d) Why railway has specified to use mono- mode step index fibre.
   2. Describe different uses of quad cable with reference to railway signalling system.
   3. Write short notes with reference to OFC, on:
      a) Joining of OFC fibre.
      b) Detection of location of fault using OTDR.
      c) Pig tail.
      d) Patch chord.
   4. Discuss: a) splice losses and precautions to be taken to reduce the same; b) rules to be observed for lying of signalling cable in area provided with 25KV AC traction.

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CHAPTER - V

ELECTRICAL SYSTEM OF INTERLOCKING

1. Interlocking, “the arrangement of signals, points and other appliances, operated from a panel or lever frame, so interconnected by mechanical locking or electrical locking or both that their operation must take place in proper sequence to ensure safety”, is made through mechanical, electrical or electronic means or through any combination of the three.

1.1 Interlocking arrangement made through mechanical means: Interlocking arrangement made through mechanical means is housed in a locking trough placed on the same standard on which the lever frame is provided. The locking is actuated by movement of levers, in case of ‘Direct’ type of interlocking frame and by actuation of catch handle in case of Catch handle type as well as ‘Double Wire’ type of lever frame. In all the three cases movement of plunger associated to the specific lever actuates the tappets, also called ‘Dogs’. The tappets concerned are tied with other tappets through tie bars. The arrangement is made in such a way that it shall not be possible to pull the concerned signal lever unless all predefined conditions, such as setting and locking of points in the route as well as in overlap, to the desired position, closure of level crossing gate etc. have been fulfilled.

For details of mechanical interlocking Indian Railway Signal Engineering Volume-III by the same author may be referred to.

1.2 Interlocking arrangement through electronic means: Interlocking arrangement through electronic means is software based made through Micro Computers known as Solid State interlocking (SSI). For details refer to ensuing chapter-VI of this volume.

1.3 Interlocking arrangement through electrical means: As discussed under chapter-I of this volume the electrical system of signalling can comprises of four basic constituents i) Control cum Indication panel for the use of Station Master to operate the signalling system, ii) Interlocking through relays used as switching device, wired in conformity to Logic circuits, iii) Power supply, and iv) Electrically operated point machines and electrically illuminated colour light signals.

2. Interlocking with switching relays: First step to take up interlocking through electrical means is to prepare a table deciding inter relationship between operated equipment which are points signals & level crossing gates and monitoring devices which are track circuits, point detectors signal aspect proving devices etcetera. This table, in mechanical system of signalling is called ‘Interlocking Table’ and in electrical system of signalling as ‘Selection Table’.

3. Selection Table: The fundamental difference in mechanical system of interlocking and electrical system of interlocking is that in case of mechanical system of interlocking the sequence of operation of levers has to be determined for which an Interlocking table is designed for preparation of a Dog Chart, while in case of electrical system of interlocking there is no lever to be operated and the interlocking is to be achieved through switching relays wired in conformity to the Selection table. In both cases the tables are framed based on ‘essentials of Interlocking’ as provided in Signal Engineering Manual. Over the period the selection table has acquired many nomenclatures as ‘Route Control Table’ (RCT) and ‘Route Control Chart’
Selection table is the basis for preparation of the logic circuits. Format of the Selection table when wiring is to be done using ‘Q’ series relays, is different than when wiring is to be done using Siemens relays.

3.1 Columns and preparation of Selection Table:

a) Selection Table designed for ‘Q’ series relays: The columns of the selection table designed for ‘Q’ Series relays, given here are basic and may change from railway to railway:

i) **Serial Number**: This number is given to each signal route and finally decides numbers of routes at the station.

ii) **Signal Number**: In this column number of the signal shall be filled. The numbers of the signals shall start with lowest and shall be in ascending order. For example if lowest signal number is 2 than the first number filled in this column shall be two and shall increase up to highest numbered signal.

iii) **Route**: In this column designation of the destination route shall be filled. A signal may be leading to more than one route in such a case the signal number shall repeat with all the routes one by one. For example if the signal number 2 leads to route numbers ‘A’, ‘B’ & ‘C’ then SN-1 shall be S2 with route ‘A’, SN-2 shall be S2 with route ‘B’ and SN-3 shall be S2 with route ‘C’. This shall be followed by next signal number in the same manner.

iv) **Approach locked by track circuits**: In this column track circuit’s numbers of the track circuits provided in rear of the concerned signal shall be filled. In case there is no approach track circuit, the column shall be filled in as ‘Dead approach locked’. In case section in rear of the signal concerned is provided with track circuits, such track circuits shall cover distance to cater for Normal Breaking Distance (NBD). If these track circuits do not cover NBD, approach locking shall not be effectively available. Under such a situation the signal concerned shall be dead approach locked. The NBD on Rajdhani route is 1400mts.

v) **Back locked by track circuits**: In this column the track circuit’s numbers which fall after passage of the signal by the train, till the destination track circuits, which back lock the signal route shall be filled.

vi) **Controlled by track circuits**: This column is further sub divided into two a) ‘In route’ i.e. track circuits falling in the route beyond the concerned signal up to the next signal and b) ‘in overlap’ i.e. track circuits falling in the overlap ahead of the next signal. Accordingly the track circuit’s numbers of the track circuits falling in the route and number of the track circuits falling in the overlap respectively, ahead of the signal, shall be filled.

vii) **Sets, locks and detects points in**: this column is subdivided into two columns a) Route & isolation and b) Overlap. Each of these two subdivided columns is further subdivided in columns ‘Normal’ and ‘Reverse’. In these columns points which fall in the route of the train in facing or trailing direction are required to be set, locked and detected normal and points which are required to be set, locked and detected revere, in route and in overlap respectively shall be filled. Points to be set normal or revere in route or overlap for the purpose of maintaining isolation, shall also be filled bracketed in these columns. Putting the number of the point in a bracket is for identification.

viii) **Locks crank Handle in**: This column is subdivided into two columns a) in route and b) in overlap. In these columns the crank handle zone numbers, points under
which are required to be locked in route and in overlap, shall be filled. This shall cover all the crank handle groups of corresponding points filled in route as well as overlap. Point number for isolation shall be bracketed here also for similar reason.

ix) **Locks route:** In this column all routes directly conflicting to the one in question, shall be filled. It is pertinent to note here that the conflicting routes are selected by setting of points. If a point is required normal by one route and reverse for other routes, such routes shall not be filled in conflicting routes column being redundant. While filling this column, all routes other than the one under consideration shall be examined with reference to conditions for taking Off calling on and shunt signals and shall always be taken in consideration. *It is pertinent to note the implications that Calling-on signals and shunt signals do not require overlap to be set.*

After filling in this column for all the routes of the table, converse should be checked and ascertained for correctness.

x) **Released by route:** In this column the route which releases the route in question, shall be filled. Such as starter signal is released by corresponding Advanced starter signal.

xi) **Remarks:** this column is meant for filling any special feature which could not be covered in columns as above shall be filed. The features such as interlocking of the level crossing gate in the route or overlap, release of the route by line clear from the adjoining station, release time for calling on signals and signal required to be On or Off conditions, are to be mentioned.

Few railways fill in aspect control, many conditional remarks, and preset conditions also in the selection table. The selection table should be a simple statement and should cover interlocking part only. More text or conditions become subject of interpretation for the circuit designer. Since the overlap is defined as default in the selection table the setting of alternative overlap is done by taking the starter signal Off first and then the home signal which is some times also added to the selection table as preset condition which is duplication only and may be avoided. A sample selection table is placed amongst last pages of the book [Figure 4.7.2.(B)].

b) **Selection Table designed for ‘Siemens’ series relays:** Unlike for Q series relays the selection table for Siemens’ system is in parts i) Control table for main signals, ii) Control table for Shunt signals and iii) Control table for route sections. The deviation is because of modular feature of preparation of selection circuits based on Signal and point groups. For preparation of control tables for main and shunt signals, table of route sections is required to be prepared first as shall be clear by the columns prepared for all the three control tables.

i) **Columns in control table for route sections:** The Siemens based selection table is prepared in three parts viz. i) Control table for main & Calling-on signals, ii) Control table of shunt signals, and iii) Control table of route & overlap section. For preparation of the selection table, Control table of route & overlap section is required to be prepared first.
a) Control table of route and overlap section has following columns:

i) **Serial number**: This number is given to each route section. It is possible that any of the route sections is used by more than one signal route. As such the serial number decides the number of route sections.

ii) **Route Section/Overlap**: A route section plan is required to be prepared first for filling in this column. In consideration that section route release is an integral part of Siemens design using point relay groups, the route sections are identified at the stage of preparation of ‘Route Section Plan’ itself.

iii) While preparing route sections, first route beyond the signal concerned is prepared as S2 U(R)S, where S2 is the number of signal with the prefix S, other route sections for S2 are prepared with the name of points to be controlled as sub-route section to S2 U(R)S and shall be controlled by S2U(R)S. These sub-route sections may be common to other main or shunt signal routes also, for the same direction. Route sections for direction opposite to the previous one for the same point, are named after the same point with a different name i.e. if one route is A105 the opposite side route for the same point number 105 shall be a105.

iv) Accordingly number of route section which is associated with a point is to be filled in this column.

v) **Eliminated**: subdivided into columns i) Route & ii) Overlap: Routes which conflict the route and the overlap in question, is to be filled in column ‘Route’ and column ‘Overlap’ respectively.

vi) **Point Setting**: subdivided in columns i) Normal & ii) Reverse; setting of each point to normal or reverse for the defined route section is filled in respective normal or reverse columns.

vii) **Picked up TPRs in UDKR**: Track circuits controlling the point zone which are required picked up for operation of point.

viii) **Route release**: Track circuits, sequential operation of which shall release the given route section through energisation of UYRs.

ix) **Signal proved at ‘ON’**: Number of the Signals, which lead to or which are directly opposite to the route section in question, are proved at On before setting and locking the route section.

x) **Locks crank handle normal**: Crank handle group number of all those points which fall in the route section shall be filled in this column.

xi) **Remarks**: Any special feature such as level crossing gate etcetera falling in the route section shall be mentioned in this column.

b) Control table of main & calling-on signals has got following columns:

i) **Serial number**: This number is given to each signal route and finally decides numbers of main routes at the station.

ii) **Signal Route**: In this column designation of the destination route shall be filled. A signal may be leading to more than one route in such a case the signal number shall repeat with all the routes one by one. For example if the signal number 2 leads to route numbers ‘A’, ‘B’ & ‘C’ then SN-1 shall be S2 with route ‘A’, SN-2 shall be
S2 with route ‘B’ and SN-3 shall be S2 with route ‘C’. This shall be followed by next signal number in the same manner.

### iii) Description of Routes:
Route shall be described briefly in this column.

### iv) Push button:
subdivided into columns i) Signal button (GN); signal button number to which the signal pertains & ii) Route button (UN); destination route button name shall be filled in.

### v) Route Sections:
subdivided into columns i) Set; in this column first route section corresponding to the signal, as prepared in the ‘Control table of route and overlap section’ in the format of S2U(R)S, shall be filled in & ii) Eliminated; this column is further subdivided into columns i) In route; in this column routes conflicting to the route in question shall be filled in & ii) In overlap; in this column overlap routes conflicting to the route or overlap in question shall be filled in.

### vi) Points Selection:
subdivided into columns i) In route; in this column points falling in the route shall be filled in, & ii) In overlap; in this column points falling in overlap shall be filled in.

### vii) Track circuits free:
subdivided into columns i) In route; Track circuits which are required to be free in route for reception of the train for the route in question shall be filled & ii) In overlap; similarly track circuits which are required to be free in overlap for reception of the train for the route in question shall be filled in.

### viii) Overlap:
subdivided into columns i) Set; in this column the overlap number, which shall be set by default, for reception of the train shall be filled in & ii) Eliminated; in this column the overlap numbers which get locked due to setting of the overlap in question shall be filled in.

### ix) Gate control:
Number of the Interlocked Gates which fall in the route, required to be closed and locked shall be filled in.

### x) Slot required:
Number of Slot required to take the signal Off for the route shall be filled in this column.

### xi) Signal replaced to danger with track circuit:
Number of the track circuit ahead of the signal concerned which shall be responsible for replacing the signal to On shall be filled in this column.

### xii) Approach locking:
In this column either Dead approach locked shall be mentioned if there are no track circuits up to distance adequate to approach lock, from the signal concerned or the track circuit numbers which approach lock the route in question shall be filled in.

### xiii) Aspect of signal ahead:
This column is subdivided into columns i) Yellow if, ii) double yellow if & iii) green if. Each of these columns shall be filled in with the signal’s aspect ahead of the signal concerned to cause the signal yellow, double yellow or green in respective given columns, based on aspect sequence chart given on the Signal Interlocking Plan for which the selection table is under preparation.

### xiv) ‘A’ marker/Calling-on:
Whether ‘A’ marker and or Calling on signal has been provided on the signal post to be mentioned in this column.

### xv) Route indicator:
Whether route indicator is provided on the signal is to be mentioned in this column.

### xvi) Locks crank handle group:
Numbers of the crank handle groups associated to the points falling in the route of the signal concerned shall be filled in this column.
xvii) **Remarks:** Special features such as in case of Calling on signal, clearance of the signal after 120 seconds and routes directly opposite, which shall be locked by the route in question, shall be filled in this column.

Control table for shunt signals also has same columns as that of control table for main & calling-on signals except sub columns pertaining to overlap which is not required in case of Calling-on signals, but retaining sub column ‘Eliminated’ of column ‘Overlap’; and columns showing aspect control of main signals.

4. **Logic or Selection circuits:** The logic of Essentials of Interlocking is translated into electrical circuits, to achieve interlocking electrically. The Selection table provides the basic data and information for preparation of these logic circuits. Accordingly these circuits are also called as selection circuits.

For the sake of easier understanding, these circuits are selectively standardised into smaller sets of circuits which shall be discussed in ensuing paragraphs.

*Before going into details of the circuits it is important to understand and know about ingredients of circuits, i) symbols used for preparation of these circuits ii) Relays, iii) Bus bar and fuses and v) stick circuits.*

4.1 **Symbols:** The symbols, nomenclatures and rear view configurations of the relays used in circuit diagrams prepared with Q series are shown in figure 4.2.1e placed amongst the pages at the end of the book.

4.2 **Relay:** A relay is an electro magnetic device used for switching circuits. Relay means to pass-on some information. When the device is energised on fulfilment of certain conditions the relay passes on this information in the form of a closed contact. With reference to power for operation, relays are i) Direct current (DC) operated, ii) Alternating current (AC) operated and iii) Electronically controlled relay for special applications. Structurally, relays are i) Shelf type and ii) Plug-in type. Functionally relays are i) Neutral, ii) Polar and iii) Neutral polar. With reference to safety implications relays are i) vital and ii) non-vital.

The characteristics & components of relays are:

i) **Components of a relay:** A relay essentially has an electromagnet, an armature and finger contacts. The armature is the moving part of the relay. Armature is responsible for making and breaking of contacts with its movement when relay is energised or de-energised. In case of shelf type relay the finger contacts insulated with each other are attached with the armature and move up and down with armature to make front or back contacts with terminal fixed on to the top plate of the contact housing glass case. In case of plug-in type relay the armature drives the contact strips to make or break the contacts. The arrangement is different in ‘Q’ series and ‘K’ series relays.

The contacts are front or back, while front contacts are those which are closed when the electromagnet is energised and back contacts are closed when the electromagnet is de-energised. Back and front contacts can not get connected at one and the same time. The contacts are independent when they make either front or back contacts at one time. Non – independent contacts are those in which front and back contacts are made in turn by the same
armature. The term ‘picked up’ and ‘dropped’ has generated from gravity based relays where the movement of armature, when electromagnet is energised, is against gravity called as picked up and otherwise when de-energised, as dropped.

ii) **Characteristics of relays:** Each type of relay has a given pick up and drop away value.

   a) **Pick value** of a relay is that minimum voltage at which the front contact of relay shall just make.

   b) **Drop away value** of the relay is the voltage at which the front contacts of the relay shall get disconnected.

   c) **Percent release & Class of Track & Line relays:** Percentage release is the ratio between the drop away current and pick up current of a DC neutral relay. For a track relay percent release should be higher as compared to the line relay because a track relay works on low voltage and has to be sensitive to voltage variations. Percentage release of a track relay should not be less than 68. In case of Line relay the relay is placed in the group of ‘A’ class when its percent release is 60 or above and in group of ‘B’ class when its percent release is 50 to 60.

A) **Direct current operated neutral line relay:** These are i) Shelf type and ii) plug-in type.

i) **Shelf type relay:** Constituents of a **shelf type relay** are, two electromagnet Cores with coils, Yoke, armature and contact terminals. The armature holds finger contacts, which move with armature getting attracted to the electromagnet’s poles when electromagnet is energised and coming back to its un-attracted position, when the electromagnet is de-energised (Fig 4.2.1). The position of the armature when attracted to the magnet poles is called as ‘picked up’ and when un-attracted, as ‘dropped’. The armature holds two to eight front and back contacts attached to it. The set of terminal contacts fixed on the top plate of glass encased housing for relay armature, which when makes connection with the armature contact, when armature is ‘picked up, are called as ‘front contacts’ and the other set of contacts fixed along with front contacts on the glass encased housing for relay armature, which when make connection with the armature contact, when armature is ‘dropped, are called as ‘back contacts’. It is therefore important for this type of relays to be placed with its base in perfect levelled position. For the reason that these relays, being essentially required to be placed on shelf, are called as **shelf type relays.** All such relay contacts are terminated on the top plate of the relay contact glass housing and the circuit is wired on the terminals provided on the top plate of the relay. This type of relays is being phased out of the system and is in use only in existing installations.

Front terminal is silver impregnated carbon and back terminal is silver while both front and back contacts attached to the armature are silver. The armature is common and is connected to common terminals housed along with front and back contacts on the top plate of the glass housing for the armature. The armature contacts are electrically connected to the armature. Accordingly drawing shows back contact connected through a copper ribbon with the armature.

This type of relay is neutral to the direction of current.
ii) **Plug-in type relay:** Ingredients of a **plug-in type relay** are a) one electromagnet Core and coil, b) armature, c) contact strips d) springs and e) base plate. Contact strips are fixed on a base in such a way that one end makes and breaks contacts and the other end is plugged into the base plate for connection to the wiring. The armature of plug-in type relay is loaded with spring, such as that the restoration of the armature back to its normal position is by force not based on gravity. This way the relay can be fixed in any way as limitation of placing the relay levelled is dispensed with. This type of relays have an added advantage of being plugged in to a relay base, which can be wired independent of the relay. This arrangement is helpful in wiring as well as in testing.

iii) **Relay contacts:** The contact between finger contacts of the armature and contact fixed with the body is either i) metal to metal, ii) carbon to metal or iii) carbon to carbon.

a) **Relays with metal to metal contacts:** Since the contact resistance of metal to metal is lowest to the tune of 0.13 ohms it always is preferable to use metal to metal contacts. However, as metal to metal contacts, especially front contacts through which flow of current is usually high (depending upon circuit), chances of welding of contacts are there, which in turn entails the necessity of proving of contacts in other vital circuits. This further requires more number of contacts than required for the bare circuits. Such relay therefore is also called as **proved type relay.** M/s Siemens manufacture and design circuits with this type of relays termed as ‘K’ series relays. Operating voltage for this type of relays is 60VDC or 24 V DC, depending upon the circuit design.

b) **Relays with metal to carbon contacts:** Indian Railways has preferred to use relays using its front contact as metal to carbon and back contact as metal to metal, the resistance of metal to carbon contacts being 0.18 Ohms. The carbon contact is silver impregnated graphite (Figure 4.2.1) for shelf type relay.
The relay is in three parts, the relay unit consisting of electromagnet, armature and contact assembly, mounted on a bakelite plate with its contact strips extended to be plugged in another base plate fixed on the relay rack. A clip is held in the base plate which is connected and soldered with the cable conductor used for wiring the circuit. The relay’s extended contact strip when plugged into relay rack base plate makes contact with the clip to make connection of the relay through the clip soldered with the wires used for logic circuits. The relay unit is held firmly with the hanger wire fastened with the base plate. The base plate is fixed with the steel rack onto square Mild steel bars with four bolts and nuts. This type of relays is called as ‘Q’ series relays [Figure 4.2.1 a]. The operating voltage of these relays is 24 Volts except where otherwise mentioned.

iv) ‘Q’ series relays: The armature is ‘L’ shaped pivoted at the bend to transfer the transverse movement due to its attraction with the electromagnet core and back to normalisation, to up & down movement of the separator bar. The separator bar is of insulating material on which common contact strips rest to make contact with another contact strip when the separator bar is lifted. As the electromagnet is de-energised the armature reverts back to its normal position resulting in the front contact getting disconnected and back contact getting connected by moving contact strip.

v) ‘K’ Series relays: In case of ‘K’ series relay the pins attached with the armature move up and down along with energisation and de-energisation of the electromagnet to connect two contact strips through the pin. Interlocked relay is shown in the figure 4.2.1 (b). As and when the armature of upper relay is energised the armature lifts the pin assembly making front contacts and breaking back contacts of upper relay simultaneously making back contacts and breaking front contacts of the lower Relay.

The upper relay gets latched by the lower relay when energised. When lower relay is energised it releases the armature of the upper relay which when released holds the armature of the lower relay in energised position even though the power is cut off for coils of both the relays. Some special features associated with ‘K’ series relays are i) major portion of the wiring in this system is use of point, main signal, shunt signal, route group and auxiliary route groups in which all relays related to points control and its functioning such as point normal and reverse control relay, heavy duty contactor relay, point lock relay, time element relay etcetera are housed in one group (box) which in turn is plugged on to a base. In of case with signal groups in which signal aspect control relay, lamp proving relays etcetera are wired within signal group.
Since major portion wiring for control and operation of point and signals is within the groups the balance part of wiring is simplified and little wiring is required to be done outside. ii) However some relays are also required to be used independently in this case twin relays are housed on one base. iii) As a measure of power conservation certain **interlocked relays** are used which are housed on the same base, as one of the relays gets energised the other relay on the same base gets locked in its last operated position till the relay which was latched is energised. These latch relays are mainly used for storing last position of button operation.

vi) **Characteristics of ‘Q’ series line relay:** Line relays are used for different purposes designed to suit the requirements. A ‘Q’ series line relay for general use is QN1 while its AC immunised version is named as QNA1, here ‘A’ stands for AC immunised relay. These relays are operated at 24 Volts. Various types of relays and their characteristics are tabulated identified by their code names in [table 4.2.1](#).

The contact layouts of ‘Q’ series relay as seen from the back of the base plate are placed amongst last pages of the book, at figure 4.2.1(e).
<table>
<thead>
<tr>
<th>Relay usage</th>
<th>Relay name</th>
<th>Maximum operating volts/current</th>
<th>Minimum releasing volts/current</th>
<th>Coil resistance in Ohms</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy duty Point contactor relay for power to point motor.</td>
<td>QBCA1</td>
<td>19.2V 3.6V</td>
<td>208</td>
<td></td>
<td>ACI 1000V</td>
</tr>
<tr>
<td>Slow to release line relay</td>
<td>QSRA1</td>
<td>19.2V 3.6V</td>
<td>230</td>
<td></td>
<td>ACI</td>
</tr>
<tr>
<td>Lamp proving relay rated at 0.4 Amp AC</td>
<td>QECX1</td>
<td>180ma 110ma</td>
<td>35</td>
<td>Lamp-SL 35/34</td>
<td></td>
</tr>
<tr>
<td>Lamp proving relay rated for 1 Amp AC</td>
<td>QECX3</td>
<td>970ma 720ma</td>
<td>4.5</td>
<td></td>
<td>PLJI</td>
</tr>
<tr>
<td>Lamp proving relay rated for 0.4 Amps AC</td>
<td>QECX13</td>
<td>225ma 120ma</td>
<td>4.7</td>
<td>Lamp-SL17 &amp; 21 ON</td>
<td></td>
</tr>
<tr>
<td>Lamp proving relay rated for 0.65 Amps AC</td>
<td>QECX14</td>
<td>220ma 70ma</td>
<td>4.7</td>
<td>Lamp-SL17 &amp; 21 Off</td>
<td></td>
</tr>
<tr>
<td>Miniature line relay for long distances</td>
<td>QS2 &amp; QS3</td>
<td>19.2V 3.6V</td>
<td>1000</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Miniature line relay sensitive to polarity of coil current</td>
<td>QBA1</td>
<td>19.2V 3.6V</td>
<td>208</td>
<td></td>
<td>ACI</td>
</tr>
<tr>
<td>Slow to operate repeater relay to track relay</td>
<td>QSPA1</td>
<td>19.2V 3.6V</td>
<td>194</td>
<td></td>
<td>ACI</td>
</tr>
<tr>
<td>Magnetically latch line relay</td>
<td>QL1</td>
<td>19.2V 9.6V</td>
<td>150/680*</td>
<td>*PU/Release winding</td>
<td></td>
</tr>
<tr>
<td>Miniature track relay working voltage 24V</td>
<td>QT1 &amp; QT2</td>
<td>74ma -</td>
<td>250</td>
<td>Min % release 45ma</td>
<td></td>
</tr>
<tr>
<td>Track relay working voltage 1.4V</td>
<td>QT1 &amp; QT2</td>
<td>148ma 120ma</td>
<td>9</td>
<td>ACI; Min % release 68</td>
<td></td>
</tr>
<tr>
<td>Heavy duty contactor relay to interface with SSI Operated by 110 V AC</td>
<td>QNHXC1</td>
<td>90V 30V</td>
<td>10000</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Lamp proving relay for LED signals rated at 0.3 Amps AC</td>
<td>QECX61</td>
<td>108ma 72ma</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamp proving relay for LED signals rated at 0.2 Amps DC</td>
<td>QECR2</td>
<td>80ma 55ma</td>
<td>45.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamp proving relay for LED signals rated at 0.22 Amps AC</td>
<td>QECX20</td>
<td>45ma 20ma</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junction type route lamp proving relay 110V AC/ 25W rated at 1.4 Amps</td>
<td>QUCX1</td>
<td>700ma 520ma</td>
<td>0.80</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Miniature Lamp proving relay rated at 0.4 Amps AC</td>
<td>QECX51</td>
<td>180ma 110ma</td>
<td>12.4</td>
<td>Lamp- SL17 &amp; 21 On</td>
<td></td>
</tr>
<tr>
<td>Miniature Lamp proving relay rated at 0.4 Amps AC</td>
<td>QECX52</td>
<td>75ma 30ma</td>
<td>53</td>
<td>Lamp- SL 17 &amp; 21 Off</td>
<td></td>
</tr>
<tr>
<td>Miniature Lamp proving relay rated at 0.8 Amps AC</td>
<td>QECX53</td>
<td>400ma 250ma</td>
<td>2</td>
<td>Lamp- SL 17 &amp; 21 Shunt</td>
<td></td>
</tr>
<tr>
<td>Miniature Lamp proving relay rated at 1.4 Amps AC</td>
<td>QFPR1</td>
<td>1400ma 400ma</td>
<td>-</td>
<td>Lamp- SL 35</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.2.1 d

Table of different ‘Q’ series relays showing their basic use and major characteristics

<table>
<thead>
<tr>
<th>Line relay</th>
<th>QSA3</th>
<th>19.2V</th>
<th>3.6V</th>
<th>1000</th>
<th>ACI 1000V</th>
</tr>
</thead>
<tbody>
<tr>
<td>110V AC driven Line relay for use with SSI</td>
<td>QNHX1</td>
<td>90V</td>
<td>30V</td>
<td>10000</td>
<td>- -</td>
</tr>
<tr>
<td>Miniature twin line relay on one base placed side by side each used independently</td>
<td>QNN1</td>
<td>19.2V</td>
<td>3.6V</td>
<td>304</td>
<td>- -</td>
</tr>
<tr>
<td>Twin line relay on one base placed side by side each used independently</td>
<td>QNN1</td>
<td>19.2V</td>
<td>3.6V</td>
<td>304</td>
<td>- -</td>
</tr>
<tr>
<td>Miniature twin line relay on one base placed side by side each used independently</td>
<td>QBBA1&amp;2</td>
<td>19.2V</td>
<td>3.6V</td>
<td>240</td>
<td>ACI</td>
</tr>
<tr>
<td>Miniature line relay used as repeater relay</td>
<td>QN1</td>
<td>19.2V</td>
<td>3.6V</td>
<td>350</td>
<td>- -</td>
</tr>
<tr>
<td>Miniature line relay used as repeater relay</td>
<td>QNA1</td>
<td>19.2V</td>
<td>3.6V</td>
<td>208</td>
<td>ACI 1000V</td>
</tr>
</tbody>
</table>

B) **Polar relay:** Polar relay is sensitive to direction of current. The armature has three positions viz. Neutral i.e. when there is no current flowing across coil, centre and not connected to any contact, turned to one side and making the contact when current is flowing to one direction, and turned to opposite side and making opposite contact when current is flowing in direction opposite to the original. Because of this it is also called as three position relay. This relay is generally used for block instruments. However since this relay is sensitive to direction of current, it cannot be made immunised to Alternating Current. Keeping in view this major impediment, only pure DC source, for operation of this relay can be used, besides when used in AC traction area adequate filters are required to be used with the line circuit to ensure that no AC ripple is available on line. A permanent magnet is placed in between pole faces of an electromagnet.

![Schematic arrangement of polar relay](Figure 4.1.2B(ii)a)

![Functional arrangement of polar relay](Figure 4.1.2B(ii)b)

The flux created in the electromagnet interacts with the flux of permanent magnet in such a way that the permanent magnet which is attached to the armature of the relay flexes to ether side depending upon direction of the current in the coil of the electromagnet. The permanent magnet remains in the centre when no current flows through the coil. The schematic
C) **Alternating Current (AC) relay:** AC relays are used as line relays as well as track relays. In area provided with Direct Current (DC) traction, the track circuits operated with Direct current can not function as such Track Circuits with Alternating Current (AC) are required to be provided. These are single element and double element relays.

i) **Single element AC relay:** This relay is single element, Volt Meter type and Watt Meter type. In both types of relays one vane is used while the difference between the two is in magnetic field system. In Voltmeter type of relay there is a laminated iron core with an air gap, forming two poles in between of which the vane is made to move on an axle. A link is attached to the vane to actuate the contact carrier. In Watt Meter type of relay two windings are used on two different laminated cores and the vane moves in between two cores [Fig 4.1.2 C(i)]. In both the cases the single element uses only one source of power supply the effective phase displacement between two fluxes is not ideal and the relay produces lesser torque as compared to double element relays. Due to this relay is used as line relay only.

ii) **Double element AC relay:** To the double element relay, also known as Induction Motor type relay, power is supplied from two separate sources. Two windings ‘A’ and ‘B’ are provided control and local windings [Figure 4.1.2C(ii)a]. The vane provided is slotted radial [Figure 4.1.2C(ii)b].

The flux created by the local and control windings gives rise to net torque which moves the vane. The torque produced is proportional to the product of currents in the two coils. A two element relay has the facility of a three position relay contacts, i.e. normal de-energised and reverse. This relay can be used for longer lengths of track circuits.

The percentage release of this type of relay is 70% when used as track relay, the control winding is resonated by providing condenser across the control winding thereby increasing impedance to i) reduce the current taken by the relay while at the same time improving train shunt resistance, ii) reduction of losses across ballast as it shall be possible to reduce operating voltage and iii) There shall not be phase swings, the coil being resonated.
D) **Neutral Polar relay:** Shelf type relay having two armatures one being attracted to the electromagnet similar to a neutral shelf type relay and another armature turning around its vertical axis and making contact according to the direction of flow of the current, is combination of neutral and polar relays. This has three cores two being electromagnets and third core which in the centre of the relay is made of permanent magnet and the polar armature moves around its axis. The polar armature makes contact first than the neutral armature makes the contact. These relays are being used for point detection. However this type of relay has since been phased out.

E) **Relays for specific application:**

i) **Slow acting relays:** For certain applications the DC relay is required to be slow acting. This means the time taken to pick up or drop by such relay shall be either more or less than normal, before this relay breaks front contact or back contact. A relay may be either i) slow to pick up or ii) slow to drop or both i.e. iii) slow to pick up and slow to drop.

a) **Slow to pick up relay:** The relay is required to be used as track relay in area provided with AC traction. In case of falling of OHE contact wire on the railway line high voltage is applied to the track thereby making the track relay pickup though momentarily. This condition may result in unwarranted releasing the route. The pick up time of the track relay is increased to be more than the time taken in tripping of the OHE power supply at source.

To make the relay slow to pick up, a copper sleeve is provided across the cores of the relay and a magnetic shunt is provided immediately below the sleeve. As the coil across core gets energised, eddy currents flow through the sleeve opposing the current across coils thereby delaying the reaction of full flux while at the same time the flux created is shorted by the magnetic shunt. The flux builds up as the magnetic shunt saturates and the armature gets attracted as the required strength of flux is available. Both factors combined together decide the total delay in pick up time for which the relay is designed. The dropping of the armature is
quick as magnetic flux diverts the flux keeping the armature attracted further assisted by sleeve flux [Fig. 4.1.2 E (a)].

**Figure 4.1.2 E(a)**

*Schematic arrangement of slow to pickup relay*

b) **Slow to release relay**: The requirement arises specifically in case of stick circuits. For example take circuit under figure 4.1.2 E (b). It may be observed in the circuit that if 18 ASR is de-energised and the condition to energise it is by pressing buttons for EUYN and 18GN, the power supply current $I_1$ shall extend from B-24 through back contacts of 18HR, 18DR, 18ALR and pick up contacts of EUYNR to energise 18ASR. Buttons may be kept pressed till the 18ASR’s self contact is firmly made or earlier. If the buttons are not kept pressed for enough time, the 18 ASR shall get de-energised along with un-pressing of any of the two buttons. To mitigate this situation 18ASR is made slow to release with the result allowing time enough to make self contact firmly allowing passing power current $I_2$ through its own front contact to keep it energised.

The relay is made slow to release by providing a diode across coil terminals. When the relay is picked up the diode does not conduct due to current $I_1$ flowing in direction opposite to the Diode’s having been provided as such. When the supply to the relay coils is cut off the, a current $I_2$ opposite in direction to the voltage applied to pick up the relay generates due to collapsing flux in the core. Since this current is allowed to flow across the coils it delays dying out of the flux holding the armature energised for about 250 to 500 milliseconds [Figure 4.2.1 E (bb)].
c) **Slow to pick up and slow to release relay:** To make the relay slow to pick up and slow to release, the arrangement is partially similar to the relay designed to be slow to pickup. A copper sleeve is provided across the cores of the relay without the magnet shunt. Eddy currents develop in the sleeves as the relay coils are energised. These currents oppose the very cause due to which these are generated there by delaying build up of the total flux required to attract the armature. When the power supply is cut off, eddy currents again develop in the sleeve but in direction opposite to the original, reducing time of decay of the flux thereby holding the armature for period longer than normal [Fig 4.1.2 E (c)].

![Figure 4.1.2 E (c) Schematic arrangement of slow to pickup and slow to release relay](image)

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d) **Time element relay:** Thermal time element relay and Electronic time element relay are in use. The thermal time element relay works on the principles of bimetallic strips making and breaking contacts when heated and cooled down. The electronic time element relay works using Uni-junction transistor, capacitor, and resistances. The required time can be adjusted by bypassing/ including set of resistances meant for the purpose in the circuit. In each case there is a prescribed time lag which starts with the energisation of JSLR named relay which in turn extends the power supply to the Time Element relay. The time element relay extends power to relay named as NJPR, a relay outside time element relay, after a lapse of 60 or 120 seconds for which the time element relay is tuned. The NJPR relay is used to release the intended circuit. Out of different type of time element relays in use, Electric clock work type time element relay which works on the principle of electric clock has been phased out.
At present by and large electronic time element relay is being used and circuits are designed accordingly. When electronic time element relay is be used, these shall be two in number and their contacts shall be used in series for the concerned time release circuit [SEM part II September 2001 clause 21.10.2].

c) **Function of JSLR & energisation of NJPR**: Common time element relay is used for releasing any of the routes at the station. However generally two time element relays are provided at one station one for up and other for down direction. On bigger station more time element relays may be used depending upon occasions of simultaneous release of routes.

![Diagram](image-url)
All JSLRs are grouped for up and down direction separately and are connected in series in each group to energise 120RJPR through back contacts of all JSLRs in series, when all JSLRs are dropped i.e. no route release is initiated. As and when the conditions are built up to release the route through time element, the corresponding JSLR picks up through front contact of 120RJPR and sticks through its own contact. Here it is pertinent to note that JSLR picks up through front contact of 120RJPR, reasoned in following paragraphs. With the picking up of any one of the JSLRs, 120RJPR drops, and feed is extended to 120JR through front contact of the JSLR and back contact of 120RJPR [Figure 4.1.2 E(e)].

It may be a clock work time relay, a thermal time relay or a solid state/electronic time relay, in any case another relay 120NJPR is energised after the lapse of 60 or 120 seconds as the situation warrants for which the time element relay is tuned. Route is released through front contact of 120NJPR along with the pick up contact of the concerned JSLR. With release of the route, the circuit for the JSLR is disconnected and the JSLR contact drops.

**Significance of 120 seconds:** As the train crosses the signal to which it is approaching shall back lock the route, it is significant that the train shall come to stop before passing the signal when the signal is put back to normal and change of route is attempted before an approaching train. Under conditions when the stop signal is red the Loco pilot shall be able to stop the train under normal conditions. However under worst conditions when he is approaching the signal with Distant signal showing green indication and the signal is thrown back to On, he should get time as much as that he is able to control his train before crossing the signal failing which entire purpose of putting the signal back shall be forfeited. A train travelling at the speed of 100 Kmph shall require more than 3 Kilometres to stop at the signal when faced with an Off aspect Distant signal flying back to caution aspect taking into consideration of reaction time and other factors controlling the breaking distance which shall take 120 seconds to stop. Trains travelling at the speed of 120 to 140 Kmph shall traverse distance 4 Kilometre to 4.66 Kilometres. Eventually the Loco pilot may cross the signal during day time. However this 120 seconds time to release the route and distances prescribed for overlap, has been arbitrarily fixed based on experience.

**f) Giving full 60/120 seconds for release of a route:** It is important that the each route is released after full time allotted for release which is prescribed as 120 seconds. 120 RJPR is used to achieve this (120 prefix to RJPR is to identify the time specified for release of the route). If any other route is required to be released concurrently while one route is in the process of release, the process for release other route shall start only when the JSLR which was in use releasing the route is de-energised after the route has been released thereby energising the 120 RJPR which is required to complete the circuit for any other JSLR to energise, with which the process is initiated for the next route in waiting to release. Number of routes, which can be released concurrently, as such depends upon number of time element relays used at a station. On station where only one time element relay is provided for one direction at the
station, release of only one route can be undertaken at one time in one direction while release of second route shall initiate only after the release of earlier route is completed with the energisation of 120 NJPR [Figure 4.1.2 E(f)].

g) **Flashers:** Flashing indication is a very important requirement for the operator of signalling system. The normal functioning indication is provided on the Control cum Indication panel to ensure that the flasher is working properly. In case of failure of the flasher the indication may get extinguished or may become steady on the panel. The indication of points when points are moving from one position to the other is flashing till they are set to normal or reverse. A fixed normal or reversed indication conveys message that the point is set in the poison displayed on the panel. When the flasher is not working the indication for point on the panel shall be fixed in last operated position even though the point may be midway. Similarly many other functions may give misleading information to the operator creating confusion and attempted wrong operation.

**Mercury based flashers** are simple, reliable and long lasting. Mercury is filled in a ‘U’ shaped glass tube. The column of mercury keeps on oscillating by a heating Tungsten filament placed in a glass tube filled with hydrogen gas. To start with, 110V AC transformer circuit is closed through mercury between contact ‘a’ and ‘b’. The filament gets heated and gas expands to push down mercury level to the extent the contact ‘b’ gets out of contact with mercury, while simultaneously the contact ‘c’ is made due to corresponding rise in mercury level at this end, closing circuit between ‘a’ and ‘c’ extending B 24 V DC to the flasher circuit and the flasher Lamp gets lighted once. A flasher relay is also gets energised to be used with all such indications on the panel which are flashing under different conditions. While at the same time, with the disconnection in transformer circuit the filament cools down thereby gas also cools down and the mercury level comes back to its original level in side tube. The whole process restarts and the indication lamp continues switching on and off. This movement of the mercury column is used to make and break the flashing contact [Figure 4.1.2 E (g)].

**Solid state flashers** manufactured by different vendors are also available which drive a relay to be used for flashing indication.

**Relay based flasher:** Two relays both made slow to pickup are connected with each other in such a way that the power is available to the coils of one relay through the back contact of other relay.
As the relay ‘A’ is energised though back contact of relay ‘B’, the power to relay ‘A’ gets disconnected and both relay continue flip flop the flashing induction is taken through front contact of any one relay [Figure 4.1.2 E (gg)]. This is done as a stop gap arrangement as relays are designed for a specific number of operations and continuous operation the relay is supposed to be short-lived.

4.3 Bus bar, fuses and Micro Circuit Breakers (MCBs):

a) **Bus bar:** Bus is the technical term for connecting more than two circuits at one point. There is requirement of more than one power supply group on any one relay room. In a typical signalling arrangement the power supply may be 24V DC internal, 24V DC external for ‘Q’ series relays, 110V DC for point machines, 110V AC for signal lighting, power supply for Block instrument circuits, Power supply for Axle counters and many more equipments and devices depending upon design of the signalling system on a particular station. As it shall be seen while selection circuits are discussed, there shall be further groups of circuits within each power supply group, for consideration of load on a particular circuit as well as for the reasons of isolation between two circuits in order to avoid blowing of fuse of one circuit may not affect other circuits. This shall require one fuse at positive terminal of the power supply and one negative terminal at the negative terminal of DC power supply, or phase and neutral for AC power supply, for each of the many circuits on the same power supply bank.

![Figure 4.3 Fuses and bus bars](image)

The connection is done on a metal bar, one end of which is connected to the source of power supply [Figure 4.3]. The thickness of the metal bar is decided based upon total current, cumulatively required for all circuits connected on it plus a factor of safety of 2.5.

b) **Fuses and Micro Circuit Breakers (MCBs):** A fuse is required in the circuit to prevent damage to the controlling Relay, contacts of relays provided in the circuit and to the wiring. Passage of current more than current carrying capacity of the relay contacts may result in welding of the contacts thereby creating unsafe situation. This requires a careful selection of the fuse to be provided in a circuit. Micro circuit breakers are also in use with the availability of sensitive MCBs. Indication type and non indication type of fuses are also in use. Indication type
fuses are those in which when the fuse is blown off an indication is displayed on the fuse to enable quick identification and restoration of the circuit. Fuse is fastened to the fuse holder one end of which is connected to the bus bar and other to the lug to which wire is crimped, twisted or soldered.

It is very important that each circuit is provided with a fuse or MCB with its current rating based upon maximum current flow plus 25% of the required current. However it may not be possible to get the fuse and MCBs of the given rating tailor-made for each circuit commercially as such the current rating shall be rounded off to nearest available current rated fuse or the MCB. This shall also facilitate installation and maintenance of the system [Figure 4.3].

4.4 Stick circuits: A stick circuit is an important feature of failsafe design of selection circuits. In any circuit which is designed to lock the route or any other function by picking up relay through fulfilment of certain conditions, an interruption how so ever small it may be shall result in release of the locked function due to dropping of the relay armature. The interruption could be a dry solder, a break in wiring connection due to pettiest reason such as cutting by rats, blowing of fuse etcetera. This is not acceptable being an unsafe condition.

To avoid such a situation, the locking circuits are designed to keep the relay, which is responsible to keep the function such as signal route locked, normally energised with the fulfilment of the requisite conditions. In this situation the function is free when the relay is energised and it is locked when the relay is de-energised, thereby making the system fail-safe.

At the same time it is undesirable to lock the function frequently due to unwanted de-energisation of relays in the circuit of such relays which, although are an integral part for fulfilment the conditions at one stage of freeing the function but subsequently it is no more required. To avoid this, contacts to energise such relay are grouped together and the group is bridged through the own contact of the relay responsible to lock the function. This circuit is called as stick circuit [Figure 4.1.2 E(b)].

Such stick circuits are also designed to achieve one signalled movement for one train. In an area where replacement of signal takes place by occupation of the track circuit ahead of the respective signal, it is not desirable that, once the signal is replaced to its On aspect due to passage of the train over the track circuit, the signal to restore to its Off aspect automatically as and when the track circuit which replaced it to On, is cleared by the train.

To achieve this feature a stick circuit is designed by energising a Track Stick Relay ‘TSR’ [Figure 4.4], which shall be proved energised in the signal circuit.

![TSR circuit for one signal one train arrangement](image)
When all signals behind a train have been put back to normal and there is no train movement, the TSR shall get energised with the fulfilment of main condition that is track circuit is unoccupied i.e. 18TPR energised, along with other conditions that the concerned route is also free i.e. 18ASR is energised, which in turn shall be free only when either complete route or a section of the route has been cleared for use of another train movement thereby 18 ASR is energised after proving further that signal has not been initiated to be taken Off for any other route i.e. 18CLR & 18 DLR de-energised. Once the TSR gets energised it shall be held energised as such through its own contact bypassing 18CLR, 18DLR back contacts and 18ASR front contact to allow the signal to be taken Off with TSR energised. It shall not de-energise due to taking Off another signal i.e. 18CLR or 18 DLR energised with which 18 ASR shall also get de-energised for locking the route for which taking Off of the signal has been initiated.

The TSR shall get de-energised with the occupation of the track circuit by the train and shall continue to be so till it is re-energised on availability of its original conditions only. The TSR, where-after shall be ready for use for the next signalled train movement only.

4.5 **Principles and Designing of Logic/Selection Circuits using ‘Q’ series relays:** In electrical system of signalling the interlocking is achieved through relays wired to establish logic required to establish relation between different operated units broadly between signals, points, crank handles and level crossing gates.

While designing the selection circuits some **basic principles of designing logic circuits** with specific reference to Essentials of Interlocking are to be understood:

i) All circuits shall be designed on fail safe principle. This means that any failure of equipment, any changes due to decay of the insulation of conductors used for wiring or cables, any single inadvertent manipulation in the circuit, or adverse affects of electrification for traction, shall either not affect the status of the signal or put the signal to most restrictive aspect,

ii) It shall always be possible to put back signal to danger whatsoever situation may be,

iii) The signal shall come ‘Off’ only when essentials of interlocking have been complied with such as all signals at the back of previous train received on the same route have been put to ‘On’, all facing points in the route have been set properly and locked, all trailing points in the route have been set, all conflicting signal routes have been locked, and level crossings in the route have been closed against road traffic and locked and once the signal has been taken ‘Off’ route for the signal has been held locked.

iv) Any interruption in power supply system should not create unsafe conditions.

4.6 **Logic circuits & wiring diagrams:** The **logic circuits** are grouped into smaller specific purpose based circuits. These groups are ultimately interwoven to make a single arrangement of interlocking, typical to the yard. For a signal engineer it is important to see the entire yard of the station as one unit. Addition or removal of a route, addition, removal or shifting of a signal or any such change in the scheme of signalling in the station yard may have cascading affect on inter-relationship between the changed signals or routes and existing signals and ultimately on interlocking.
4.6.1 **Circuit diagram:** is the design part of the interlocking which contains principal interlocking of the given yard as such the factors involving wiring are not included in the circuit diagram therefore the circuit can not be wired at site without preparation of a wiring diagram.

4.6.2 **Wiring diagram:** While preparing **wiring diagram** the placement of relays on the relay rack is specified, relay contacts used in the circuit, fuses and negative terminals, wire terminals are defined keeping in view many more factors to be discussed in ensuing paragraph. For these two factors a relay rack chart and contact analysis is prepared.

4.6.3 **Relay rack chart:** Preparation of relay rack chart is crucial for length of wires to be used. The placement of relays on the relay rack is identified first, base on which the relay rack chart is prepared keeping in view the possible number of repeater relays. Important considerations for preparation of relay rack chart are [Figure 4.6.3]:

- Requirement of repeater relays is to be worked out before-hand by counting number of contacts used for each relay on the circuit and contact configuration type of relay being used. Such repeater relay shall be contiguously placed on the rack.
- Adequate space shall be left by the side of each group of relays viz. button relays treated as one group to be on safer side as it is almost impossible to introduce relay in between when contact analysis requires so.
- The groups shall be kept on the rack to ensure minimum length of the wire required to be used viz. signal button relays (GNR), route button relays (UNR), other group relays (WWNR, GBNR, GBRNR, EUYNR, EUUYNR, COGGNR, EWNR, EGRNZR), Interlocking checking relays(LR), Point control relays (NUR/ RUR), Point indication relays(NWKR/RWKR), Point lock relays(WZR), route checking relays (UCR), Approach stick relays(ASR), Track circuit repeater relays(TPR), signal relays(HR), signal lamp checking relays(ECR). Relay contact configuration in each group shall be similar such as if 8F/8B contact configuration is used it should be uniform for all relays in one group.
- Relays in each group shall be in ascending order starting from lowest to highest.
- For convenience of location of fault and other maintenance work, adequate space shall be kept in between relay groups also.
- Two methods of numbering of relay position on relay rack are prevalent, i) relays are numbered from 1 to last relay continuing on rack to rack up to the last rack and ii) numbers on each rack shall start from 1 in first row, 11 in second, 21 in third and so on irrespective of number of relays accommodated in a row.

4.6.4 **Contact analysis:** Contact analysis is done after relay positions have been allocated through relay rack chart. The format for filling contact analysis is placed in the same sequence
and position as marked on relay rack chart. Each relay contact is allocated with a contact number on the wiring diagram sheets where the relay contact has been used. This way all wiring diagram sheets are filled with contact number of each relay in the circuit. Once all the relay contact numbers are filled on the wiring diagram, the contact analysis is done by filling sheet number in the contact analysis format on the contact analysis chart [Figure 4.6.4]. The darkened corner of the table is to represent a back contact for easy identification.

Factors to be taken in consideration while numbering relay contacts of the circuit diagram, i) some contacts are kept earmarked for specific purpose which shall be used only for the given purpose or left vacant such as contact number of each main relay is used/kept vacant for creation of its repeater relay, or D1/2 shall be used for monitoring relay status by data logger, ii) There shall be uniformity in use of relay contact for the sake of easy identification of the fault such as if back contact A3/4 of 18UCR is used in one 18ASR circuit, same numbered contact of 3UCR shall be used in 3ASR circuit, iii) at least one back and one front contact shall be used in a vital circuit in each relay to ensure that there is no welding of contacts even in metal to carbon contacts, iv) relays of one configuration shall be used for one group such as if ASR is used of 12/4 contact configuration, all ASRs shall be of same configuration.

It is important to understand the difference between a circuit diagram and the wiring diagram.

4.7 Selection circuit groups: All circuits related to electrical interlocking operate through Control cum Indication panels are grouped as:

a) Circuits connected with Indication cum operating panel,
b) Interlocking circuits,
c) Subsidiary circuits connected with control of level crossing gates, inter-cabin slotting, and preparation of contact analysis and relay rack chart.

4.7.1 Circuits associated with Control cum Indication panel: Out of different systems of operation, the systems in vogue are, i) first, operation of points to set the route using rotary switches and then using two buttons to take the concerned signal Off and locking the route, ii) Setting of points individually to set the desired route by pressing the point button with point group button and then taking Off signals by pressing signal and route buttons and iii) pressing signal button and route button simultaneously to check the route for being free, set the route if found free, take Off the signal and lock the route, iv) Operating the system though Visual Display Unit (VDU) of computer by using key board and mouse or using panel or by having provision of both and selecting any one by a switch provided o the panel, in case of Solid state Interlocking. In case of solid state interlocking only route setting type of system is adopted.

System i) and ii) as mentioned above are non route setting type and system iii) & iv) are route setting type.
It has been decided by railways that all future installations shall be provided with only route setting type of system on operation.

i) **The route setting type of panel operation:** The present system of operation, inherently constitute route checking, route setting and route locking etcetera as such independent setting of point system of operation shall not be taken up here. However independent operation of points even in route setting type of system is inherent, being an integral part of operational requirement

As already discussed in preceding chapter-II of this book, all commands are given by the Station Master to operate signalling system through panel by pressing buttons provided on the panel face. Before giving any command the Station Master is guided by the indications of the status of track occupancy, points setting normal or reverse, signal aspects, crack handles locked or free, Level crossing gates en-route locked or free, flasher blinking etcetera. Here button circuits are being discussed, this activity being first of the sequence of operation. The indication circuits accordingly shall be discussed in the last.

Before discussing the circuits it is essential to understand the language used in the circuit diagrams. The nomenclature of buttons is symbolised by repeating the radical letter such as for signal the radical letter is ‘G’, for point it is ‘W’, as such the common signal group button shall be GGN and for point group button shall be WWN.

The symbols and their genesis are given amongst last pages of the book while few are given in the table number 4.7.1(i).

<table>
<thead>
<tr>
<th>Signal</th>
<th>G</th>
<th>Signal button</th>
<th>GN</th>
<th>Signal group button</th>
<th>GGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point</td>
<td>W</td>
<td>Point button</td>
<td>WN</td>
<td>Point group button</td>
<td>WWN</td>
</tr>
<tr>
<td>Button</td>
<td>N</td>
<td>Route button</td>
<td>UN</td>
<td>Emergency route release group button</td>
<td>EUUYN</td>
</tr>
<tr>
<td>Route</td>
<td>U</td>
<td>Crank Handle release button</td>
<td>CHYN</td>
<td>Emergency sectional Route release group button</td>
<td>EUYN</td>
</tr>
<tr>
<td>Timer</td>
<td>J</td>
<td>Crank Handle lock button</td>
<td>CHLN</td>
<td>Emergent signal release button</td>
<td>EGRN</td>
</tr>
<tr>
<td>Slot</td>
<td>Y</td>
<td>Calling-on group button</td>
<td>COGGN</td>
<td>Emergent point operation button</td>
<td>EWWN</td>
</tr>
<tr>
<td>Crank handle</td>
<td>CH</td>
<td></td>
<td></td>
<td>Point normal operation button</td>
<td>NWWR</td>
</tr>
<tr>
<td>Station Master</td>
<td>SM</td>
<td></td>
<td></td>
<td>Point reverse operation button</td>
<td>RWWR</td>
</tr>
<tr>
<td>Button pressed</td>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 4.7.1(i)*

Symbols for buttons on Control cum Indication panel
ii) **Circuit for energisation of button relays:**

a) **Station master’s control:** The Station Master is provided with a key to facilitate him leave the panel ensuring that the panel buttons are not fiddled while he is away from the Control cum Indication panel. The key, when inserted & rotated into a lock provided onto the panel, makes a contact which is used to energise SM’s control relay SMCR. [Figure 4.7.1a]. The ‘X’ shown with double lines symbolises a special contact made. Here in the figure it may be seen that the SMCR is energised with the key contact made. It shall also be observed, while circuits are discussed further, that front contact of this relay is used in all vital circuits affecting train movement.

b) **Route & signal buttons:** For taking Off a signal to receive, despatch or shunt, a signal button and a route button shall be pressed simultaneously for 2-3 seconds, which shall energise the respective signal and route button relays [Figure 4.7.1(b) & Figure 4.7.1(c)]. The combination of these two relays energising simultaneously shall translate the intention of the Station Master to receive, despatch or shunt the train by taking the signal Off.

When it is intended to receive a train from home signal number 3 on common loop line which is numbered as line number 4 and is designated as route ‘D’, the button for signal number 3 i.e. 3GN shall be pressed simultaneously with the button for route number ‘D’ i.e. D UN.

It may be seen in the diagram [figure 4.7.1 (b)] that with the pressing of button 3GN, button relay 3GNR picks up. The diagram shows circuit for 18 GNR also. On small station, all such signal relays are grouped into one circuit however on bigger stations where number of signals is large the signal button circuit may be made in more than one group to avoid failure of entire group of signal button relays for a single fault.

A common Signal button normal checking relay GNCR is energised by proving back contacts of all GNRs in the group.
The diagram [Figure 4.7.1 (c)] shows circuit for route button for ‘D’ route. It may be seen that by pressing route button for route ‘D’ relay DUNR is energised. In the same diagram circuit for route ‘C’ is also shown.

All such route button relay circuits are grouped together in one circuit for a small station this circuit may be made in group more than one for larger stations where number of routes is more for reasons similar as in case of signal button relay group. Route button normal checking relay UNCR is energised proving back contacts of all such UNRs in the group.

c) **Energisation of GGNR**: A relay GGNR is energised when any of the signal buttons is pressed. The relay is used in energisation of calling on circuit to be observed in ensuing paragraphs. [Figure 4.7.1 (c)(ii)].

d) **Common group button to throw back signal to ‘On’**: In electrical signalling system the signal is replaced back to ‘On’ with the occupation of the track circuit provided just ahead of the signal, automatically. However in certain situations when a planned movement is required to be cancelled or under any other situation, signal is required to be put back to ‘On’.

A common signal group button is provided, which when pressed together with the concerned signal button results in throwing back of the concerned signal. While the signal group button is discussed here, the detailed circuit for throwing signal back shall be discussed in ensuing paragraphs of this volume. The Relay EGRNZR remains energised through break contact of push button and a 50 Ohms resistance in series. The relay gets de-energised as and when the button EGRN is pressed which bypasses the flow of current through the push button contact thereby de-energising relay coils. The 50 Ohms resistance is inserted to cause voltage drop against the resistance & protect the power supply source from getting short circuited [figure 4.7.1 (d)]. Throwing the signal back to On shall be under extreme exigencies as such fail safe arrangement is made by keeping the relay normally energised to ensure its de-energisation when needed and observance of fail safe principle.
e) **Point buttons:** Some times points are required to be operated independently for testing or un-signalled move. Since it is mandatory that any operation has to be done with the help of two buttons, a common point group button is pressed with the button for the point to be operated. All point button normal checking relay WNCR is energised by proving back contacts of all point button relays. There are two methods of operation of points independently as in-vogue [figure 4.7.1(e)].

i) **Under one method** a common single button when pressed simultaneously with the button for the point desired to be operated, is used to throw point from its present position to the other position. Accordingly if common point button is pressed with the individual point button the point shall move from its present position to other i.e. if it was lying normal it will move to reverse and vice versa. The point shall continue to move further in the same manner with each attempt. When point group button is pressed, the point group relay WWNR is energised proving pick up contact of SM’s control.

ii) **In other method,** two group point buttons ‘Normal’ & ‘Reverse’, are used [figure 4.7.1(e)(ii)]. The point group normal button, when pressed simultaneously with the button of selected point, it shall make the point to be thrown to normal and when group reverse point button pressed simultaneously with the button for the point, it shall result in throwing point to reverse.

Here it must be kept in view that in route setting type of system, points in the route are set by the system itself on pressing of signal and route buttons. Independent and individual operation of point shall be done for testing or un-signalled moves. Of course, in either case, point shall move only when it is free and not locked with any route.

One button is provided by the side of profile of one of the point of each crossover or by the side of the single ended point. All such point button relay circuits are grouped into one circuit on the same pattern as in case of signal and route button relay circuits. The diagram shows energisation of point button relay for point number 55 energising point button relay 55WNR. Similarly circuit for point button relay 59WNR is shown in the circuit diagram.
Point button normal checking relay is energised through back contacts of all point button relays in the group [figure 4.7.1 (e)(iii)].

f) Crank Handle control buttons: point may fail to operate due to any reason out of, power supply failure, cable fault, or failure of point machine itself. Not only entire station yard shall get crippled but entire section may get affected if points can not be made to move. To safeguard against such a situation, arrangement is made to operate the point manually by attaching a crank handle to the shaft of the point machine through which it becomes possible to impart rotary movement mechanically in place of electrical system. However such an arrangement warrants that the crank handle should be an integral part of the interlocking system so that as and when it is required to use the crank handle, it shall not be possible to make a signalled move on all such routes in which the concerned point lies.

Accordingly all points operated by panel through electric point machines are put into groups in such a way that failure of any one point requiring operation by crank handle does not affect route other than the one in which the already crippled point falls.

Different methods are in vogue to release and lock the crank handles, one being, using single button CHN with the prefix of the crank handle group number, for identification of each crank handle group and using one general group button for locking and one for releasing the crank handle. Under this method when the crank handle is to be released the group button GBNR, is pressed simultaneously with the individual crank handle button to be released. Similarly when the crank handle group is to be locked, the button for the concerned crank handle group CHN shall be pressed simultaneously with the locking group button GBRNR. GBRNR and GBLR are also used for locking and releasing of level crossing gates, slots simultaneously with corresponding level crossing gate and slot buttons.

In other method two buttons are used with each crank handle group one for releasing the crank handle and other for locking, to be pressed simultaneously with a common group button CHN. Accordingly 55CHYN button is pressed simultaneously with the common crank handle button GHN, to release the crank handle and CHN is pressed simultaneously with 55CHLN to lock the crank handle.

Under this system, locking and releasing of level crossing gate and slot is done by using specific locking and releasing buttons separately for level crossing gate and releasing and withdrawing slots. Detailed function and circuit is discussed in ensuing paragraphs along with other interlocking circuits.

In case of crank handle group buttons (CHNs), all CHNRs are proved dropped to energise crank handle normal checking relay (CHNCR). Crank handle release (CHYNCR) and lock checking relay (CHNLCR) [Figure 7.4.1f(i)] & Figure 4.7.1f(ii)], energised to check all normal condition can also be clubbed to make only one
CHNCR using CHNCR, CHYNCR and CHLNCR pickup contacts in series into one group for crank handle button circuits.

All such button normal checking relays for signal, route, point, crank handle etcetera are proved normal to energise a bell relay XR [Figure 4.7.1 (j)]. As and when any of the signal buttons is pressed, the energisation of corresponding relay breaks the circuit of GNCR, there by causing GNCR to de-energise. With de-energisation of GNCR, the XR which is slow to release keeps on holding for 10 seconds and de-energises thereafter and makes the bell circuit to give an alarm to the operator that any of these buttons is kept pressed for more than 10 seconds. This is true for any of the normal checking relay viz. UNCR, WNCR, CHYNCR, CHLNCR or Gr(N)NCR as any one of these relays getting de-energised due to prolonged pressing of corresponding button shall cause the XR to de-energise and drop after 10 seconds.

4.7.2 Interlocking circuits: The operating device for electrical interlocking system is Control cum Indication panel by default although hybrid arrangement such as operation of points by point machines and colour light signals by levers from cabins is also in practice. The Selection Table is the basis for preparation of the interlocking circuits. The data available in the Selection Table is used for preparation of these circuits in either case of operation done by either levers or by panel. Interlocking circuits taken for discussion here are based on the Signal & Interlocking plan as figure number 4.7.2(i) and a part selection table placed along with it as figure number 4.7.2(ii) placed amongst last pages of this book.

(A) Interlocking circuit groups: For the convenience of discussion, better understanding and grasp, the interlocking circuits are grouped as:

a) Checking of interlocking, route initiation and route setting commands for operation of points to desired setting for the given route - LR & NUR/RUR,
b) Point Operation, indication and locking– NWKR/RWKR,
c) Route checking – UCR,
d) Route locking–Approach locking, Dead Approach locking and Back locking- ASR,
e) Route release– Normal, route cancellation –EUUNR and emergent route release - EUNR.
f) Signal control – HR, UHR, DR.
g) Signal lighting & lamp checking – ECRs
h) Panel indication.

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I) **Checking of interlocking and route initiation (LR) circuits:** Once the intention of the Station Master is communicated to the system a) by pressing of signal and route buttons simultaneously, b) Simultaneous energisation of signal and the route button initiates ‘LR’ circuit; c) Basic interlocking is checked at this stage and when on checking it is found that the route which is proposed to be set is free for setting. *It is pertinent to recall here that the route consists of mainly points (in present context) besides level crossing gates.* As such, first it is important to ascertain that, all those routes which conflict with the route over which the movement is proposed, have not been initiated and are not set and locked (ASR picked up), all points which fall in the desired route as well as in overlap are free i.e. not locked (WZR picked up), and crank handles of all such points falling in the route are locked (CHNPR picked up); d) Setting of points is initiated to form the desired route including the overlap, e) the route is checked and locked if found all points to be correctly set and locked to form the selected route (UCR), f) the route is locked and g) signals are taken Off, h) simultaneously providing all indications on the Control cum indication panel.

The LR circuit for routes 18 C and 18 D is shown in fig. 4.7.2 (I)(a).

![Figure 4.7.2(I)(a) main signal LR circuits](image-url)

The circuit shall be read in two parts, *first limb which is common to routes 18C & 18D* and second two limbs which are specific to route 18C & 18D. Reading the common limb of the circuit, 18CLR or 18DLR is energised through 18 HSRR pick up contact used to put the signal back to normal when required, 21 ASR pick up contact to prove that routes of shunt signal number 21 leading to routes 18C or 18D are free, CH59 NPR pickup contact to prove that crank handle meant for point number 59 is locked and 59 WNLR pickup contact if the point 59 is already set normal as its last setting which is bypassed by 59WZR pickup contact in case the point is lying reversed but is not locked in any route, 59 RUR back contact to prove that no
command to reverse the point 59 is pending. Similarly CH55NPR pickup contact is provided to prove that the crank handle for point number 55 is locked and is not in use.

*Second two limbs* are specific to the routes 18C & 18D. Limbs are selected by the combination of the signal button relay and route button relay pickup contacts. The requirement of the route ‘C’ is selected by C UNR pick up contact along with 18GNR pick up contact by pressing corresponding signal and route buttons simultaneously. Limb of the circuit for route 18C requires point 55 normal as such the limb is selected by 55 normal proved by 55WNLR pick up contact in case the point is already set in its last operated position, the 55 WNL is bypassed by 55WZR pick up contact if the point is not set normal and not locked in any other route, 55RUR drop contact to prove that the point 55 is not initiated for reverse setting, drop contacts of 21CLR and 24 JLR and 24ASR pick up contacts are proved to ensure that these signals have not been initiated to be taken Off and corresponding route is not locked. 18CLR is energised through pickup contacts of C UNR and 18GNR as already explained, which is kept energised through its own pick up contact after 18GNR & C UNR buttons are released, along with 18/18C UYR1 drop contact through negative limb of the power supply. 18/18C UYR1 pick up contact is bypassed by pick up contact of C18LR, the Calling on LR, and is normally not picked up when signal 18 is being taken Off. The 18CLR or 18DLR remains energised and is proved thus in signal circuit of 18HR. As the train approaching signal crosses the signal post occupying first track beyond the signal, UYR1 gets energised thereby disconnecting power and de-energising 18CLR. To de-energise 18CLR, 18TSR pickup contact may also be used in place of 18UYR1.

Similar is the circuit for 18DLR.

*Accordingly LR circuit is to check the routes conflicting to the route selected using Drop contacts of conflicting route LRs, pick contacts of conflicting route ASRs, points being not locked in any route conflicting to the route in question by proving corresponding WZR energised if the point is not set in position required for the route in question and initiate operation of points which are not set to the position required for the route.*

**Putting back the signal to On:** LR, which is proved picked up in the signal HR circuit, is put back, for putting back the signal to On. HSRR is created to facilitate putting back of the signal when there is more than one route, instead of directly putting back individually the concerned LR. As such either HSRR is used in the limb for de-energising LR or EGRNZR is used to raise the LR for putting back the signal concerned to On. The HSRR is normally kept energised through its own front contact and back contact of the signal button relay 18GNR (GNPR is button repeating relay).

![HSRR circuit](image-url)

*Figure 4.7.2(I)(b) HSRR circuit*
EGRNZR gets de-energised as and when the concerned signal button GN and the Emergency signal release button EGRN are pressed simultaneously [Figure 4.2.7 (I)(b)]. With de-energisation of 18HSRR the corresponding LR relays, which is proved picked up in HR circuit, shall also be de-energised resulting in putting back the concerned signal to On.

**LR circuit for Calling on signal:** When the main signal, on the post of which the calling-on signal is fixed, fails to come Off, calling on signal is taken Off by pressing group calling on signal button COGGN along with main signal button, retaining the signal button pressed the route button for which the main signal did not come Off is pressed energising COOGNR. There is no independent button for calling-on signal.

With this C18LR is energised [Figure 4.7.2(I)(c)] on the lines same as energisation of main signal LR. It is pertinent to note here that 18CLR and 18DLR pickup contacts are taken in parallel to ensure that one of the routes was initiated by attempting signal 18 for taking Off.

**Figure 4.7.2(I)(c) LR circuit for Calling-on signal**

*Energisation of COOGNR:* When the signal fails to come Off on pressing of signal and route buttons simultaneously, taking Off of the Calling on signal is initiated by pressing signal button and common button COGGN. Thereafter while keeping the signal button pressed the route button is pressed simultaneously. It may be noticed that taking calling on signal Off is a three button activity. With the pressing of COGGN button COOGNR is energised and is kept held through its own contact and GGNR pickup contact. GGNR is energised with the pressing of any of the signal buttons on the panel. As the signal button is kept pressed and the route button is pressed leaving button COGGN the C18LR is energised through proving interlocking in the same way as that in case of main signal, C UNR pick up contact, COGGNR pick up contact & 18GNR pickup contact energised simultaneously and pickup contact of EGRNZR and shall be kept held picked up through its own contact, 18/C18 UYR1 back contact and EGRNZR pickup
contact. The COGGNR shall be de-energised as the signal button is released. The Calling-on signal shall be replaced back to On through 18/C18UYR1 common to the main signal and in case of failure of any of the UYRs due to any reason out of most probable reason of track circuit failure, the calling-on signal shall be put back manually through EGRN button pressed simultaneously with signal button 18GNR which is counted on the panel.

II) **Route setting command and circuits for automatic and independent operation of points:** With energisation of the concerned LR, setting of points to the desired position takes place [Figure 4.7.2(II)(a)]. The circuit is for setting one of the points in position required for the initiated route. Similar circuits shall be drawn for each point in the complete yard controlled by the panel. Here in this case first point is 59 which is required to be set normal for both 18 C & 18 D routes. Point controlling relay NUR is energised to throw the point to normal and RUR to throw the point to reverse. The circuit is designed to a) energise NUR or RUR depending upon requirement of the route initiated, b) for individual operation of point as well as for, c) emergent operation of point when the track circuit covering the point zone fails. There are as many circuits drawn for each point as many points are there in the yard.

![Figure 4.7.2(i)](image)

**Energisation of WZR for point number 55**

Before proceeding ahead, it is pertinent to understand the conditions of points being locked. As we proceed ahead it shall be observed that the points in the route, overlap or isolation shall be checked to be free or to be locked as and when required. Point being free is checked by proving point lock relay WZR picked up contact. One WZR dedicated for each point/crossover, is picked up through pick up contacts of all such ASRs in the route, overlap or isolation, of which the concerned point falls. Accordingly WZR when picked up proves the route, to which the given ASR pertains, is free. As such de-energising of WZR proves point locked in any of the routes to which the said point is common. Proving dropped contact of WZR relay is based upon fail safe principle [Figure 4.7.2(i)].

a) **Energisation of NUR & RUR by respective LR:** Under ‘Q’ series relay system of designing the point control circuits, separate heavy duty contactor relay and time element circuits are required to be designed. However it is found convenient to use Siemens make point group for point control with rest of the circuits designed based on ‘Q’ series relay. Accordingly here Siemens point group is taken for point control circuit where all relays associated to the point concerned are compacted in the point group [Figure 4.7.2 (II)(a)].

**Automatic operating control of point through LR:** [Figure 4.7.2(II)(a)] Reading circuit for point number 59, from fuse end, first the point is checked for not being locked in any of the routes through 59WZR pickup contact. After proving that the point is not locked there are two limbs one with all those LR’s which require the point in normal condition connected in parallel to each other. Here point number 59 normal is required for routes 18C and 18D. Other limb contains all those LR’s in parallel which require the same point in reversed condition.

It may be seen that 18CLR is provided in the limb in which all those LR’s are put in parallel to each other which require point number 59 normal, as such through pickup contact of 18CLR,
the circuit to energise 59NUR is completed through 59NUR coil, cross protected by 59WZR back contact, 59RUR back contact, 59N/R neutral polar latch relay of point group and 59XR the time relay of point group back contacts and WZR pick up contact to negative limb of the power. 59WZR is proved near negative limb again as an abundant precaution to ensure that the point does not move when locked in any other route.

Similarly as the shunt signal route 40C and 40D require point 59 reversed, energisation of 40CLR or 40DLR shall initiate circuit through coil of 59RUR connecting negative limb of power through 59NUR back contact, cross protected by 59WZR back contact, 59N/R, 59XR back contacts & and 59 WZR front contact to negative limb of power. With the energisation of
NUR or RUR the normal setting latch relay 59 N/R and 59 XR also get energised diverting the circuit through 59 NUR pick up contact, 59 WNR back contact (as the point is not operated manually in this case) and 59 WZR pick up contact to negative limb of the circuit.

*It is pertinent to understand the portion relevant of point operation before going ahead. The point machine draws heavy initial current to the extent of 3-5 Amps (110 V DC point machines). Therefore a relay with heavy duty contacts with its contacts capable of passing through this amount of current is required to be used. Under domain of ‘Q’ series relays heavy duty relay QBCA1 is used which is immune to 1000 V AC.*

With the energisation of 59 NUR the latch relay coil for normal setting of point 59 (N)/R (point operation circuit) gets energised which in turn energises 59 WNLR through back contact of 59 (R) R. The (N)/R or (R)/R being, latch relays are kept held in last operated position till another operation for reverse setting of point is initiated. With the 59(N)/R energised and held latched the WNLR remains energised till another operation for reverse setting of point is initiated. Relays WNLR and WRLR are ‘Q’ series relays and are not the part of point group and are energised outside along with other ‘Q’ series relays on the relay rack.

For the purpose of **track locking**, operation of point should be done only when the track circuits covering the point zone are not occupied and as such are energised. In the circuit under study for operation of point number 59, the track circuits covering point zone are provided in limb for operation of individual point by WWNR and 59 WNR while the track circuits are provided along with point group circuit to ensure that the point is operated only when the track circuits covering the point zone are energised even though NUR or RUR is energised [Figure 4.7.2(II)(d)]. Some railways prefer inclusion of track circuits covering point zone in NUR/RUR circuits before energisation of NUR or RUR itself. Accordingly the track circuits covering point zone pick up contacts may also be added to the circuit in limb controlling energisation of NUR or RUR when controlled automatically through LRs.

b) **Operating control of individual point**: Operation of individual point is done by pressing the concerned point button 59 WNR along with group point button WWNR. Having proved 59 WZR picked up contact along with picked up contacts of track circuits 59 aT and 59 bT which covers point zone for track locking, track being un-occupied. Now if last operated condition of point 59 was normal the path for energisation of RUR shall be available through 59 WRLR back contact only, back contact of 59 WNLR not being available, as when WNLR is picked up WRLR shall be dropped, which is proved in the WNLR & WRLR limbs. The rest of the circuit is completed similar to energisation of NUR or RUR as through ‘LR’s. The points shall continue to be operated from normal to reverse and reverse to normal as many times as the WWNR is pressed along with 59 WNR [Figure 4.7.2 (II)(a)].

It may be observed that the arrangement for operation of individual point is by pressing point button with common point group button. Independent operation of point is also resorted to by specific selection through normal group or reverse group point button pressed with the individual point button simultaneously. In this case when individual point button is pressed with point normal group point button, the point shall be thrown to normal setting only, similarly when individual point button is pressed with reverse group point button, the point shall be thrown to reverse setting only.
c) **Emergent operating control of point:** [Figure 4.7.2 (II)(a)] Emergent operation of point is required to be done in case of point zone track circuit failure as such the limb 59WWNR with track circuits 59aT & 59bT covering the point zone is bypassed by EWNR while rest of the point operation circuit is akin to independent operation of point. This operation is highly unsafe and is carried out under extreme exigency as bypassing the track circuit bypasses the track locking and point is rendered free for operation irrespective of being occupied by a vehicle. This operation is counted through a counter.

When independent or emergent operation of point is resorted to it is by pressing two buttons simultaneously. The operator is supposed to keep the buttons pressed for 3-5 seconds during which the point may not be able to complete desired setting. As such to keep the NUR or RUR energised till point sets & locks, the limb containing respective LRs, which require the point normal, is bypassed by the point normal indication relay NWKR back contact along with point controlling relay NUR pick up contact. Similarly the limb containing respective LRs which require the point reversed is bypassed by the point reverse indication relay RWKR back contact along with point controlling relay RUR pick up contact. As the buttons are pressed and respective NUR or RUR is energised and alternative limb of the circuit is made through either NUR pickup contact with NWKR back contact or RUR pick up contact with RWKR back contact keeping the NUR or RUR, as the case may be, held picked up through its own contact till the respective NWKR or RWKR is energised.

As soon as NWKR or RWKR is energised the power supply, to NUR or RUR respectively, shall get disconnected thereby de-energising the corresponding NUR or RUR making the circuit ready for next operation.

d) **Operation of points & control of crank handle:** 110 V DC point machines operation through Siemens point group is taken for study [figure 7.4.2(II)(d)].

For the purpose of study of the circuit, throwing of point 59 from reverse to normal is taken up. The circuit is same for normal to reverse setting of point which may be gone through by the reader.

The neutral polar relay 59N/R provided within the Siemens point group has two elements one which picks up the neutral armature and the other which energises the normal latch relay coil through pick up contact of the reverse latch relay contact or energises the reverse latch relay coil through pick up contact of the normal latch relay contact. The latch relay 59(N)R/(R)R has two relays on the same base such that picking up of normal relay 59(N)R, latches the other relay 59(R)R in released position and vice-versa.

As 59 NUR gets energised, the neutral armature along with normal latch relay coil gets energised first, for which the power is extended from fuse, proving pickup contact of 59WZR to prove that the point is not locked in any route, pick up contacts of track relays 59aTPR and 59bTPR covering zone of point number 59 to prove that there is no vehicle over the point, through 59NUR pick up contact and then through first limb ‘A’, through pick up contact of the 59(R)R, the latch relay, which is lying latched due to last operation of the point for reverse. The power supply is extended through back contact of 59WCR and back contact of 59XR, and pick up contacts of 59NUR and 59WZR to the negative limb.
With the energisation of 59(N)R, 59WNLR gets energised through back contact of 59(R)R [figure 7.4.2 (II)(a)].

Secondly as the neutral armature 59N/R is energised, the power is extended through second limb ‘D’ through back contact of 59(R)R and pick up contact of 59N/R, to energise 59XR through 59WNR back contact, 59NUR pickup contact and 59WZR pickup contact to negative.
limb. Once the 59XR is energised it is held through its own contact bypassing pick up contact of 59N/R. An inductance – capacitance circuit is connected across the coil of XR to impart 10 seconds time delay.

The heavy duty relay 59WCR has two coils one which needs higher current to energise the relay and the other which holds the relay energised using lower current. As 59NUR is energised 59 N/R neutral polar relay pickup contact results in energisation of i) 59XR as discussed and ii) through limb ‘E’ pickup contact of 59XR, energising 59WCR through its own back contact extending power supply to the negative limb through 59NUR pick up contact and 59WZR pick up contact. The back contact of 59WCR is bypassed by a 50 ohms 10 watt resistance which results in passage of lower current across 59WCR coil enough to hold the picked up armature energised due to disconnection of 59WCR back contact.

A capacitance –resistance circuit is connected across hold up coil of WCR through back contact of 59N/R which keeps the capacitors charged. As the 59N/R is energised it disconnects the power supply limb for the hold up coil of 59WCR while at the same time the capacitance– resistance circuit is connected across hold up coil of 59WCR starts discharging current through pickup contact of 59N/R and back contacts of 59 NWKR and 59RWKR, to keep the armature of 59WCR picked up for 10 seconds. The 59WCR de-energises on lapse of 10 seconds or energisation of 59 NWKR whichever is earlier.

It is pertinent to note that once the command is given for point operation the point machine shall not stop moving even if the track circuit covering the point zone is de-energised when the point is midway. Read the circuit from fuse the power supply is extended through pick up contact of 59WZR, 59aTPR pick up contact and 59bTPR pickup contact to energised 59(N)R or 59(R)R. The track circuit relays 59aTPR & 59bTPR are by passed by emergent point operation relay EWNR as well as by 59XR pick up contact connected through limbs (F) & (G). Relay XR energises along with energisation of NUR & RUR and continues to be held picked up for 10seconds thereby bypassing both the TPRs. Bypassing of both TPRs by EWNR is required for emergent operation of point, which may take place under the wheel also.

e) Point machine operation & point detection: Energisation of 59WCR extends 110V DC to normal operating field of the point motor to move point from reverse to normal via 59(N)R pick up contact while return path from point motor is through common limb for normal as well as reverse operation of point. The return current is also passed through 59WCR contact for normal as well as reverse setting. For reverse setting of point 110 V DC shall be extended in manner similar to normal setting, through 59WCR pick up contact, 59(R)R and
return current through common limb via 59WCR pickup contact to negative limb. Power supply for operation of a double ended point i.e. a crossover is shown in the figure 4.7.2(II)(e).

Under route setting type of panel operating system there is possibility of movement of two or more of point machines simultaneously. In case of a crossover, at least two point machines shall be moving simultaneously. This shall require additional conductors of the cable to suit current requirement failing which there may be voltage drop at the point machine depending upon distance between power supply source and the point machine, resulting in sluggish or no movement of the machine at all.

While at the same time capacity of the battery bank shall have to be such that it is able to withstand the required load e.g. if four machines operate simultaneously, initial starting current may be 6x4 = 24 amps. For this, a battery bank should not be less than of 300AH capacity to cater for safe discharge rate of 10% of the capacity of the battery with marginal safety factor. To keep this problem within a manageable limits M/s Siemens circuits cater for operation of point machines one by one in tandem. It is desirable to follow this system which shall limit the use of conductors as well as capacity of battery bank, of course at the cost of some negligible loss of time in setting the entire route in bigger yards. Siemens system of operating point also provides detection circuit superimposed on point operation conductors thereby reducing cable requirement considerably.

f) **Point indication:** With operation of point machine the sequence of operation is divided into three steps, i) Unlocking the point switches, ii) throwing the point switches to desired position and iii) locking the point switches in last operated position. A point detection assembly is housed within the point machine which contains a spring loaded trolley, which tilts due to its rollers falling into notches of point detection slides being spring loaded and makes contact after the switch operation and locking slides fall in line, to make the contact proving point’s position set as normal or reverse and locked [Figure 4.7.2(II)(f)]. The power is extended from fuse through point detection contacts of point machine 59a and 59b to energise point normal Indication relay NWKR and similarly for the reverse setting of points. The symbol for point set & locked normal contact is 🔄 and for reverse contact is 🔄.

Reverse contact of point 59 is proved in 59NWKR circuit and vice versa as a cross protection measure to ensure that both the detection relays are not energised at the same time under fault conditions.

g) **Crank handle control:** An electrical failure or a failure in the point machine may cripple the entire yard if it is not possible to operate the point machine. To mitigate this
situation a lever is provided to crank rotate the point motor spindle mechanically. This device is popularly known as Crank Handle.

Points are interlocked with the signals and as such moving any point when the route is already set or a movement is contemplated over the point, operation of the point locally using a crank handle, without safeguarding the system could be hazardous. For this reason two measures are taken, i) The crank handle is locked with the locking arrangement in such a way that release of the crank handle shall not be possible if any movement over the given point is contemplated and after the crank handle is released, it shall not be possible to set the route in which the point in question falls, ii) arrangement is made to ensure that, the crank handles which are marketed suitable to be fitted to any of the point machines, each is made to match the specific point machine only or if it is a crossover, to both point machines of the crossover. In bigger yards more than one point machine is put into a group with a common crank handle for all the point machines in the given group. The groups are formed in such a way that failure of any one point machine requiring crank handle operation shall not affect other route. In this situation it shall be possible to put one crank handle in one group for all the point machines. Crank handles which are not interlocked are not made available to any one at the station.
Out of two systems of control, under one of the systems there is one common group button GBNR and two buttons CHYN & CHLN for each crank handle group, to release and to lock the crank handle, respectively. The common group button is pressed simultaneously along with individual Crank handle button CHYN or CHLN to release or to lock the crank handle respectively. Under other system the method used is to provide common lock GBLN and release GBYN group buttons to be pressed with individual crank handle group button 59CHN.

**Location of crank handles:** The crank handles for each group of points are provided in Station Master’s office in case of road side stations and the porter is to carry the crank handle so released to the concerned point. However in case of bigger yards where carrying the crank handle shall consume more time keeping the concerned routes locked it is kept in a location box at site near the concerned point along with a telephone connection with the Station Master.

There are two methods in vogue to lock the crank handle: **one in vogue** is through a relay which is designed to keep a key locked with itself in normal condition and to release it on getting energised. This relay designed by Siemens is known as KLCR. When released, the key is extracted out of the relay assembly and is used to open the related point machine flap to allow access to a universal crank handle. The key wards are so chosen that it is not possible to open the flap of a machine other than with which the key ward matches. The KLCR relay is energised instead of lever lock as shown in figure 4.7.2(II)(g).

**In other method** the crank handle shaft is provided with feathers to match the counter slots corresponding to feather’s orientation, provided on a metal plate fixed at the opening of the point machine to allow the only crank handle with matching feathers to be inserted for operation of the point motor spindle after opening of the flap by another key.

The crank handle is chained or welded with the key of ‘E’ type lock attached to the plunger of 2½” stroke lever-lock. When the coil of the lever lock is energised on getting release command, it becomes possible to rotate the key into the ‘E’ type lock and extract it, with this the crank handle also gets released to be used to operate the point motor [Figure 4.7.2(II)(g)].

Crank handle control circuit used here is single group button GBNR with separate buttons for releasing (CHYN) and locking crank handles (CHLN). It may be seen through the circuit [Figure 4.7.2(II)(g)] that with the pickup contacts of 59CHYNR and GBNR, relay CH: 59YR is energised after proving back contacts of all LRs in the route of which the point 59 falls, to prove that no route has been initiated in which the point 59 falls. With the energisation of CH: 59YR, 59NPR gets de-energised and feed is extended to indication lamp through pickup contact of 59YR and drop contact of 59NPR. On getting the indication the person at the crank handle location shall press the button CH: 59ZN, which shall extend feed to the coil of lever-lock magnet to enable the person to rotate the key of ‘E’ type lock and extract it along with the crank handle. With the rotation of the key the plunger of the ‘E’ type lock shall move to rotate a circuit controller assembly also which shall disconnect the circuit for relay CH59: NPR, due to which it shall not be possible to energise 59NPR even if 59YR is de-energised. After completing the operation of the point motor the key shall be inserted back to the ‘E’ type lock, rotated to be locked which in turn shall re-connect the circuit for 59NPR through normal band
of Circuit controller of the lever lock energised through 59YR back contact. Pickup contact of the 59NPR is used in signal circuit to prove that crank handle is locked with the system.

h) **Operation of points by levers:** When operation of signalling system is done by levers using colour light signal, Circuit controllers are attached with the tail piece of the levers to function as switching device. In such cases operation of points by rod run is retained while signals are switched over to colour light. In such a situation the levers are also interlocked with each other mechanically through a locking trough attached to the lever frame, be it single wire or double wire type. In this case electrical interlocking circuits get minimised to great extent as much of the interlocking is shared by the mechanical interlocking provided with the levers. Some times when the operation of points is also resorted to by electric point machines, there remains little scope to retain levers for operation of electrical system of interlocking. However in such a case levers of point machines are provided with lever-locks to ensure Check locking and indication locking of points. The route holding, in case of mechanically operated points and locks is usually achieved by way of providing Holding bars and Lock bars but when it is not possible to insert lock bar or holding bar, the area is provided with track circuits and route is track locked by providing lever lock on the levers of lock bars or holding bars as the situation may warrant.

i) **Lever lock:** Lever lock is an electromechanical device connected to the down rod of the lever which is to control the movement of lock or electrically operated point on which it is provided through a down rod. It has, a) ‘Plunger’ attached to the lock or point lever, b) The plunger moves a set of circuit controllers through worm-wheel arrangement, and c) an electromagnet to unlock the plunger.

Under normal conditions the locking lever is inside the notch of the plunger keeping the plunger held in the last operated condition which in turn does not allow the lever to which the plunger is attached, to move from its last operated position. The lock lever is held inside the notch of the plunger due to a counter weight attached to the lever lock. As and when the conditions to release the plunger to move are fulfilled, the power is extended to the electromagnet thereby lever lock comes out of the notch of the plunger and releases the plunger to move.

ii) **Check locking and indication locking:** [Figure 4.7.2(II)(h)] When the point is operated by a lever it should not be possible to move the lever from its last operated position if the point is locked due to being engaged in some other movement or due to the point zone track circuits being occupied by a vehicle or due to the failure of the track circuit. In case the point is engaged in any other route which is set and locked, the point lever shall not be able to be moved because of being mechanically interlocked itself. However in case the point lever is otherwise free but its point zone track circuit is occupied by a vehicle or has failed, the ‘Lever-lock’ shall lock the slide in position ‘B’ **this is known as check locking.** If this locking is due to track occupancy, it is track locking as well. Normal position of the lever is recognised as position ‘N’ and complete reversed position as ‘R’. If the point zone track circuit is also free, it shall be possible to move the lever beyond position ‘B’ whereupon the circuit for throwing point to reverse shall be completed and the point shall start moving from its present normal position to reverse. While the point is moving from normal to reverse, it shall not be possible to set the lever to complete
reversed position ‘R’ and shall be held locked at position ‘D’ by the lever-lock till the point is set and locked and its reverse set & locked indication is available to the operator. This position of lever is called as **Indication locking**. The point lever can now be put to complete reverse position ‘R’. Operation of signals is similarly by pulling signal levers. The circuit controllers are connected to levers which actuate the desired signal circuits, proving correct setting of points and locking of interlocked level crossing gates.

**III) Route checking circuit:** Once all the points in the route are set and locked including the overlap, the system checks for correctness of the route and corresponding overlap set with reference to the given command. The relay which energises having checked correctness of the route is UCR which is common to all the routes to which the signal leads. Another important role of UCR is to lock the route by its energisation. If the route is found to be set correct the UCR is energised and Approach Stick Relay (ASR) gets de-energised as the back contact of UCR is proved in ASR circuit.

[Figure 4.7.2 (III)] To energise 18UCR power is extended from fuse through back contact of 18/18C JSLR to prove that the route cancellation has not been initiated, back contact of 18/18C UYR to prove that emergency section route release has not been initiated, back contacts of UYR1 to prove that after movement of previous train the UYRs had de-energised, 59NWKR and 42 NWKR picked up contacts as the point number 59 in route and 42 in overlap are required normal in either case of signal having been initiated for route ‘C’ or route ‘D’. Thereafter the limb is divided in two parts one for route 18C for which point number 55 in route and point number 46 in overlap are required set and locked in normal position, pickup contacts of 46NWKR, 18CLR & 55WKR are taken to energise 18UCR. The other limb for route 18DLR point 55 in route and 46 in overlap are required reversed, as such pickup contacts of 46RWKR, 18DLR & 55RWKR are taken in other limb to complete the circuit through negative limb.

18CLR and 18DLR are taken in parallel in the negative limb of the circuit as an abundant precaution to ensure that the UCR does not energise for any reason other than positive action.

*It is pertinent to note that the UCR is held picked up through i) 18CLR or 18DLR according to route initiated and ii) UYR1 pick up contact. The significance of 18 LR or 18DLR in the circuit is that the 18UCR shall get de-energised when the concerned LR is de-energised due to putting back of the signal. The significance of 18/18C UYR1 is to de-energise the 18 UCR when the train crosses the first track thereby energising the UYR1. Both the situations prepare circuit for energisation of 18ASR.*
**Track locking**: A route consists of track, points and destination with reference to a specific signal. Out of these three, the points are capable of changing path of the train but movement of points under the wheel of a moving train can cause derailment. The points are locked by a signalled route as well as individually. Individual locking of point to prevent movement under the wheels is called *track locking*. In mechanical system of signalling the track locking is achieved through lock bars (for details refer to volume iii of Indian Railway Signal Engineering by the same author). However under electrical system of interlocking the track locking is achieved by the track vacancy monitoring device which could be a DC track circuit, axle counter or of any other form covering the point zone. The track locking circuit is given in figure 4.7.2(II)(d). In this circuit the energisation of NUR or RUR shall not be effective if any one or both of the track circuits 59aTR and 59bTR are de-energised.

IV) **Route Locking**: A route is the portion of track between two signals in the direction of scheduled movement of the train. For example the route for Home signal commences immediately after the foot of the Home signal post and ends at the foot of first stop signal post, falling in its path in the direction of the movement of the train. It could be an Intermediate Home or if there is no such signal in between, it shall be first starter signal. Any level crossing gate falling in between these two signals shall be said to be ‘in the route of the Home signal’. The domain of each such signal shall be up to the next stop signal as well as an adequate distance beyond the next stop signal, called as ‘Overlap’, which in the present example, for Home signal shall be beyond starter signal up to which the Home signal is leading. The overlap shall be reckoned up to 120 meters in case of Multiple Aspect Signalling system and shall be treated in the same manner as the route of which this overlap is, fulfilling all conditions as in case of main route. This is true for the set of any two signals except shunt signals where Overlap is not required.

A shunt signal shall lead only up to first signal encountered by it in the direction of movement of the train which could be a shunt signal or a running stop signal. A loco performing shunting movement shall, under no circumstances cross through a stop signal unless specifically authorised by the Station Master, in writing.

In terms of Indian Government Railway General rule, 2006, Clause 3.36 (2) which provides that ‘A signal once taken Off for the passage of a train shall not be placed to On until the whole of the train which it controls has passed it, except (a) in case of emergency or (b) where arrangement is provided to restore the signal to On automatically. The control operating the signal shall not be restored to its normal position till whole of the train has passed it.

Accordingly it shall be ensured that once the signal has been taken ‘Off’ it shall not be possible to disturb the route including the Overlap, once the Loco pilot has accepted the signal, even after putting back the signal to On. This feature is known as **Route Holding**.

Accordingly in compliance to achieve route holding, ‘Essentials of Interlocking’ provides that it is essential that all facing points in the route are set and locked before the signal is taken ‘off’.

If we take example of Home signal again, this implies that all points between Home signal and the Starter signal, if that happens to be the only signal after Home signal, shall be set and
locked. In case even if Overlap is not mentioned, all points beyond Starter signal falling in the zone of Overlap shall also be locked. This arrangement is known as Route Locking.

There are two situations when the route is required to be kept held. One is when the train is approaching the signal and other when it has passed the signal. Keeping the entire route beyond the signal up to its destination including all level crossing gates falling in the route, locked when the train is approaching the signal is Approach Locking and when the entire route beyond the signal up to its destination including level crossing gates falling in the route, is required to be kept locked after the train has passed the signal is Back Locking (keeping the route locked at the back of the signal). The destination is always up to the next signal in the direction of the movement of the train.

a) **Approach Locking:** The distance between sighting board and the first stop signal shall be minimum 1.4 Kilometres at station as well as level crossing gate. This distance shall be suitably increased to cater for gradients if any [SEM part –I, 1988, clause 7.47]. On Rajdhani route and on the routes where heavy hauls are run, where emergency braking distance is more than 1.6 KM an additional Distant signal is provided [SEM part –I, 1988, clause 7.48]. In such case the first Distant signal from Home signal is renamed as Inner Distant and the second distant signal from Home signal as Distant signal. The Inner Distant signal is provided at a distance of one kilometre from the Home signal and the Distant signal is provided at a distance of two kilometres from the Home signal. It may be noted that the distances of both, Distant & Inner Distant signals are measured from the Home signal only, to ensure that the distance of the Distant signal does not get effected due to change in the distance of Inner Distant signal from Home signal. In this case no sighting board is provided and the braking distance is taken from the Distant signal. This is the distance available to the Loco Pilot to control his train and bring it to stop at first stop signal, if the Home signal is red and accordingly pre-warned by a Distant signal. If the first stop signal is ‘Off’ with green light, and the loco pilot crosses the Sighting Board or the Distant signal with green light at full speed and the signal is put back to ‘On’ after this, controlling the train before the signal shall depend upon reaction time, gradient, mass of the train and application of normal/emergency brakes. It is not possible to visualise the sequence of events but in case the Loco crosses the signal, it must be ensured that the route beyond signal is maintained intact till the train reaches destination of the signal. This maintenance of route intact while the train approaching the signal till the train reaches the signal post is Approach Locking. In British glossary of terms Approach locking is defined as “Electric Locking effective whilst a train is approaching a signal, and adopted to prevent manipulation of levers or devices that would endanger the train” (Selection circuits by K. Ramaswamy Iyengar).

By now it should be amply clear that for achieving approach locking in case of Home signal, the entire length of the track between the Sighting Board/Distant signal and the Home signal concerned shall be required to be provided with contagious track circuits. Similarly in case of all other signals the track circuit shall be provided starting from a place from where braking distance which shall include sighting and reaction distance is available up to the foot of the signal.

In case of shunt signals the track just in rear of the Shunt signal on which the train is standing shall function as the approach track.
For level crossing gates in the territory of Automatic Block Section Signal Engineering Manual part – II, September 2001, paragraph 20.1.3.2 (a) & (b) provides that 1) level crossing gates in automatic section shall be worked by lifting barrier gates operated mechanically or electrically and shall be interlocked with signals. The gates shall be both approach locked and back locked by track circuits. They shall also be provided with audible warning on both sides of the road, actuated by approaching trains. In addition, road warning lights shall be provided on both sides of the gate, which will be lit when there is any train on the approach or whenever the gate is not in the open condition. 2. a) The approach locking on the level crossing gate shall be effective from the moment the train occupies the track circuit, in rear of the signal which assumes clear aspect when the gate signal is taken Off and the back locking shall be effective until the train clears the level crossing. The audible warning shall stop when the gate is closed and locked but the red warning lights for the road users where provided shall be exhibited till gates re-opened for traffic. 2. b) Approach locking should be effective from a distance not less than braking distance required for maximum permissible speed on the section, at a distance of more than 2 Km.

b) Dead Approach locking: In consideration of the fact that in normal course such situations are rare that the route is required to be changed in face of a train approaching Home signal. Owing to financial considerations and feasibility of maintaining track circuits for such a long length between Home signal and the Sighting board, usually the approach track is not track circuited and the Home signal is Dead Approach Locked i.e. once the signal is taken ‘Off’ it is locked irrespective of any train approaching the signal or not. In such a situation the route can be released under compelling circumstances, by putting the signal back to On and processing release of route. However although the signal shall be replaced back to On immediately but it shall take 120 seconds to release the route after cancellation of route is initiated. The 120 seconds time is provided for the train to come to stop before the route is physically disturbed. This is true for any other signal which is dead approach locked. However in case when the approach track circuit is available for the desired distance, or in case of Home signal which is preceded by Automatic Block Signalling section where adequate length of track shall normally be available track-circuited, or in case of starter signal for which approach track circuit of desired distance may usually be available, the approach locking becomes effective the moment train occupies first approach track circuit and continues through all track circuits in between up to the concerned signal. This is true for any signal in the yard.

c) Back locking: As discussed in preceding paragraph, back locking is ‘holding the route after the train passes the signal, till it reaches its destination’. Accordingly it is keeping the route locked at the back of the signal.

In mechanical system of interlocking it is the signal lever which keeps the entire route locked till the train is approaching the signal as once the signal lever is put back to normal after the train has crossed the signal the route ahead of the signal is held by the holding bars and lock bars placed at an interval of not exceeding 180m between each other beginning from signal post. However in case of electrical interlocking holding the route once the signal is taken Off, has been done through track circuits ahead of the signals. The approach locking and the back locking circuits are split by TSR energised or de-energised which is physically at the signal post. Split between approach locking and back locking at the point of signal post is operational requirement too. As, when the train is approaching the signal such as reception from the block section or departure to one of the branch lines on a junction station, change of route in
emergencies is a big facility till the train crosses the signal post. Once the train has crossed the signal post the train shall traverse entire route beyond, till next signal over which there is no control to stop it.

d) **One signal one train, TSR circuit:** It is important to understand the circuit of 18Track Stick Relay i.e. 18TSR [Figure 4.7.2(IV) (d)]. Main controlling relay for the TSR is its own track circuit relay. 18TSR is energised through pickup contact of 18TPR, both route initiating relays 18CLR & 18DLR back contacts and 18 ASR pick up contact to prove all normal conditions. Once 18TSR is energised it is held picked up through its own contact.

The relay is slow to release to give time to make its own contact build enough contact pressure. Energisation of this relay takes place proving complete movement over the route when 18ASR is picked up to ensure that second train movement takes place only when first is completed and all signals are put back to normal at the back of the previous train.

e) **Circuit for approach and dead approach locking:** Approach Stick relay (ASR) is responsible to take care of Approach and Back locking.

There is one ASR for each signal leading to any number of routes. In conformity to the basic ‘fail safe’ principle, the Approach Stick Relay (ASR) is energised when the route controlled by ASR is free and locks the route when de-energised. This in effect means that the ASR shall not get energised under normal circumstances till the train traverses ‘approach locked route’ while approaching the signal and the ‘back locked route’ after passing the signal, till it reaches its destination.

It is points and level crossing gates in the route as well as in the corresponding overlap, which are locked when the signal is taken Off for the route. As already discussed, to keep the point free for operation, point lock relay, WZR for each point is kept energised and proved in point operation circuit. With de-energisation of the WZR, the point cannot be operated [Figure 4.7.2(i)].

The ASR is de-energised with the initiation of route. The circuit design is in three groups i) Route initiation, ii) De-energisation of ASR, thereby locking the route and iii) Re-energisation of ASR there by releasing the route.

De-energisation of ASR could be to lock the route purposefully or due to any failure of fuse blowing off, cutting of wire or any reason whatsoever. Accordingly no circuit is there for route locking, be it approach locking, dead approach locking or back locking.

All locking circuits are designed to release the route which takes place under different circumstances, in compliance to the Essentials of Interlocking and provisions of Chapter–III.
clauses 3.36 of Indian Government Railway General Rule, 2006, relevant portion of which in the present context is given in preceding paragraph (IV) Route Locking.

Indian Government Railway General rule, 2006, Clause 3.40 provides for conditions for taking Off Home signal as, 1) When a train is approaching a Home signal otherwise than a terminal station, the signal shall not be taken Off until the train has first been brought to a stand outside it, unless a) On a double line, the line is clear for an adequate distance beyond the starter signal or, (b) On a single line, the line is clear for an adequate distance beyond the trailing point, or under approved special instructions for an adequate distance beyond the place at which the train is required to come to a stand.

As such to understand the locking circuits forthwith, route release circuits shall be discuss.

V) Route clearance, cancellation or release: Under normal system of working, the route once set and locked gets cleared automatically with the passage of the train reaching up to its destination. This is also true for release of points one by one or in smaller groups as the train traverses the track to reach its destination on the station to facilitated other movements in the station yard, termed as sectional route release. In any condition other than normal, the route has to be cancelled or released manually.

Whenever a route is required to be cancelled or released, which could be when it is required to change the route in face of a train approaching the signal or when the train has traversed the entire route but the route does not get cancelled automatically due to either an equipment failure which could be as simple as blowing off of the fuse or failure of any track circuit in the route. Such release of route which is not cancelled by the passage of train automatically and has to be released manually is termed as Emergent route Release.

The situations for clearing, cancellation or release of routes may be classified as i) clearing of complete route automatically by the passage of the train reaching up to destination, ii) Emergent cancellation or release of route when the train is approaching the signal, iii) Emergent release of route after arrival of the train at destination, iv) Emergent release of route of one or more sections which failed to clear automatically and v) automatic clearance of route section by section at the back of the train conventionally termed as ‘sectional route release’ and

Whenever route is required to be cancelled or released manually, first the concerned signal has to be put back to On by pressing EGRN button and the concerned signal button simultaneously thereby de-energising corresponding LR. (See button relay circuits for de-energisation of EGRNZR and GNRs in figures 4.7.1(b) for signal button and 4.7.1(d) for signal cancellation button).

i) Circuit design for clearing, cancellation or release of route: To understand cancellation or release of a signal route, first sequence of locking of the route is required to be understood.

a) Sequence of locking the route resulting in de-energisation of the ASR: Reverting back to route initiation and UCR circuits it shall be seen that with the pressing of signal and route buttons concerned route LR is energised after checking that no route conflicting to the
concerned route has been initiated or is already set and locked, and if found free, points are set to form the desired route and locked and after finding that all points in the given route are set and locked, concerned UCR for the chosen route is energised. Energisation of UCR causes the main limb keeping the ASR energised through its own contact, to disconnect and de-energise the ASR. With the de-energisation of ASR route gets locked, route strips on the Control cum indication panel gets illuminated, HR for the concerned signal gets energised illuminating the signal lamp. With this the ECR of the signal is also energised disconnecting complete limb which is required for energisation of the ASR.

b) **Clearing of complete route automatically by the passage of the train reaching up to destination**: Conditions under which the route of a signal shall be free resulting in energisation of ASR are i) All signals in the approach section including the signal concerned are On, ii) All track circuits starting from approach section of the route up to the destination, are free being neither occupied by a vehicle nor failed except the destination track which shall continue to be occupied, iii) last train has traversed the entire route having reached the destination track.

With specific reference to first stop signal which is Home signal in case of Multiple aspect signalling territory, one of the important conditions for granting line clear on single or double line sections is “All signals have been put back to On behind the said train” [Indian Government Railway General Rule 2006 clause 8.02(b), 8.03 (1)(b) and 8.03(2)(b)].

i) **Clearing of approach locked route**: For study of approach locking example of Home signal number 18 of SIP placed as figure 4.7.2(A) placed amongst last pages of the book is taken. The approach track circuits for approach locking of this signal may by assumed as A18T, B18T & C18T (not shown in the Signal Interlocking plan). The Distant signal A18 precedes signal number 18 while there are no points in approach route. The distance between Home signal post and the starting point of approach track circuit A18T shall be not less than 1400 meters which is the normal braking distance. Refer to figure 4.7.2(V)(a) for study of the circuit in ensuing paragraphs.

![Figure 4.7.2(V)(a) ASR Circuit](image-url)
Limb-1 & Limb-1B: As the signal number 18 is taken Off, 18ASR is de-energised which continues to be so as the train moves on occupying approach track circuits A18TPR, B18TPR & C18TPR. As the train passes the Home signal number 18 and occupies track circuit 18T, the 18TSR de-energises due to occupation of 18TR. 18UCR as well as 18DLR also de-energises, due to energisation of 18/C18UYR1 [Figure 4.7.2(I)(a) & Figure 4.7.2(III) respectively]. Consequent upon occupation of 18TR by the train and 18UCR and 18TSR de-energising, home signal 18 is also put back to On automatically. Even though if approach track circuits have been cleared by the train, the route ahead of the signal number 18 is still required to be kept back locked, which is achieved by de-energisation of 18TSR. Accordingly approach locking gets effective from the time first approach track is occupied and switches over to back locking through 18TSR back contact.

ii) **Clearing of back locked route:** Circuit for release of Back locked route is an integral part of the Approach locked circuit as the ASR is common to both. [Figure 4.7.2 (V)(a)]. Accordingly as the train traverses the approach route and crosses the signal, the back locking release starts. Limb-1 & limb-1A are common to release of approach locking while limb-2, 2A, 2B & 3 pertain to back locking.

As the train passes the Home signal 18 and occupies first track circuit 18T, the Distant and Home signals are replaced to On. Simultaneously UYR1 gets energised [Figure 4.7.2 (V)(e)] causing 18DLR to de-energise [Figure 4.7.2(I)(a)]. De-energisation of 18 DLR as well as energisation of 18UYR1 shall cause 18UCR to de-energise.

It may further be seen that to energise 18ASR through back lock releasing limb, 18TPR energised is proved along with 18 TSR de-energised. It is so because 18TSR shall be energised only after energisation of 18ASR all other TPRs in the route beyond the signal post except the destination/berthing track, are also proved energised in the circuit. This is to establish the ‘All normal’ principle after the arrival of the train at the destination track. Accordingly the ASR is energised by the passage of train on route 18D, through limb-2.

Limb-2, 2B & 3: The ASR is energised through limb-1 power extending up to 18UCR, as discussed under preceding paragraph, further through back contacts of 18DLR and 18CLR, pickup contacts of 18TR, 55bTR, 59aTR train having occupied and cleared the track circuits, pickup contact of 55aTPR, 55WRLR, back contact of 18TSR, back contact of UUYR to prove that emergent release of route has not been initiated and pickup contacts of UYR1, UYR2, UYR3, YYR4 & UYR5 (Limb3) train having passed the route energising these UYRs in sequence, through 18ASR coil to negative limb. As 18ASR is energised releasing the route, it is held as such through its own contact through limb-1A.

Similar is the release of route 18C through limb2, 2A & 3.

c) **Emergent cancellation of route when the train is approaching the signal:** Situations may arise for emergent cancellation of the route when i) the signal 18 has not been taken Off and a train comes to an stop at the foot of the signal, ii) signal 18 has been taken Off but the train has not occupied the approach track, and iii) Signal has been taken Off and the train has occupied the approach track and when iv) the signal is dead approach locked, there being no approach track circuit.
Emergent cancellation of route is under conditions when i) Cancellation of route set is done without bypassing any track circuit as a normal operational requirement and ii) release of route is done under compelling circumstances bypassing the track circuits under emergent conditions. Release or cancellation of route shall be instantaneous or under time delay for 120 seconds depending upon different conditions to be discussed under ensuing paragraphs. Button EUUYN is used for cancellation of route without bypassing track circuits and EUYN is used to release the route under compelling circumstances bypassing the track circuits also. EUYN button is therefore kept under lock & key of the Station Master and seal of the Signal & Telecommunication organisation representative staff. Each operation of EUUYN & EUYN is counted on the panel.

Cancellation of route: Taking the example of Home signal number 18, first limb of the ASR is energised through back contacts of Distant signal A18 HR to illuminate yellow light of Distant signal, A18HHR to illuminate double yellow light of Distant signal, & A18DR to illuminate green light of Distant signal similarly for main stop signal 18HR to illuminate yellow light of Home signal, 18HHR to illuminate double yellow light of the signal, 18DR to illuminate green light of the signal, 18 HECR yellow lamp lighted proving relay, 18 DECR green lamp lighted proving relay & 18 UHR to illuminate route lights of the home signal along with back contact of UECR route lights lamp proving relay. The last and most important relay is back contact of 18UCR. The UCR is held energised through the pick up contact of concerned LR. Energisation of Route Checking Relay 18UCR disconnects the circuit of 18ASR. Once the ASR is de-energised circuit for holding it picked up through its own contact is cut off and shall be made again only after the ASR is energised after compliance of the desired conditions and kept held through its own contact through limb-1A. Refer to figure 4.7.2(V)(a) for ASR Circuits.

i) **Signal 18 has not been taken Off and a train comes to an stop at the foot of the signal:** The locking is required only when the signal has been taken Off for the train as such once the train has reached the signal post and the signal has not been taken Off, approach locking is no more required. Back locking shall be effective as soon as the signal is taken Off and the route shall be cleared by passage of the train as discussed in preceding paragraph. However if the route is required to be cancelled immediately after taking the signal Off before the train moves, the signal shall be put back to normal and route shall be cancelled by pressing EUUYN button. See the condition for cancellation of route as given under ensuing paragraph (iii) **Signal 18 has been taken Off and the train has occupied the approach track.** However once the train has moved, crossed the signal post and occupied first track circuit 18TR, the cancellation shall be possible when train has reached the destination except by attempting release of the route bypassing the track circuits.

ii) **Signal 18 has been taken Off but the train has not occupied the approach track:** First the signal shall be put back to normal thereby de-energising 18DLR (considering that the route was set for 18D) with this 18UCR shall also be de-energised [Figure 4.7.2(III)]. Till approach track circuits A18TR, B18TR and C18TR have not been occupied by the train, 18ASR shall get energised instantaneously through 18UCR back contact, 18TSR pick up contact, 18ATPR,18BTPR and 18CTPR pick up contacts (limb-1 and limb-1B) and shall be held picked up through its own contact through limb-1A.

iii) **Signal 18 has been taken Off and the train has occupied the approach track:** Assuming that route 18D is set, as the train occupies the approach track and is moving, its position on
track is highly dynamic and it is not possible to visualise the location of the train by the time signal is put back to On. As such as the signal is put back to cancel the route and the 18DLR is de-energised, consequently 18UCR also de-energises along with de-energisation of 18DLR and extending power supply through A18HR, A18HHR, A18DR, 18HECR, 18DECR, 18HR, 18DUHR, 18DR, 18UECR, up to 18TSR pickup contact through limb-1. However since any or all approach track circuits are occupied the power supply shall be routed through 18CLR and 18DLR back contacts through 18TPR pick up contact, 55bTPR and 59aTPR pick up contacts through limb-2 and then 55aTPR and 55WRLR pick up contacts through limb-2B, reaching to 18TSR back contact. Since the train has not traversed the route at the back of signal none of the UYRs shall be energised and the limb-3 shall not be available.

After the signal has been put back to normal, button UUYR shall be pressed along with signal button 18GN to energise 18/C18UUYR [Figure 4.7.2(V)(b)], which is kept held through its own contact bypassing UUYNR pick up contact to keep it energised when the EUYN button is released. It shall be seen through the same circuit that 18/C18UUYR is de-energised with the energisation of 18ASR. Energisation of 18/C18UUYR results in energisation of 18/C18 JS LR through pickup contact of 120RJPR [Figure 4.7.2(V)(c)], which in turn initiates energisation of time element relay. As the time element relay energises 120NJPR, the power supply gets extended through 120 NJPR pick up contact, 18/C18JSRLR pick up contact (120 seconds after energisation of 18/C18JSRLR), C18LR back contact and 18/C18 UUYR pick up contact to energise 18ASR which is kept held picked up through its own contact through limb-1A.

If the train passes the home signal occupying 18TR, it shall not be possible to cancel the route without bypassing track circuits in the back lock area. The route can only be released using EUYN button bypassing the track circuits under such a situation.

![Figure 4.7.2 (V)(b)
Circuit for energisation of UUYR](image)

18/C18UUYR is energised when signal 18 or C18 is On, track circuits beyond signal 18 are not occupied, but 18ASR continues to be de-energised, and EUUYN button is pressed [Figure 4.7.2(V)(b)].
iv) **Signal number 18 is dead approach locked:** Signal is dead approach locked if the approach track of the signal is track circuited covering length less than breaking distance of 1400 meters or there is no track circuit at all. There being approach track circuits of length less than 1400 meters or no track circuit at all, once the signal has been taken off there is no means to detect presence of the train as well as to detect actual position of train with respect to the signal to which it is approaching (the 1400 metres distance is subject to variation in terms of SEM part –I, 1988, clause 7.47 & 7.48, see preceding paragraph IV(a) of this chapter ). As the signal is taken Off the route is back locked. Cancellation of route shall take 120 seconds after initiation to ensure that the route at the back of the signal is not disturbed till the train comes to stop or occupies the first track circuit after passing the signal. Release of route shall take place in the same manner as when the signal has been taken Off and the train has occupied the approach track circuit as discussed in preceding paragraph.

Energisation of UUYR energises JSLR through back contact of 120RJPR to initiate energisation of time element relay [Figure 4.7.2(V)(d)].

In case of Calling-on signal when the route is not released automatically with the arrival of the train at the destination, it shall be released as emergent operation after 120 seconds of putting the C18LR back by pressing EGRN button with the signal button and then pressing 18GN with EUUYN buttons. 18/C18 UUYNR shall be energised through C18HR, C18LR and C18ASR back contacts, 18ASR, 18GNR and EUUYNR pickup contacts, when C18ASR fails to energise by the common UYRs with the passage of train. 18/C18UUYNR is held energised with its own contact and initiated energisation of 18/C18JSR.

**Energisation of JSLR:** Energisation of JSLR through pickup contact of 120 RJPR is significant [Figure 4.7.2(V)(c)] as in order to avoid delays due to inadvertent de-energisation of ASR, route cannot be kept held which shall create a traffic jam like situation. As such each signal shall have a JSLR associated with its ASR to release the route when time delay is required between initiation of route cancellation and actual route cancellation. There are only one or two time element relays in one yard depending upon the size of yard. In normal course such occasions would be rare when route is required to be cancelled with time delay. However when if such a situation arises there could be a situation that another route is required to be cancelled while one is already in process. In this situation, when there is one common time element relay for the yard which has already lapsed 110 seconds for release of one route and another cancellation is initiated the second route shall get cancelled within 10 seconds only, the balance of 120 seconds, along with the first route.

Premature release of the second route shall create unsafe conditions. In order to mitigate this condition, all JSLRs are configured in such a way that relay 120 RJPR is kept energised through back contacts in series of all the JSLRs in the circuit [Figure 4.7.2(V)(d)]. As soon as UUYR is energised it makes circuit for energisation of the concerned JSLR through pick up contact of 120JPR

![Figure 4.7.2(V)(c)](Energisation of JSLR)
As the JSLR gets energised it disconnects the circuit of 120 RJPR which de-energises and breaks the circuit for energisation of the JSLR but the JSLR being made slow to release to give enough time and contact pressure to the JSLR to hold it energised through its own contact by the time 120RJPR de-energises. With this 120RJPR shall not get energised till any of the JSLRs is energised, and the front contact of 120 RJPR shall not be available to the next JSLR till the lapse of 120 seconds for the first JSLR, which shall de-energise due to energisation of the ASR. The second command for release of another ASR shall go waste and shall have to be re-initiated after the first ASR’s cancellation. A flashing indication 120NJKE is provided on the Control cum Indication panel for the purpose of keeping Station Master apprised that 120 second timer is on and that one route is already under release and another route can not attempted only after release of first route.

**Energisation of time element relay 120JR:** With the energisation of 18/C18JSLR the circuit is made for energisation of 120 JR through back contacts of all other JSLRs, pick up contact 18/C18JSLR and back contact of 120RJPR [Figure 4.7.2(V)(d)].

120 JR could be electronic or any other type of time element relay it shall energise its repeater relays, there being many contacts required to be used in the circuits of all JSLRs. Energisation of 120JPR extends power supply for energisation of 120 NJPR though pick up contact of 18/C18JSLR, back contact of 120RJPR and pick up contact of 120JPR.

During emergent cancellation, the ASR is energised through UUYR pick up contact, JSLR pick up contact, all LRs for the signal back contacts and 120 NJPR pickup contact through limb-4 [Figure 4.7.2 (V)(a)], The limb to keep the UUYR energised is broken de-energising JSLR [Figure 4.7.2 (V)(c)] thereby preparing the circuit for release of next route if required.

d) **Emergent cancellation of route when the train has reached destination and the route does not get cancelled automatically:** After the train has passed the signal number 18 and occupied first track 18TR, it should not be possible to cancel the route till the train reaches the destination as there is no signal in between to stop it. Under normal circumstances the route shall get cancelled automatically but for failure of any track circuit in between the signal and the destination or non-energisation of any of the UYRs.
When read through limb-1[Figure 4.7.2 (V)(a)], the concerned signal 18 and its Distant signal lighting relay i.e. A18HR, A18HHR, A18DR, 18HECR, 18DECR, 18HR, 18DUHR, 18DR & 18UECR and 18UCR back contacts as the signal was put-back to On, all LRs back contacts (limb-2), all track circuits beyond the signal pick up contacts (limb-2,2A & 2B) and 120NJPR pick up contact, 18/C18 JSLR pickup contact, Calling on C18LR back contact & 18/C18 UUYR pick up contact (limb-4), bypasses the limb-3 consisting of UYRs contacts & 18TSR back contact, energises 18 ASR which is held picked up through its own contact through limb-1A. This situation would arrive due to failure of energisation of any of the UYRs. The route shall be released after the lapse of 120 seconds.

However in case the route is not released due to failure of track circuit, option of using EUYN button shall be resorted to.

It is pertinent to note that under the system of release of route using EUUYN button, any of the track circuit is not bypassed in the back locking area of the route governed by the signal required to be held. In case the train occupies the track circuit in back lock area the route cannot be released unless after bypassing the track circuit, while when approach track is occupied by the train and the signal also has been taken Off the route shall be released after a lapse of 120 seconds of pressing the EUUYN button till the track circuit beyond the signal is occupied.

c) Emergent release of route of one or more track sections due to failure of track circuits: [Figure 4.7.2(V)(a)]

i) Emergent release of route bypassing all track circuits: In case of failure of one or more track circuits after passage of the train, the route shall not be released automatically either for approach locking track or back locking tracks.

Under this situation the route is released by bypassing the track circuits. Any action shall be taken after ensuring that the train has come to a dead stop and the signal has been put back to normal de-energising 18UCR. With this, back contacts of all relays in limb-1, i.e. A18HR, A18HHR, A18DR, 18HECR, 18DECR, 18HR, 18DUHR, 18DR & 18UECR and 18UCR shall be available extending power up to 18TSR pick up contact. Power shall be further extended through back contacts of 18CLR and 18DLR. Pressing of EUYN button along with concerned signal button 18GN shall energise 18ASR (limb-1C) through negative limb releasing entire route instantaneously without any lapse of time. It may be observed that this process bypasses all the approach locking and back locking track circuits.

It is pertinent to note that bypassing the track circuit has to be done under extreme emergency and with utmost care. In consideration of its complexity the button is kept locked & sealed under a box in the panel and such operation is required to be done only by two persons.

ii) Emergent Release of route section by section bypassing track circuit associated to the specific track section failure to release: As, with the operation of points commanded by the respective LRs [Figure 4.7.2 (II)(a)] by energisation of respective NUR or RUR to throw the point to normal or reverse respectively, operation of individual point is done by pressing group
point button WWN with individual point button (say) 59WN energising WWNR & 59WNR respectively.

Under this arrangement the operation takes place if i) point is not locked in any route i.e. 59WZR is energised, ii) track circuits covering point zone are energised and iii) 59WN is pressed simultaneously with WWN. However when the point becomes inoperative in a route section due to the failure of track circuits covering the point zone, emergent operation of the concerned point may be resorted to by operating EWN and individual point button (say) 59WN simultaneously, energising EWNR and 59WNR. Refer to figure 4.7.2 (II)(a) where the limb for operation of individual point machine by energising WWNR and 59 WNR along with energised contacts of 59aTPR and 59bTPR is bypassed by the limb containing EWNR pickup contact only. Accordingly the NUR or RUR shall get energised bypassing the track circuits covering the point zone when the point is not locked in any route. Refer to circuit for point group, figure 4.7.2(II)(d), where control for operation of point is extended to the group with the energisation of NUR or RUR through picked up contacts of track circuits covering zone of the point. It may further be observed in the same diagram that the track circuits pick contacts have been bypassed by the pick up contact of EWN to avoid involvement of these track circuits during emergent operation of individual point.

This operation is required to be done under guarded conditions after ensuring no train over the track covering point zone as operation through EUYN as such EWN is also kept locked and each operation of this button is counted on the panel.

f) Energisation of UYRS: After the train crosses the home signal and occupies first track circuit the Signal goes back to On (Discussed in signal lighting circuits). With this the track stick relay TSR gets de-energised. The de-energisation of 18TSR becomes selective of the limb of back locking circuit as well as for energisation of UYRs.

UYRs are a set of relays forming a circuit to prove sequential occupation of the track circuits in the route for which the signal was taken Off, till the train occupies the berthing/destination track.

The UYR circuit is designed in such a way that the relays 18/C18 UYR1, 18/C18 UYR2 18/C18 UYR3, 18/C18 UYR4 & 18/C18 UYR5 are energised only when the route is set and locked proved through 18ASR back contact, train has passed the signal and occupied first track beyond, de-energising first track and the TSR. Taking example of signal number 18, UYR1 is energised through back contact of 18ASR or C18ASR, back contact of 18TSR, back contact of first track circuit relay 18TPR and pickup contact of next track circuit relay 59aTPR which has not been occupied by the train while moving on energising UYR1, which is held picked up through its own contact bypassing back contact of 18TSR & 18TPR and pick up contact 59aTPR [Figure 4.7.2(V)(e)].

It is pertinent to note that for UYR circuit, first controlling relay is the back contact of 18ASR or 18C ASR. This means that the UYR circuit shall start working only when the path is created by de-energisation of the ASR of the main signal or its calling-on signal, which means that the UYR circuit for a specific signal route will be initiated only when the route has been set and locked. The second feature is sequential positive proving of track circuits de-energising and re-
energising to ensure that the train is moving on the path and in the direction set for it. While tracing the UYR circuit, after back contact of 18ASR/18CASR it is the back contact of 18TSR & 18TPR and then pick up contact of the next track circuit in the direction of movement of the train is 59 TPR to prove that train has passed the Home signal and has occupied first track circuit but not the next track circuit. This energises 18UYR1. To retain the status, the UYR1 is held picked up through its own contact. The UYRs are slow to release to ensure adequate contact pressure and time on its own contact for firm connection.

Next, i.e. 18UYR2 is energised through back contact of ASR along with the picked up contact of UYR1 to preserve sequence of train movement. All UYRs are accordingly energised through back contact of ASR, pick up contact of previous UYR, previous track circuit relay energised and next track circuit relay de-energised.

To energise UYR4 two limbs are there, first for movement on main line which is route 18C, in which when the train occupies the berthing track circuit 03A/BTPR. As the train occupies berthing track on main line the 18/C18UYR shall be energised energising 18/C18ASR as 18/C18UYR is bypassed by 55WNLR pickup contact.

When the movement of the train is scheduled for loop line i.e. route 15D which is through point number 55 reversed, the 18/C18 UYR4 is energised through second limb i.e. pick up contact of 55WRLR and back contact of 55aTPR. 18/C18 UYR5 shall be energised through pickup contacts of 18/C18UYR4 & 55aTPR and back contact of 04A/BTPR and shall be kept held picked up through its own contact bypassing contacts of 18/C18UYR, 55aTPR & 0$A/B TPR. 18/C18ASR is energised through pickup contact of 18/C18UYR5 in this case as point 55 is set reversed and 55WNLR pickup contact is not available in this case.

The set of UYRs is common for one ASR since ASR is common to all routes of the signal.

g) **Automatic release of route section by section at the back of the train:** In a road side station with 4-5 running lines the outermost points shall be situated at about 500metres from the

![Figure 4.7.2(V)(e) UYR circuit](image.png)
middle of the platform. The train approaching the platform negotiating the turnout at 15kmph shall take about 2 minutes to clear the outermost point to permit another movement. However in larger yards where the outermost points may be placed at a distance much higher and where movement of trains is frequent, complete arrival of a train to its destination may take time longer than 4-5 minutes thereby hampering movement of other trains in waiting affecting efficiency. To avoid this delay, instead of waiting for release of complete route in one go, routes at the back of the train are cleared section by section to facilitate movement of other trains to other routes to which the points so released by the moving train can be used.

With reference to the Signal & Interlocking plan [Figure 4.7.2(V)(g) (a)], the signal number 24 leads to routes 24A, 24D & 24E. While a train is being received on route 24A the point number 60 can be released after the train clears it so that another following train approaching the station can be received on route 24D or 24E or while a train is being received on route 24A another train in waiting on line number 3 may be despatched by taking Off signal number 17, as soon as the point number 60 & 54 are released by the route 24A.

To achieve sectional route release, the domain of the 24ASR is kept limited up to point number 60 only and Track Section Stick Relay (TSSR) identified by point’s zone it covers, is created. These relays energise on similar principle as UYRs. TSSR is nothing but an extension of ASR as such TSSR created for holding route further also get de-energised with the de-energisation of the ASR. Point number 55 is kept held by 55TSSR & 54 & 52 by 54TSSR.

Due to limiting of domain of ASR up to point number 60 only, as against covering last point of each route up to destination including overlap, 24ASR is energised after clearance of the track circuit 60aT of point number 60 zone, with the energisation of UYR3 when the train is being received on route 24D or 24E and by the
energisation of UYR4 also when the train is being received on route 24A [Figure 4.7.2(V)(g)(b)]. The point number 60 gets freed while the chain of TSSRs continue holding the points ahead in a sequence till the train reaches the destination thereby holding the entire route.

**Energisation of ASR:** The ASR circuit [Figure 4.7.2 (V)(g)(b)] for the signal 24 of the Signal & Interlocking Plan of figure 4.7.2(V)(g)(a) is on the same lines as that of signal number 18, based on Signal & Interlocking plan in figure 4.7.2(A), discussed in preceding paragraphs, as such is not discussed again in details.

This plan is selected for specific study of sectional route release, for which the role of ASR is limited to locking the point number 60 [Figure 4.7.2 (V)(g)(c)] and rest of the points are kept held by Track Section Stick Relays (TSSRs). Here it may be seen that ASR shall get energised as soon as UYR3 is energised when the train is being received on route 24D or 24E and shall require 24/C24 UYR4 also when train is being received on route number 24A [Figure 4.7.2 (V)(g)(b) & Figure 4.7.2(V)(g)(c)]. UYRs are numbered as 24/C24 as the same set shall be used to release the route when calling-on signal is taken Off.

Looking at 24/C24UYR circuit, when the route 24D or 24E is set, pickup contact of UYR4 shall not be required as the route 24A is not involved as such UYR4 pickup contact is bypassed by 60WNLR pickup contact in 24ASR circuit limb-3. When 24A route is set, point 60 shall be reversed and UYR4 shall be required to energise the 24ASR. UYR3 is energised through two limbs being i) with 55TPR back contact if point 60 is set to normal and ii) 55TPR back contact bypassed by 60WRLR pick up contact and 60bTPR back contact, to release 24ASR, when point 60 is set to reverse. In situation (ii) 24 ASR shall be energised by UYR4 pickup contact in addition to UYR1, UYR2, and UYR3 pick up contacts. Accordingly it transpires to that when point number 60 is set to normal the 24ASR shall be energised by occupation of 55TR with clearance of 60aTR and by occupation of 60bTR and clearance of 60aTR when point 60 is set
to reverse. With this while 24ASR shall get energised, corresponding TSSR shall continue to be
de-energised holding points further.

Accordingly 24ASR shall get energised as soon as the track circuit 55bT is occupied after
clearing 60aT when the train is being received on route 24D or 24E and by clearing of track
circuit 60bT and occupying 54bT when the train is being received on route 24A. As soon as
24ASR is energised point number 60 shall be free of route locking.

TSSRs are route section relays and are designated so for the sake of study, however, for easy
identification, the TSSR used for the purpose of release of the route by the
train movement from left to Right is
designated as TRSR and when used for release of route by the movement of the
train from right to Left is
designated as TLSR.

**Role of TSSR in sectional route release:** After energising 24ASR,
balance part of the route section is
grouped in i) 24A and ii) 24D & 24E. Route 24A comprising of points 54
and 52 shall be held by the 54TSSR
named after the point to which it
keeps locked (the 54TSSR can also be
named as 54/52TSSR as it keeps
points 54 & 52 locked) when the train
is being received on route number
24A and by 55TSSR when the train is
being received on route 24D or 24E.
It is also ensured that route 24D or
24E is locked when the train is being
received on route 24A while the route
24A is not affected when the train is
being received or despatched on and
from route 24D or 24E.

Accordingly 24ASR pickup contact is
bypassed by 60WRLR in the 55TSSR
circuit. 55TSSR and 54TSSR are
created for route sections containing point numbers 55 and 54 & 52 respectively. In case more
points are there ahead of point number 52 similar TSSRs may be created. More than one point
may be grouped to be held locked in one TSSR group depending upon requirement. Siemens
point groups are designed inherently for sectional route release. 55TSSR and 54TSSR which
fall next to the domain of 24ASR are energised through pickup contacts of 24ASR.

![Figure 4.7.2(V)(g)(c) UYR circuit for 24 ASR](image-url)
Accordingly both of the TSSRs shall get de-energised with the de-energisation of 24ASR concurrently when route is set for 24A and only 55TSSR shall get de-energised with the de-energisation of 24ASR when the route is set for 55D or 55E. In case the movement of the train has to take place on route 24A, points 55, 54 & 52 should get locked, however when the train is scheduled for route 24D or 24E, points 54 and 52 are not required to be locked to facilitate simultaneous up direction movements (as per interlocking requirements), as such 24ASR pickup contact to energise 54TSSR is bypassed by pickup contact of 60WNLR.

Sectional route release of route when 24A set: Route 24A is set with point numbers 60, 54 and 52 reversed. 54TSSR de-energises with the de-energisation of 24ASR, there by holding route section covering point number 54 and 52. This shall also lock the route section for point number 55, as discussed in preceding paragraph. Accordingly instead of proving 24ASR energised, 54TSSR is proved energised to free the point numbers 52, 54 & 55 in WZR circuits of these points.

54TSSR shall require, 54bTPR, 54aTPR, 54TSSR1, 54TSR2, TSSR3 and 54TSSR4 pick up contacts in addition to 24ASR pickup contact, to energise. However the 54TSSR shall continue to be de-energised even after energisation of 24ASR holding points 54 & 52. Point 55 shall also continue to be locked due to de-energisation of 55TSSR also [Figure 4.7.2(V)(g)(d)(g)(i) & Figure 4.7.2(V)(g)(d)(g)(ii)].

![Figure 4.7.2(V)(g)(d)(g)(i) 54 TSSR circuit](image_url)

As the train moves on after passing Home signal number 24, for route 24A, and crosses point number 60 in reversed position, the 24 ASR is energised on release of the track circuit 60bTR and occupying 54bTPR, thereby energising 24/C24UYR, while keeping 54 TSSR de-energised and simultaneously energising 54TSSR1 through back contact of 54TSSR, pickup contact of 54WRLR to ensure that the track circuit pertains to route with point 54 reversed, back contact of 54bTPR and pickup contact of 54aTPR and held picked up through its own contact bypassing contacts of 54WRLR, 54aTPR and 54bTPR.
TSSR2 is energised through back contact of 54TSSR, pickup contacts of 54TSSR1 and 54WRLR, back contact of 54aTPR and pickup contact of 52TPR and is held picked up through its own contact bypassing 54TSSR1, 54WRLR and both the TPR contacts. Similarly 54TSSR3 is energised and held picked up through 54TTSR back contact, 54TSSR2 pickup contact, 52WRLR pickup, 52TPR back and berthing track UDLTR1 pickup contacts and is kept held picked up through its own contact bypassing 54TSSR2, 52WRLR and TPR contacts. TSSR4 is energised through back contact of 54TTSR, pickup contacts of 54TSSR3, 52WRLR, 52TPR and back contact of UDLR1 and is kept held through its own contact bypassing contacts of 54TSSR3, 52WRLR, 52TPR and UDLR1.

Figure 4.7.2(V)(g)(d)(g)(ii)

54 TSSR1, TSSR2 TSSR3 & TSSR4 circuit

With the energisation of 54TSSR1, 54TSSR2, 54TSSR3 and 54TSSR4, 54TSSR shall get energised clearing route section for point number 54 and point number 52 rendering point numbers 52 & 54 free for operation. Energisation of 54TSSR shall disconnect the 54TSSR1, 54TSSR 2, 54TSSR3 and 54TSSR4 circuit, de-energising all of them making it ready for next move [Figure 4.7.2(V)(g)(d)(g)(ii)].
It may be observed that in this SIP, berthing track circuits have been numbered as UDLTR1 for up & down common loop line track circuit number 1 and ULTR1/2 for up mainline track circuit number 1 & 2. This practice of numbering berthing tracks is adopted by some of the railways.

Sectional route release of route when 24D or 24E set: As the route 24D or 24E is set the 54TSSR does not get de-energised while 55TSSR de-energises with the de-energisation of 24ASR. This as such does not lock the route section of point numbers 54 and 52 as discussed in preceding paragraph. As the train traverses through point 60 set normal, and 55bTPR gets de-energised thereby energising 24ASR, TSSR1 is energised through back contact of 55TSSR, back contact of 55TPR and pickup contact of DMT1 when route 24D is set. In case of route 24E is set, the DMT1 TPR pickup contact is bypassed by pickup contacts of 55WRLR and DLTPR1 pickup contact. The 55TSSR1 is held energised through its own contact bypassing TPRs. Similarly 55TSSR2 is energised through back contact of 55TSSR, pickup contact of 55TSSR1, 55TPR and back contact of DLTPR1 when the route is set of 24E, and is kept held through its own contact bypassing 55TSSR1 and track circuit relay contacts consequently energising 55TSSR. [Figure 4.7.2 (V)(g)(d)(v) and Figure 4.7.2 (V)(g)(d)(vi)].

![Figure 4.7.2 (V)(g)(d)(v) 55 TSSR circuit](image)

However when the route is set for 24D, the 55TSSR2 is energised through 55WRLR pickup contact and DLTPR1 TPR back contact bypassing the DMT1 TPR contact of other limb.

Provision of time element in TSSR circuits: In normal course the concerned TSSR shall get energised automatically by passage of the train energising TSSR1 & TSSR2 or more, in sequence with sequential proving of de-energisation and re-energisation of track circuits in the direction of the train movement. However in case any of the TSSR1 or TSSR2 or more, fails to energise or due to any other reason, even if the TSSR1, TSSR2 & more energise but fail to energise the concerned route section TSSR, the concerned point shall remain held in the route. To avoid such a situation when the concerned route section TSSR continues to be de-energised even when ASR has been energised and also concerned point zone track circuit has been cleared, taking the example of 55TSSR for route 24D or 24E, the power is extended to the 24JSLR through pick up contacts of 24ASR, 55TPR & 120RJPR and back contact of 55TSSR;
Figure 4.7.2 (V)(g)(d)(vi) 55 TSSR1 & TSSR2 circuit

[Figure 4.7.2 (V)(g)(d)(v)]. As 120NJPR is energised the power is extended to 55TSSR bypassing 55TSR1 & 55TSR2 pick up contacts after the lapse of 120 seconds after clearance of 55TPR, through pickup contacts of 24ASR & 55TPR.

This feature is also required for release of route onto which train is not scheduled to traverse but the route is required to be locked as is the case of release of route section of point number 55 when locked with the route 24A. In this case the release of 24D or 24E route is initiated after energisation of 24ASR and clearance of 60bTPR as 55TPR is not occupied.

Accordingly in case of locking of route 24D or 24E when 24A route is set, the route 24D or 24E shall be energised after 120 seconds of train traversing on route 24A clears track circuit 60bT thereby energising 24ASR, releasing point number 60.

h) Signal overlap, its setting, holding and release: Whenever a signal other than last stop signal of the station is taken Off, it leads to the next stop signal only and thereafter when next signal is also taken Off, next to next and so on. Each time a signal is taken Off, not only clearance of route, setting & locking of points in the route and closing of level crossing gates if any up to next stop signal is to be ensured but also all requirements of the route have to be ensured for an adequate distance beyond the next signal, known as signal overlap. In the Multi aspect signalling territory the signal overlap is 120 metres unless otherwise approved under special instructions.

The setting of overlap is dependent of yard layout and as specified by the designer. Taking the example of yard in figure 4.7.2(A), for discussion, placed amongst last pages of the book, the default overlap setting beyond signal number 15, for route 3A shall be towards sand hump. It shall be up to Advanced starter signal number19 for route 3B while for route 18D the overlap beyond signal number 6 has been demarcated on the plan up to level crossing gate number 415 so that the gate is not required to be closed each time a down train is received on common loop line. For route 3D the default overlap beyond signal number 11 is designed to be set for 120M dead end siding. However in case the train is required not to stop on the loop line, the corresponding starter signal shall be initiated for departure first, before taking the home signal Off, thereby setting the route up to Advanced starter signal. For example if the up train is received on route 3D, common loop line, the starter signal 11 shall be initiated for being taken
Off up to Up Advanced starter signal 19. Indian Government Railways General rules, 2006 clause 3.46 (2) provides that “At stations where advanced starter signal are provided, starter signal may be taken Off for shunting purposes, except where the interlocking interferes with this practice, in which case hand signals shall be used where shunting signals are not provided”. At the same time SR3.42/1 of North Central Railway provides that “For despatch of a train, the Starter/Intermediate starter signal where provided shall be taken Off only after taking Off the Advanced starter signal. At terminal and large stations where lines are Track circuited, exception to this rule is permitted. It should be specifically incorporated in Station Working Rules (SWR)”.

It is evident that on taking Off the starter signal, GR is liberal and has left for the railways to decide. In the given plan the arrangement is shown with shunt signals below starter signals to avoid taking Off of starter signal for shunt movement also. In such case the starter shall assume Off aspect only when Advanced starter signal has assumed Off aspect. That is why when starter signal is initiated to be taken Off for departure of the train up to Advanced starter signal, only the route shall be set, while starter signal shall assume Off aspect only after Advanced starter signal has been taken Off and has assumed Off aspect.

Accordingly overlap for the route where it has two options shall be set for the sand hump or 120 metres dead end siding in normal course set by default but it can also be set for departure by initiating starter for taking Off for departure of the train. For route 3B the overlap in any case is required to be set up to Advanced starter signal number 19.

i) **Circuit for overlap setting and holding:** Refer SIP as per figure 4.7.2(A) placed amongst last pages of the book. With the initiation of a route, the concerned LR initiates setting & locking of points in the route as well as default setting and locking of points in the overlap as designed on SIP. On the same lines UCR checks the overlap points along with the points in the route. With this a relay named as OVSR to hold the overlap, similar to ASR, is energised [Figure 4.7.2(V)(h)].

Taking route 18C for study, once the 4 OVSR, named after the starter signal beyond which the overlap is provided for the train scheduled to be received on route 18C, is energised it is held energised through its own contact. 4 OVSR de-energisises with the energisation of 18UCR along with de-energisation of 18ASR. The release of overlap depends on situations, i) in case the train runs through and clears berthing track or ii) in case the train is scheduled to stop at the starter signal.

**Release of the overlap when the train runs through:** 4 OVSR energises through 18UCR back contact, C18LR (Calling-on signal) and 18CLR back contacts & 18ASR, C18ASR and DMT1/2 TPR pickup contacts, directly without a time gap and is held through its own contact bypassing18CLR, 18ASR, C18ASRs and DMT1/2 TPR contacts [Figure 4.7.2(V)(h)].

**Release of the overlap when the train stops at the starter signal:** In case the train stops at the starter signal, 4 OVJSLR energises as the train occupies track circuit 55bT preceding the berthing track along with the berthing track DMT 1/2, through back contacts of 18UCR, C18CLR, DMT1/2 TPR, 4 OVSR, 55bTPR and pickup contact of 120 RJPR; and is held picked up through its own contact bypassing 120RJPR and 55bTPR contacts. With the energisation of
4 OVJSLR, 120 JR and in turn 120NJPR is energised after a lapse of 120 seconds. 4 OVSR is energised through back contacts of 18UCR, C18LR & 18CLR and pickup contacts of 4 OVJSLR, 55bTPR & 120NJPR thereby proving clearance of entire route and occupation of berthing track by the train. The 4 OVSR is held energised through its own contact bypassing the 120 seconds release circuit. The Station Master shall know the process of release through 120 NJKE indication illuminated on the panel.

It is pertinent to note here that when the train stops at the berthing track, overlap is kept held locked and OVSR is energised after 120 seconds to give margin for stopping of the train failing which the very purpose of providing overlap stands forfeited.

Emergent release of the overlap manually when the train stops at the starter signal: In either case when the train runs through or stops at the starter signal and the 4 OVSR does not re-energise by itself or the overlap is required to be released short of 120 seconds, emergent release of the overlap shall be resorted to by pressing the group OVYN button and concerned signal button simultaneously, provided with a counter to release the overlap manually, thereby energising 4 OVSR through back contacts of 18UCR, C18CLR & 18CLR and pickup contacts of 4 OVJSLR, 55bTPR, OVYNR and 4GNR pick up contacts bypassing 120 seconds time element in case the track circuit 55bT preceding the berthing track, has been cleared by the train and the train has come to a stop (to be verified physically). This manual release is counted by a counter.

j) **Aspect control and Signal lighting:** Signal lighting circuit is taken for study with reference to SIP placed amongst last pages under figure 4.7.2(A). The fundamental advantage of Multiple Aspect signalling system is that each signal is pre-warmed by a signal preceding it. In case of first stop signal of the station i.e. the first stop signal faced by a Loco pilot approaching the station from block section, the signal is preceded by a permissive signal where the Loco Pilot is not supposed to stop the train. Accordingly Aspect of the signals are controlled depending on the signalling scheme on the station defined at the time of preparation of SIP, which is wired through energisation of controlling relays first, being depending upon interlocking superimposed by aspects of the signals to which the signal in question precedes.
Once the route is set & locked, the signal relay HR is energised. There is one HR for each
multi-aspect signal and DR for a two aspect signal to take the signal Off. For a permissive
signal the normal Off aspect indication shall be yellow. So in both the cases of stop signal as
well as permissive signal the HR shall illuminate yellow indication. When the indication of the
signal should be other than yellow depending of indication of the signal in advance,
the indication required may be double yellow or green. In any case HR is required as minimum
signal relay supplemented by HHR for double yellow or DR for green indication. Taking the

Figure 4.7.2(V)(j)(i)  Signal 18 HR circuits
Signal Interlocking Plan figure 4.7.2(A), the HR circuit is drawn for routes 18C & 18D [Figure 4.7.2(V)(j)(i)].

The **HR circuit** is amongst most vital circuits. Energisation of HR proves i) crank handles of all the points in the route of the signal locked by pickup contacts of CH: NPRs, ii) energisation of UCR to ensure that the points in the signal’s route are set and locked, iii) ASR back contact to prove that route is set and locked, iv) TSR pickup contact to ensure one signal one train principle, v) All points individually, in the route set and locked through NWKR/RWKR pickup contacts, vi) all track circuits in the route including berthing tracks are free through respective track relays energised, vii) respective overlap stick relay energised to ensure that the overlap is set and locked, viii) respective LRs energised for each route separately, ix) next signal ahead is not blank; and in case of signal is being taken Off for loop line, x) the HR is energised after proving route proving relay energised and route lights lit through its lamp checking relay energised. UCR is proved twice in the circuit as an abundant safety precaution.

18HR circuit for routes 18C & 18D: A part of the limb-1 is common while the limb-2 branches away for route 18D, continuing with limb-1 for route 18C.

Limb-1: Power is extended through pickup contacts of CH59NPR for crank handle of point number 59 locked, 59WLPR for point 59, 59NWKR for point set and locked normal, back contact of C18LR for calling-on signal not initiated, pickup contacts of 18TPR, 59aTPR, 59bTPR, 55Btpr, 18TSR and back contact of 18ASR for route being locked, CH: 55NPR pickup contact and 55WLPR pickup contact there from the limb-1 branches Off for limb-2 for route 18D.

Limb-1 is continued further through for route 18C: Pickup contacts of 03A/BTPR, 46 RWKR, 42NWKR & 4TPR proving berthing track and overlap clear. Thereafter signals 4RECR or 4DECR energised i.e. next signal is lit, 18CLR energised for route 18C set and routes conflicting to 18C not initiated, 18UHR and 18UECR de-energised since route is set for main line, 18UCR energised as the route is set for mainline energising 18HR through 18UCR pickup contact via negative limb. 18 UCR pickup contact and 18ASR back contacts are proved additionally in the negative limb as an abundant precaution.

Limb-2 is continued further from first part of the limb-1 for route 18D: After branching off from 55WLPR pickup contact of limb-1, the power is extended through 55RWKR proving point set and locked for the route 18D with point 55 reversed, pickup contacts of 55aTPR in route and pickup contacts of 04A/BTPR & 6TPR in overlap, 6OVSR de-energised as the overlap is set and locked, 6RECR pickup contact as the signal is illuminated, 18DLR and 18UCR pick up contacts proving route set and checked for 18D, energising 18 UHR. With the energisation of 18UHR route lights of junction type route indicator shall be illuminated and 18UECR shall get energised thereby extending power to 18HR through 18UHR and 18UECR pickup contacts illuminating signal 18. It may be noticed that it is the route lights which illuminate first and then only the main signal is taken Off. This feature also ensures that the main signal is taken Off only when route lights are illuminated when route is set for loop line.
In limb-1 for route main line, where HR is energised through 4 RECR as well as 4DECR while in case of route for loop line only RECR energised contact of starter is taken as in case of loop line the starter is considered to be **approach cleared** to be taken Off only when the train occupies berthing track circuit.

**Approach cleared signal continues to be red and acquires off aspect only when its approach track circuit is occupied by the train to ensure that the Loco pilot does not pickup speed in advance while negotiating a turnout or any other reason warranting such requirement.**

Energisation of 18DR Limb-4: 18 DR is energised only when the 18HR is energised as HR is the relay which energises after satisfying relevant conditions of interlocking. The DR is also controlled by the aspect of the signal ahead. The Home signal number18 can only be taken Off to display green indication when the train is scheduled to traverse through main line without negotiating any turnouts and the next signal in advance display green indication. Accordingly 18DR is energised through 18UHR back contact and pickup contacts of 18CLR, 4DR, 4DECR as the starter signal has been taken Off and the pickup contact of 18HR. The DR is made slow to release to avoid bobbing of the signal indication when the signal in advance changes aspect from yellow to green (Condition does not apply in the present case). 18DR is bypassed by 18HR back contact for cross protection to ensure that DR does not energise if HR is de-energised.

**Signal 18, aspect lighting circuits:** The signal lighting circuit is designed with LED signals in the present example. As 18HR and 18DR are energised these are repeated at signal location as 18HPR and 18DPR in the area provided in 25 KV AC traction because of limitations due to induced e.m.f. when the distance of parallelism between controlling relay and the signal lamp is 400meters or more [Figure 4.7.2(V)(j)(ii)].

For illumination of yellow indication, 110V AC is extended to the signal location through pickup contact of 18HR, back contact of 18DR, 18HECR coil, and 18HMECU. The power is extended from 18HMECU through 18HPR pickup contact and 18DPR back contact to Yellow LED signal (18HGE) through signal location box.

For illumination of green indication; When the signal is taken Off for main line and the signal ahead displays green indication, 18DR is also energised, as such the power is extended to the signal location through 18HR and 18DR pickup contacts, 18DECR coil and 18DMECU whereupon power is extended through 18HPR and 18DPR pickup contacts to green LED signal (18DGE).

Power to red LED signal is extended through back contacts of 18HR, 18RECR coil, 18RMECU to signal location where the power is extended through 18HPR back contact to 18RGE.

Junction type route indicator provided at the signal having 5 lamps in series of which one is common to all the route indicators and remaining four are part of each route indicators. However there is only one route to be illuminated on the signal number 18. The power to the route indicator is extended through pickup contact of 18UHR, 18UECR coil, and 18UMECU to the signal location where it is extended through pickup contact of 18UHPR to the set of four
route lamps and to the pilot lamp as the standard arrangement, pilot lamp being located in the central cabinet of the route indicator.

*Cascading arrangement of signal lighting:* Incandescent lamps used for signal lighting are prone to fusing more than LED signals causing blanking off of the signal as such cascading arrangement is essentially required to be made when incandescent lamps are used for signal...
lighting where as the arrangement may not be essentially required to be made with LED signal owing to its long life and sufficient provision of indications of its deteriorating health.

The basic principle of cascading are i) to avoid blanking off of the signal and ii) to display an alternative signal indication which has to be lower in order to the indication of which the lamp has fused.

In case of fusing or any other reason causing DGE lamp not being lighted, when DR is picked up, DR pickup contact along with DECR back contact is provided bypassing the 18DR back contact in the HGE lighting limb. With this when DR is energised but its ECR does not pickup, signal’s yellow indication lamp shall get illuminated. Similarly when HR is energised to illuminate yellow indication lamp which fuses or does not illuminate for any other reason, causing HECR not to energise, the 18HR back contact in the RGE lighting limb is bypassed by the HR pickup contact along with HECR back contact to illuminate signal’s red indication lamp.

In each such case the ECR shall be energised for the aspect which is being illuminated at site resulting in display of corresponding lesser aspect on the preceding signals but none of the signals shall ever be blanked although it shall cause detention to the trains.

k) Calling on signal: Under multi-aspect colour light signalling system, the calling-on signal is a miniaturised unit fixed on the same post as that of the main signal. A calling signal may be provided on the post of any signal except on the last stop signal post, with the ‘C’ marker [Indian Railways General Rule 2006, clause 3.13].

Indian Government Railways General Rules 2006 clause 3.79 provides that “The loco pilot of a train shall be guided always by the indication of the Stop signal below which the Calling-on signal is fixed. If this Stop signal is at On, he shall bring his train to a stop. If he finds that the Calling-on signal is taken Off, he shall, after bringing his train to stop, draw ahead with caution and be prepared to stop short of any obstruction.”

Calling-on signal displays no light when On and yellow when taken Off. When it is On the loco pilot shall follow the indication of the stop signal on the post of which Calling-on signal has been fixed. When Off, the signal indication is ‘Stop and then draw ahead with caution and be prepared to stop short of any obstruction’ [Indian Government Railways General Rules clause 3.13]. In bigger yards where the distances are large, accordingly, the Calling-on signal is used to move in the train in case of failure of the stop signal on the post of which it is fixed. **Energisation of Calling on ASR:** For study, the SIP placed as figure 4.7.2(A) amongst last pages of the book, shall be referred to. ASR of calling on signals is named based on the signal on the post of which the Calling on has been provides. Accordingly it is numbered as C18ASR.

With the energisation of COGGR, C18LR [LR circuit for Calling-on signal, Figure 4.7.2(I)(c)] is energised after checking all conflicting routes and setting of points in different routes put in parallel as only one common LR is energised for all the routes for the calling-on signal.
C18ASR is energised through back contacts of its own signal relay C18HR, C18HECR and its own LR along with back contacts of all conflicting LRs i.e. back contacts of C18CLR, 18CLR, 18DLR, pickup contacts of C18TPR, 18TPR, 59aTPR, 55bTPR, 55WNLR, back contact of 18/C18UUYR and pick up contacts of all the UYRs common with signal number 18.

In majority of cases it is the failure of track circuits in the route compelling reception of the train on Calling on signal as such although track circuits in the calling on ASR energisation routes are provided for proving clearance of the track, but in all probability any one or all of the UYRs may not be energised with the passage of the train and in that case ASR shall be required to be energised to release the route through cancellation button UUYR or EUYNR. UUYR is used in this circuit to enable release of entire route section having failed due to track circuit failure with 120 seconds delay.

Figure 4.7.2(V)(k)(i) Calling on ASR circuit

To ensure that the Calling-on signal is taken Off only when the train has come to a stop, a track circuit dedicated for the Calling-on signal is provided on approach end of the signal post of five rail length to ensure that the signal is taken Off only after 120 seconds of occupation of the calling-on signal track circuit. Since the Calling-on signal is fixed on post of stop signal, the signal on the post of which calling-on signal is fixed, is taken Off first the setting of points is ensured through illumination of route lights. The stop signal may not come Off due to failure of track circuits in the route which is bypassed in the circuit for energisation of Calling-on signal lighting relay [Figure 4.7.2 (V)(k)(i)].

Lighting circuit of Calling on signal: [Figure 4.7.2(V)(k)(ii)] Major deviations in lighting circuit for Calling-on signal with the main signal lighting is that i) no track circuits are proved in the HR circuit of Calling on for the obvious reason that in case of track circuit failure calling on shall also not come Off along with main signal, ii) Since calling on signal leads to all the routes pertaining to the main signal on the post of which the Calling on signal is provided it
proves points set and locked for different routes in parallel limbs corresponding to different routes, and iii) the Calling on signal is required to assume Off aspect only after 120 seconds of occupation of Calling on track circuit as such the C18/18JSLR being common to main signal 18 as well as to Calling-on signal is energised through back contacts of C18HR, UUYR and C18TPR and pickup contact of 18LR. For energisation of JSLR circuit see figure 4.7.2(V)(c).

Figure 4.7.2(V)(k)(ii) Calling on HR circuit

C18HR is energised through pickup contact of C18LR, back contact of 18HR, pickup contacts of CH:59NPR, 59WLPR, 59NWKR, CH:55NPR, 55WLPR, 55NWKR, 4OVASR, 4RECR C18/18 JSLR and 120NJPR, back contacts of C18TPR (Calling-on signal track occupied) and C18ASR to energise the C18 HR after 120 seconds of occupation of the calling on track circuit. Pickup contact of C18LR and back contact of C18ASR are used in negative limb also as an abundant precaution. Contacts of JSLR and 120NJPR in the limb are bypassed by pickup contact of C18HR to keep the C18HR energised after these two relays are de-energised, see figure 4.7.2(V)(k)(ii). The circuit as discussed is for route 18CLR the limb is bypassed by corresponding pickup contact of 55RWKR, back contact of 6OVSR and pickup contacts of 6RECR & 18DLR.

Panel indication circuits: Panel being interface between the yard status and the Station Master, indications play an important role in train working. Different indications on the panel are i) Route, including track occupancy, ii) point status set & locked, iii) Signal aspect display, iv) flasher on and v) other miscellaneous indications. Refer Panel diagram at Figure 2 placed amongst end of the book.

Route, including track occupancy indication: As the signal is taken Off, the route getting locked is displayed by white light illuminated strips reflecting all the track circuits in the route including overlap [Figure 4.7.2(V)(k)(iii)]. In consideration that many a times same track circuit shall be common to many routes, the indication circuit is designed selectively in such a way that while the route strip gets illuminated for a route to which it is part, at the same time it should not get illuminated in any other situation. Accordingly each such strip shall be illuminated with i) pickup contact of the TPR and ii) back contact of respective ASR often selected through point setting status. Each track indication strip has one red and one white light lamp/Led. When C18 is taken Off, track circuit strips C18TKE1(W) & C18KE2(W), white (W) light lamps shall be illuminated through C18ASR back contact and C18 TPR pickup contact.
Similarly 18Track indication strips 18TKE1(W), 18TKE2(W), 18TKE3(W) & 18TKE4(W) are illuminated through back contacts of either of 18ASR or C18ASR and pickup contact of 18TPR. 59NWKR pickup contact is added for selection to eliminate illumination of these strips when any of Signal 11, 31, 39 or 40 is taken Off with point 59 reversed.

![Figure 4.7.2(V)(k)(iii)](image)

**Route indication circuit for panel**

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While at the same time 59aCWKE(W) for which the point indication common (C) strip whether the point is set for normal or reversed is required to be illuminated white with 59aTPR pickup contact in case of de-energisation of any of 18ASR, C18ASR, 11ASR, 31ASR & 40ASR.

Route strips 59aTKE1(W), 59a TKE2(W), 59a TKE3(W) & 59a TKE4(W) are part of signal 18 as well as signal C18 route for which point 59 is required normal accordingly these four track indication strips are selected through 18ASR or C18ASR back contact and 59aTPR pickup contact selected by 59 NWKR pickup contact so that these do not illuminate through back contacts of 11,31, 39 and 40 ASRs.

While indication for energised track circuit is displayed only when a route is set and locked Any track circuit failure indication is displayed red (R) on the panel directly through back contact of the concerned track circuit [Figure 4.7.2(V)(k)(iii)].

Signal Indication: Two methods are prevalent in one case only i.e. i) On & Off aspects are displayed on the panel in other case ii) all indications provided at the signal are replicated on the panel. Accordingly in case where all indications of the signal are provide on the panel, signal 18 red, yellow, double yellow or green indications are provided on the signal profile [Figure 4.7.2(V)(k)(iv)].

Point indication: Indication of a Point is in the form of letter Y formed by three strips, one the lower limb of the letter Y being common for both normal or reverse setting of point while other two strips provide normal or reverse set point indication. At the junction of these three strips a small lamp is provided which illuminates when a point, if it is single ended, or the crossover, is locked in a route.

The point setting indication remains flashing when the point is setting to either position till it is set and locked after which it becomes steady. In case of failure of flasher contact getting stuck in energised condition the indication on the panel may look like as if point was set and locked. This makes it important to provide a flashing indication on the top right hand to ensure that the flasher is working. This further provides reason to use two flasher relay contacts in series of all such circuits. Taking example of point number 59 [Figure 4.7.2(V)(k)(v)], when point is under the course of setting, power is extended to 59NWUKE(W) through flasher relays FR1 and FR2 pickup contacts, 59 NWKPR and 59RWKPR back contacts as the point is under movement and as such both the indication relays are de-energised, 59RUR back contact if the point is given command for normal setting and pick up contact of 59aTPR thereby causing 59NWUKE(W) indication strip to flash. If the 59aTPR gets de-energised the 59NWUKE(R) indication strip
shall be illuminated red flashing through same circuit changing path through 59aTPR back contact. The other limb is similar but for point given command for reverse setting through back contact of 59NUR. The entire indication is replicated for 59b also through 59bTPR connected in parallel to a limb.

When point 59 is in transition stage of setting to either position, 59 NWKR as well as 59RWKR are de-energised and normal as well as reverse setting indication strips flash during this period while either of normal or reverse indication strip becomes stabilised and other extinguishes with the setting of point to normal or reverse selected by energisation of NWKR or RWKR respectively, as the case may be.
WLPR is the point locked proving relay. Accordingly as and when the point is locked in a route thereby energising 59WLPR, the small circular point lock indication is illuminated in between the point setting indication strips.

Other miscellaneous indications: i) A small circular indication is provided by the side of each signal to indicate Emergent route release. As the emergent route release is initiated the Emergent route release indication gets illuminated which distinguishes along with release of route after a lapse of 120 seconds from the time of initiation. A 120 NJKE indication is provided on the panel top to show that the time release system is working. ii) Each crank handle location is marked on the panel near each of them with indications of crank handle being locked or released. Similarly it is for level crossing gates controlled by the panel. Besides indications for power supply health, fusing of signal lamps, Electronic Interlocking (EI) system working, panel/VDU operation switch indication, IBSS passing at On and more indications may be provided to facilitate the Station Master organise train working from one compacted place of operation.

5. Auxiliary interlocking circuits:

i) Gate Control circuit: Only interlocked gates are controlled by signalling system. Out of these interlocked gates the gate might be placed within station section or in block section. Independent gate signals are provided on both sides of the interlocked gate at an adequate distance from the edge of the road of the gate when the gate falls in block or station section. The adequate distance of gate signal from the gate is 180m which is equivalent to block overlap in case of multi aspect signalling system. The gate signals are provided along with Distant signals. When the gate falls within station section or within station limits, the signals provided at the station are used to protect the gate. Level crossing gates in station limits may also require gate signals with the ‘G’ marker in addition to the stop signals of the station, to protect the level crossing.

It is pertinent to understand that when a signal provided within station section is used to protect the gate it shall function as a stop signal only and shall not be provided with the ‘G’ marker not to be guided by the rules of a gate signal.

ii) Level Crossing Gate placed in station section controlled by station but operated by gateman: [Figure 5(ii)]. When the signalling system of the station is operated through Control cum Indication Panel, the interlocked gate placed in station section controlled by station but operated by gateman can be allowed to be opened or closed for road traffic depending upon its classification. (Refer Indian railway Signal Engineering Volume-I, by the same author)

Accordingly a slot designated as L-XING YR is energised at the level crossing gate relay hut after proving all LRs de-energised, which lead towards the gate [Figure 4.7.2(V)(m)(i)]. L-XING YR is energised by pressing group button GBNR along with the button XNR of the level crossing gate concerned. As the L-XING YR is energised it is held picked up through its own contact and back contact of GBRNR. The L-XING YR is repeated at gate lodge with the designation as L-XING YPR proving the L-XING ZPR back contact and gate operation crank handle-in contact made if the power operated lifting barriers, is used. This L-XING YPR energised allows the gateman to open the gate.
As and when the gate is opened back after clearing the road traffic, and the Station Master calls back the gate control, he shall withdraw the slot by pressing simultaneously L-XING XN along with group button GBN, disconnecting the circuit and de-energising the L-XING YR and YPR in turn.

As the gateman closes gate, L-XING XCKR is energised at the relay hut of gate extending power through its pickup contact & crank handle-in contact, when gate is power operated, energising L-XING ZPR in the relay room of the station through back contacts of L-XING ZYPR & L-XING ZYR and pickup contact of L-XING XNR, as the L-XING XN when pressed simultaneously with GBRNR to withdraw control over L-XING gate. The L-XING XNR is bypassed by the own contact of L-XING ZPR to keep the relay energised when the button L-XING XN is released. Pick up contact of L-XING ZPR is proved in all the LRs, the routes of which lead to the said level crossing gate.

Station Master’s control over the gate in the block section is limited to telephonic communication and exchange of private numbers. The gate operation, in such a case, is controlled by an all normal proving relay XOR which proves all gate signals provided across the level crossing at On along with all such conditions to prove that no train is approaching towards gate through track circuits or Track Actuated Warning System.

iii) Power operated lifting barrier level crossing gate: Power operated ‘Electric Lifting barriers’ are manufactured and procured under specification number IRS S 41-70. However Electric lifting barriers with hand generators are also manufactured and procured for operation under specification RDSO/SPN/180/2005.
When the level crossing gate i) falls within station section controlled by the Station Master and operated by the Gateman from the Gate Lodge and ii) falls in the block section connected on telephone with the Station Master of adjoining station. The lifting barrier may be mechanically operated through a winch or power operated through a Gate Control cum Indication panel provided in the gate lodge. With the provision of the power operated lifting barriers, road signals with red and yellow indications along with hooters on the signal unit, are provided. These road signals are provided on the left bank of the approach road near the lifting barriers so as to be clearly visible to the approaching road traffic. The hooter sounds when the gate is required to be and is being closed.

*The Gate Lodge is a room attached to the concerned level crossing gate where the Gateman performs his duty and has an attached relay room to house signalling system, if required for gate operation control, not accessible to the gateman.*

Power operated lifting barrier level crossing gate normally opened against road traffic is taken here for study [Figure 5(iii)]. Relays L-XING XCKR and L-XING XOKR are energised when the gate is closed and opened respectively. Relay L-XING XCKR is energised by B24 power extending through back contact of L-XING XOKR proving that the gate open proving relay is not energised, $0^\circ$ to $5^\circ$ boom horizontal contacts made proving that the gate is properly closed and is within permissible limits, gate locked contacts made and Gate crank handle-in contact made to ensure that crank handle for manual gate operation has not been taken out, extending to negative limb. Relay L-XING XOKR is energised through SM YPR energised contact to ensure that the Station Master had extended permission to the gate man for opening the level crossing gate, L-XING XCKR back contact to prove that the gate closed proving relay is not energised, $80^\circ$ to $90^\circ$ boom vertical contacts made to prove that gate is open and booms are vertical within permissible limits, and Gate crank handle-in contact made extending to negative limb.

iv) **Operation from Gate Control cum Indication Panel:** As and when a train movement is contemplated across the level crossing gate, Station Master shall advise the Gateman through telephone to close the gate and withdraw SM YPR which was so far energised to allow the gate to be kept opened. Since the SM YPR is not required for closing of the gate the gate man is free to close it.

![Figure 5(iii)](image_url)

*Gate closed and gate open relays*
However with the de-energisation of SM YPR the hooter is switched on due 110V AC power getting extended through hooter energisation circuit and gate road signals becoming red (Circuit not shown), informing the approaching road traffic of the level crossing booms being closed.

The gateman shall press gate close button on the Gate Control cum indication panel, with this 110V AC is extended through the button’s make contact ‘Open P’, L-XING XCKR back contact to ensure that the gate is not closed as well as to disconnect the power when the relay is energised on gate being properly closed, L-XING OPEN contact made, to the 02° to 90° position of the booms energising heavy duty CLOSE CR coil, through GATE CH: OUT contact to ensure that the crank handle is not inserted into the gate gear spindle for manual operation of the gate, to the negative limb [Figure 5(vi)].

For opening of the gate booms Station Master’s permission is received at the gate through energisation of SM YPR. The 110 V AC power is extended through pickup contact of the SM YPR, Open button on the gate Control cum Indication Panel pressed ‘Close P’ contact, back contact of L-XING XOKR, L-XING CLOSE contact of the boom and 00° to 88° position of the booms, energising heavy duty OPEN CR coil, extending power to negative limb having proved pick up contact of SM YPR as an abundant precaution and through crank handle out contact.

For closing and opening of booms its 02° to 90° and 00° to 88° position is taken respectively to manipulate booms’ opening and closing midway as during this period either of XOKR or XCKR or both are de-energised.

v) **Gate motor control circuits of power operated lifting barriers:** As the heavy duty CCR is energised 110V AC power is extended to both the booms of the gate through MCB, CCR heavy duty contacts to the start coil and run coils of the boom motor along with to solenoid coil. The phase is reversed to RUN coil of the boom motor when OCR is energised which decides direction of movement of the motor gears [Figure 5(v)].
vi) **Electrical control over Mechanically operated lifting barriers:** The Station Master’s control over the winch operated lifting barriers is through i) Happer’s Key Transmitter (HKT), through ii) 2½" stroke lever lock with its plunger welded to the plunger of ‘E’ type lock or iii) KLCR.

All the methods are used to release the ‘E’ type key to enable the gate man open the booms by manually operating winch and or to lock the ‘E’ type key back to either of the equipment out of key transmitter, lever lock or KLCR.

The key transmission is, locking the key of a given ward with the HKT at one place say with the Station Master and releasing another key locked with the HKT at another place say with the Gate man. With the release of key from the lever or from the lever lock for the purpose of key transmission, in the Station Master’s room, the interlocking stops taking Off of the signals leading to the level crossing gate.

In either case the key transmitted by Station Master through the key transmitter, is extracted by the Gateman from lever lock or KLCR and is inserted and rotated in the ‘E’ type lock provided on ground lever frame boom lock lever to allow the lever move to normal and unlock the boom. When the lever is put to normal it releases another key from duplet ‘E’ type lock, interlocked with each other fixed on boom locking lever. The key so extracted is used to unlock the winch crank handle and open the barriers. During the process of opening the booms the key used to open the lifting barriers gets locked with the winch handle. During this period when the gate is open to road traffic, signals leading towards gate remain On can not be taken Off.

For closing the gate the same process is retraced and the ‘E’ type key is locked back into the lever lock, the key transmitter or KLCR.

vii) **Gate signals in Automatic Block Signalling territory:** In addition to the back locking of the level crossing gates as mentioned above, the SEM part-II, September 2001, paragraph 14.1.10 provides that audible warning by a bell /buzzer operated by the approach of a train shall be provided at interlocked gates in accordance with paragraph 3 of annexure-10 to the SEM paragraph. Accordingly the bell warning should be provided on level crossing gates classified and placed at table 5(vii).
A track circuit is provided at a distance of two kilometres from the edge of the level crossing gate road in direction of approach on double line section. Two such track circuits are provided in case of single line section to establish direction. As the automatic block signal section is already provided with continuous track circuits the same is used to initiate alarm and approach locking to the level crossing gate.

viii) **Approach and back locking of Level crossing gate:** The level crossing gate may fall in automatic block signalling territory or absolute block signalling territory on single or double line sections.

When the level crossing gate falls in block section the YPR relay used for opening of the gate controlled by Station Master [Figure 5(ii)] is replaced by XOR. XOR is energised through all up and down line gate signal’s RECRs energised contacts and all track circuits placed in approach to the level crossing gate up to a distance of more than two kilometres from the edge of the road of the level crossing, track relays energised, to ensure that no train is approaching the level crossing gate on up or down lines and no gate signals have already been taken Off. Relay AR is energised through approach track circuit/circuits energised contacts for initiating back locking of the level crossing gate.

a) **Level crossing gate in automatic block signalling territory on double line section:** Since the entire automatic block signalling section is continuously track circuited, all track circuits beginning from at a distance of two kilometre or more from the edge of the road across level crossing gate are selected and a relay AR is energised through pickup contacts of all such relays, at the level crossing gate relay room. As soon as first track is occupied by the train approaching the level crossing gate, the AR de-energises. Pick up contact of the AR is proved in XOR circuit. De-energisation of AR initiates buzzer to sound and road signal to show red giving signal to the gate man to close the gate if not already done. With the de-energisation of XOR, the level crossing gate once closed can not be opened till the train clears the approach track circuits and the first track circuit provided ahead of the gate signal extending beyond the road of the level crossing gate by three metres at least.

b) **Level crossing gate in automatic block signalling territory on single line section:** Since on single line section trains move on both the directions on the same track, two track circuits are selected or carved out of the track circuits designed for Automatic Block signal control, used to establish direction of movement by energising sequence proving relays akin to UYRs, placed at a distance of more than two kilometres from the edge of the road of the level crossing on both sides of the gate. In this case XOR is de-energised after direction of traffic is

<table>
<thead>
<tr>
<th>Special class</th>
<th>‘A’ class</th>
<th>‘B’ class</th>
<th>‘C’, class (manned)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>When out side station limits.</td>
<td>In Suburban section when out side station limits.</td>
<td>In Non-suburban section when in automatic signalling and APB sections.</td>
<td>Provision of warning bells operated by approaching trains should be confined to interlocked level crossing gates only.</td>
<td></td>
</tr>
</tbody>
</table>
established by the train approaching level crossing gate. Energisation of AR and remaining part
of the circuit shall be same as discussed in preceding paragraphs.

c) **Level crossing gate in absolute block signalling territory:** Situations may be when the
absolute block signalling section is i) continuously track circuited, or ii) the section is provided
with block proving with axle counters, or iii) track vacancy is not monitored.

When the block section is provided with continuous track circuits the arrangement for back
locking the level crossing gate shall be similar to as described for automatic block signalling
section in preceding paragraphs.

When the block section is provided with block proving by axle counters it may not be possible
to use this track monitoring device except when the level crossing gate positioned at or near a
distance of more than two kilometres from the nearest edge of the road of level crossing from
the transducer of the axle counter.

In any case, a two rail track circuit is be provided at a distance of more than two kilometres
from the edge of the road of the level crossing in case of double line section and two track
circuits of two rail each in case of single line section. Another track circuit shall be provided
ahead of the signal extending beyond level crossing gate road on departure end on double line
section and two track circuits on single line section. The relay AR shall be energised with the
pickup contact of the approach track circuit/circuits on double line and single line sections
respectively which once de-energised by the occupation of the approach track by the train shall
continue to be so even after clearance of the approach track by the train, AR and XOR shall be
re-energised only after occupation of the track circuit provided beyond gate signal thereby
energising sequence proving relays akin to UYRs.

In each case XOR is energised to control opening of the level crossing gate booms as discussed
in preceding paragraphs.

6. **Wiring standards:** [SEM Part II September 2001 clause 21.15] Internal wiring of relay
rack and locations and cabins shall be generally carried out with plain annealed copper
conductors, PVC insulated un-armoured flame retarding type 1100 grade with size as:

a) Single core 1mm conductor.
b) Multi core 1mm or 0.6 each conductor.
c) Flexible insulated 16/0.020 mm conductor.
d) Flexible multi strand 3/0.737 mm conductor.

6.1 **Rack to rack wiring shall be:** Mutli core plain annealed copper with each conductor
of 1/0.6 mm or multi strand 16/0.2 mm.

6.2 **Plug in non proving type (Q series) relay to relay connection:** shall be with flexible wire
16/0.20 mm.

6.3 **Plug in type proving type (K series) relay to relay connection:** shall be with 0.6/1mm
single strand multi core cable.

6.4 **All connections from cable termination rack to tag blocks and indication etcetera:** shall
be with 1mm single strand wires.

6.4 **All connections to circuit breakers, lever locks etcetera shall be done with 1.5/1.6 sq.m
conductor.
1. **Multiple choice questions.**

1. Automatic sectional route release is:
   (a) Release of full section route on reaching of the train to its destination.
   (b) Release of points step by step with the passage of train.*
   (c) Release of route with the occupation of first track beyond home signal by the train.
   (d) All of the above.

2. Calling-on signal can be taken Off:
   (a) Only when main signal on the post of which it is fixed fails to assume Off aspect.*
   (b) For performing shunting.
   (c) When points in its route fail to set in either position.
   (d) When point & track circuits in its route fail.

3. Route can be approach locked only when track circuit provided in the section in approach of the signal concerned are:
   (a) Not less then 1400 metre.*
   (b) Not move then 1300 metres
   (c) Not less then 1000 metres.
   (d) Not more than 900 metres.

4. Dead approach locking shall conform to conditions:
   (a) Same as back locking.
   (b) Under which release of rout once signal is taken Off shall take 120 seconds*.
   (c) Release of rout takes place only when, once signal is taken Off, the train reaches its destination.
   (d) Route shall be locked dead once the signal is taken off.

5. A polarized relay is:
   (a) Sensitive to direction of current.*
   (b) Powered by A.C.
   (c) Insensitive to alternating current.
   (d) Sensitive to DC.

6. Circuit diagram:
   (a) Does not differ to the wiring diagram.
   (b) Can be used for wiring the relays.
   (c) Can not be used for wiring the relay.*
   (d) Can be help full in preparation of contact analysis.

7. Point can be operated from panel by pressing:
   (a) Pressing individual point button with group point button*
   (b) Pressing individual point button with group point normal or group point reverse throwing button.
   (c) Either of the two.*
8. Track locking is:
   (a) Locking the track circuit in dropped condition.
   (b) Locking the point in normal or reverse condition when track circuit covering point zone is de-energised.*
   (c) Locking the point in normal position when track circuit covering point zone is de-energised.
   (d) None of above.
9. What is the approximate maximum distance for Direct Feeding of conventional signal lamps on Double Line RE area?
   a. 180 meters.
   b. 600 meters.
   c. 595 meters.
   d. 200 meters.*

2. Select the right answer (True/False)
   1. Selection table is the basis for preparation of circuit diagram. – True*/False
   2. Tuner of AFTC is essentially required to be provided near track. – True*/False
   3. Transmitter of an axle counter has no role other than causing flux linkage with receiver. – True*/False
   4. Electronic junction box of analogue axle counter does not require power supply. – True*/False*
   5. Any one of the press buttons on control cum indication panel make no difference when kept pressed for time longer then 10 seconds. - True*/False*
   6. Signal button relay for emergency cancellation is unique in the way that it de-energises when the emergency signal cancellation button is pressed.
   7. Percent release of a track relay shall be better than 68. – True*/False
   8. Percent release of an ‘A’ class line relay shall be better than 60.- True*/False.

3. Answer the following question:
   1. Write short notes supported by explanatory circuit:
      (a) Approach locking.
      (b) Block locking.
      (c) Dead approach locking.
      (d) Route Holding. Explain means to achieve the same.
   2. What is interlocking? Discuss essentials of interlocking.
   3. Write short notes on:
      (a) Release of route through EUYN and EUUYN buttons and implications of each. Why release by EUYN is always counted.
      (b) What are UYRs & their significance, reply supported by circuit on a plan given in the book.
      (c) Emergency replacement of signal back to on, supported by circuit.
      (d) Triple Pole lamps? Describe their merits over Double pole lamps.
   4. Discuss automatic release of route by passage of train supported by circuit with respect to SIP placed at figure 2.4.7(A) in the book.
5. Write short notes on:
   (a) Winch operated lifting barrier controlled by Station Master through control panel.
   (b) Control panel power operated lifting barriers in block section under absolute block system of working trains.
   (c) Flasher relays.
   (d) Reason for selecting 120 second for release of rout.
6. Draw circuit for back locking of power operated lifting barrier gates provided on double line section based on description given under paragraph 4.7.2(m) (ix) of their chapter.
7. Draw an aspect control circuit for an inner distant signal in Double Distant signalling territory.
8. What is cascading of signal aspects? Explain with suitable circuit.

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CHAPTER – VI

ELECTRONIC INTERLOCKING

1. **Electronic system of Interlocking (EI):** In case of electro-mechanical interlocking, switching of circuits is done through relays. An alternative that is becoming increasingly popular is to use semiconductor based switching devices. These semiconductor based devices offer several advantages over relay based switching viz. a) much smaller size as compared to relays, b) no moving part hence not prone to mechanical wear and tear, c) switching rates of up to several MHz, d) lower power consumption and longer life. Furthermore, semiconductor based interlocking systems can be accommodated in a very small space and it is very easy to incorporate the modification to the yard layout into the system. The interlocking provided by means of semiconductors is though Electronic Interlocking it is also called **Solid State Interlocking**.

These semiconductors used as solid state switching devices are miniaturised to the extent that a number of transistors used in Intel's current state-of-the-art Pentium 4 microprocessor, has 4,20,00,000 transistors capable of executing 1.7 billion instructions a second (Markoff, John. "Researchers Make an Ultra-Tiny Chip." *New York Times*, 06/10/01: A42) prepared on a small chip of silicon to make an Integrated Circuit (I/C) to be used as processor of the computer to perform multifarious tasks.

Under electronic system of interlocking the operating device is essentially a Control cum Indication panel or the Visual Display Unit (VDU) with a key board and mouse operating electrically operated signals, inter-cabin slots, points, crank handles & Level crossing gates.

2. **Microprocessor:** Microprocessor or the central processor is a very large-scale integrated circuit (VLSI). The Central processor is sub grouped into four main sections viz. i) Memory ii) Control Unit (CU), iii) Arithmetic-logic Unit (ALU), and iv) Input/Output (I/O) devices.

A micro processor can be a single Very Large Scale Integrated (VLSI) circuit, or it can be a module made up of many integrated circuits.

2.1 **Evolution of Microprocessor:** First microprocessor was announced in 1971 by INTEL CORPORATION. This was the first 4004 model. It was a processor on a single chip. It also had a control unit which could perform various control functions like fetching instruction from memory, decoding it and generating 4 bits of data at a time. Intel itself announced an enhanced version of 4004 as the 4040. Since then, many other 4 bit microprocessors have been announced.

First 8 bit microprocessor which could perform arithmetic and logic operation on 8 bit words was announced in 1973 again by Intel. This was named 8008 which was followed by a later version as 8080 from the same company. There is a variety of 8 bit processors, some examples
being Motorola’s M 6800, National semiconductors 8c/MP, Zilog Corporation’s Z80, Fairchild’s F8 and Intel’s 8085.

Now AMD & Intel microprocessors operating on 64 bit data are available.

3 **Evolution of Electronic Interlocking:** A project to develop Electronic Interlocking was taken up by IIT Delhi in July 1983 associating two officers from Indian railways and two firms M/s DCM & M/s CEL. System was designed by 1985 and was presented in CSTE's meeting at IIT Delhi. It was evaluated through software simulation at IIT Delhi and a prototype was fabricated in 1987.

A project to develop four such SSI units bringing out improvements over prototype was taken up. Two prototypes were fabricated one by M/s DCM and other by M/s CEL. The prototype prepared by DCM was installed at Duskeda station of Central Railway in July 1993. Based on observations on this system, improvements were proposed which were subsequently incorporated by M/s RPIL who had taken over this work from M/s DCM in December 1993.

Another system for which development was taken up by M/s CEL was finally installed by M/s Crompton Grieves at Badli station of Central Railway. At these stations working PI was retained and wired in such a way so that in case of faults in E.I, station interlocking could be switched over to Panel Interlocked working. Performance of above two prototype Electronic systems was very encouraging.

First ever independently working SSI system was commissioned at Srirangam station of Southern Railway manufactured and commissioned by M/s Union Switch & Signals in 1989 under the system named as ‘Microlock’. The system was manufactured by M/s Union Switch & Signals, USA.

Over the period, EI installations have been done selectively. The biggest ever work has been undertaken by Indian railways in Ghaziabad (excluding) and Kanpur (excluding) section of North Central Railway replacing the existing installations with EI at all 47 stations in this section along with the provision of Automatic Block Signalling in entire stretch. A large number of EI have also been provided in Kanpur – Mughalsarai section of NCR and in SER, SCR, ECOR, SECR etcetera.

Railway Board issued policy for provision of interlocking systems to be used on Indian railways, through letter number 2003/Sig/G/5 dated 14th September, 2006 as:

i) **Up to 50 routes** : Relay based interlocking of metal to carbon or metal to metal type according to the expertise available on the railway.

ii) **Up to 200 routes** : Electronic Interlocking.

iii) **Above 200 routes** : RRI with relay based interlocking of metal to carbon or metal to metal type according to the expertise available on the railway.

Owing to pressing requirement and having gained experience for taking up provision of EI, RDSO has issued draft specification for EI for more than 200 routes which is under
consideration. It may be expected to provide EI on larger yards for which replacement of RRI is
due in near future.

4. **Specifications:** The Solid State Interlocking system shall be provided under
specification number IRS S-102/2004. Accordingly the system shall cover use of
microprocessor based equipment for operation of points & signals, control over level crossing
gates and crank handles and slots or any other control including interfacing block working,
ATP, CTC, Intermediate Block signalling and Automatic Block signalling. The system shall be
compatible to Control-cum-indication panel as well as VDU with key board and mouse.

The system shall analyse the input commands given by the Control-cum-indication panel or
VDU terminal, based on yard status and logic fed to the system and shall also issue commands
for operation of points to set the route if not already set and to take the signals Off.

In case of end cabin operation it shall be possible to interface more than one Control-cum-
indication panel or VDU control terminals.

The SSI system must meet with Safety Integrity Level (SIL)-4 as defined in European
Committee for Electro Technical Standardisation (CENELEC), standards. The software and
hardware should be validated by a recognised agency in conformity to the CENELEC standards
before putting the system in service.

4.1 **System Architecture:** The specification provides one of the following architecture to
be used for the EI system:

i) **Single hardware architecture with diverse software.** In addition, warm standby/hot
standby processor(s) system shall be provided with facility of automatic changeover.

ii) **Two out of two hardware architecture with identical or diverse hardware and
common or diverse software.** In addition, warm standby/hot standby processor(s)/system,
shall be provided with facility of automatic changeover.

In case of both the architectures i.e. single hardware with diverse software and two out of two
hardware architecture with common or diverse software, as mentioned above the standby shall
be either warm or hot:

a) In case of warm standby system, the standby system should start functioning after
expiry of 120 seconds of failure of main system. Preferably, the train operation shall
not be affected or otherwise, there shall be no unsafe occurrence due to switching over
from main system to standby system.

b) In case of hot standby system, train operation shall not be affected. It should also be
ensured that the fault, which affected the main processor/system, should not affect the
hot standby processor/system.

iii) **Two out of three hardware architecture with identical or diverse hardware and
common or diverse software.**
4.2 **Control terminal:** The control cum indication panel, Cathode Ray Tube (CRT) or Liquid Crystal Display (LCD) with Thin Film Technology (TFT) VDU shall be used as control terminal. The VDU shall be colour monitor, with a keyboard and mouse. The current status of the yard equipment and track circuits, a flashing indication to prove that the flashing system is working and in specific case of VDU three colours viz. red, blue and green dot markers to show that these colours are available in right proportion onto the system, shall be displayed. The system shall be able to display on the VDU complete yard or a part of it as required by the operator.

4.3 **Software requirements:** Software used shall be developed in conformity with software engineering standards issued by recognised standards body such as CENELEC with special relevance to safety critical applications.

Full documentation on Quality Assurance Programme especially the verification & validation (V&V) procedures carried out in-house or by any other agency shall be made available to RDSO.

Self check should be in-built to detect possible hardware faults. Integrity of the final output of the system for control of the field equipment should be continuously read back and checked to guard against inadvertent operation of the equipment. The software should have two layers, one having all software programming common to Indian railways containing fixed and non variable functions and other layer having programmable functions containing variable functions and requirements peculiar to individual railway.

**Basic difference between hot and warm standby:** Two systems are wired for working EI under one out of two configurations. These systems are used in either of the two methods of reliability i.e. one system is always in use while the other system is standby. The standby arrangement is either hot standby or warm standby.

In case of **hot standby** system, all commands from operating panel or the VDU and inputs from field are collected and output commands are generated by both systems. Both the systems continuously compare the outputs but output generated by only one system is used for operation of field gears like points, L.C.Gates & for indication etc. In case of fault in the working system for any reason i.e. hardware/software faults etcetera, the standby system takes over seamlessly having all the information on real time basis.

In case of **warm standby** system, power supply to the standby system is normally not extended. The standby system does not receive/process the inputs from field gears and command from the panel. When main system fails due to any reason, the warm standby system gets switched on through fail safe relay contacts. After switching on of the standby system, all field equipments are put in the fail safe condition i.e. all signal to On aspect, points locked in its last operated position etcetera. The standby system enters in the self diagnostic mode and performs power on compressive health check of all modules. The system waits for 120 seconds before coming to operational mode. Operation from the panel/VDU can be initiated only after 120 seconds of the switching-on of the system. In case a train has occupied the route, the same
shall get locked to be reset and released manually. 120 seconds is the standard time allowed for a train to get controlled if a signal goes to red in the face of an approaching train.

5 **Requirements of the EI system:** based on different manufacturer’s design in conformity to IRS specifications, basic requirements of EI are worked out as:

5.1 **High standards of safety:** Those who have come across the problems of ‘Error’, printing out of garbage by the printer or other erratic behaviour of the common computer shall be able to realize that a signal going green when it should have been red cannot be accepted. As such the hardware as well as software shall be fail safe and shall be of high integrity. RDSO has specified the Safety Integrity level (SIL) 4.

Out of the three types of architecture for the purpose, as mentioned in specifications, taking two out of three hardware architecture with identical or diverse hardware and common or diverse software, for the purpose of example, the interlocking system works on two out of three voting system. Each one of the three modules runs independently, and the final interlocking decision is made by a voting on the decisions of the three modules. Each module is provided with the feature that as and when it falls back in majority voting, it gets out of the system. This exclusion is irreversible, and the other two modules continue working on two out of two system. In order to achieve good reliability the failed module shall have to be replaced quickly.

5.2 **Reliability:** The system being software based with no moving parts, it is more reliable as compared to relay based interlocking where thousands of relays with almost four times as many contacts are main source of failure.

RDSO specification includes provision of hot/warm standby for EI with single or two out of two architecture. In Hot standby arrangement of the system, two EI systems are installed both of which are identical in all respects and fed with all inputs. In case of failure of the working system, the function is transferred to the other system waiting as hot standby. In consideration of the fact that the function is transferred from working to other system within predefined time without any interruption and seamlessly. In case of warm standby as already discussed, the standby system shall takeover from the main defective system after a lapse of 120 seconds.

5.3 **Interconnectivity:** The system shall be designed for being able to be connected to Centralised Traffic Control (CTC), Automatic Train Protection (ATP) or any other EI system as well as it shall be able to remotely control the signalling of station placed distantly.

6. **Electronic Interlocking (EI) devices and their configuration:**
The micro computer used for EI is designed to be dedicated to EI. Such Micro computer essentially has **internal and peripheral** devices [Figure 6]. These devices are **configured in modular** form. Here the description is grouped into two parts one is in the form of internal and peripheral devices and other is the modular structure of the system. Both descriptions are complimentary to each other and are to be read as such for better understanding of the system:
6.1 **Internal devices:**

6.1.1 **Micro processor:** Central Processing Unit (CPU) is the part of the system where commands given by control unit are processed based on relevant input information of the yard, commands for operation of points, if required, are given, and final command is issued for taking off signals based on compliance of logics required for the same.

6.1.2 **Memory:** Memory is grouped as i) **Erasable Programmable Read Only Memory (EPROM)** which is used to load and store onto it the application and logic software, no temporary data can be stored into this section of the memory. This data continues to exist even when the computer is switched off as such this is not volatile and is used for the computer which performs same set of instructions repeatedly, and ii) **Random Access memory (RAM)** used by the CPU as its writing pad where the desired software or a part of it is retrieved from EPROM to process the commands from operating panel or VDU and the status from the yard and action to be taken. This memory evaporates with the switching off the system and as such is volatile.

As and when a command is given to the system by the control unit for taking off a given signal, it is analysed by the CPU to check for the feasibility of its execution depending upon fulfilment of essentials of interlocking, analysing and using logic application programme. The commands shall be generated by the system to operate the points if found feasible and then if required and issue further command for taking the concerned signal Off on receipt of input about setting & locking of points in conformity to the command given for its setting to desired position. On fulfilment of requirements for taking Off of the signal the route is locked and the signal is taken OFF.

6.2 **Peripheral devices:** Peripheral or also known as Input Output (I/O) devices are:

6.2.1 **Input devices:** Input devices are that interface part of the system which receives commands, as given by the Station Master, from i) **Control cum Indication panel** or a keyboard with a mouse or either of the two, through which the Station Master shall give commands for train operation and ii) **status of the yard** such as signal aspects which are illuminated, status of points being normal or reverse and locked, track clearance of different track circuits and axle counters, status of level crossing gates closed & locked or open and status of crank handles released or locked.

6.2.2 **Output devices:** Output devices are that interface part of the system which sends indications and commands from the central processing unit to i) **Operation cum indication panel** or VDU for all indications about status of the yard with regard to setting of points, track clearance, signal aspects, flasher system, locking or releasing of routes, health of power supply and status of colours displayed in the form of red, yellow and green circular dots in case of VDU and ii) **field units** for setting of points, locking or releasing of level crossing gates en
route, locking or releasing of crank handles, acknowledging block clearance or any other function required to be controlled by the Station Master.

6.3 **Interface for interaction with Maintenance terminal:** An independent terminal is provided for monitoring at the Maintainer’s desk consisting of a reliable PC, a printer, and a keyboard. The terminal shall be used for i) display of current status of the yard, ii) storage of at least 100000 events, iii) display of recorded events, iv) data transfer to a Floppy or CD and iv) diagnosis of faults.

*Control operation of the yard is not be possible from maintenance terminal.*

6.4 **Modular configuration of the EI:** Although basic structure of the system has been described above, the system is designed in modular form. As discussed above the EI system constitutes of hardware and software while modular configuration is given in ensuing paragraphs.

6.4.1 **Hardware:** Hardware is that part of the computer which can be touched and seen. Accordingly all that parts of the computer which is hard wired including the microprocessor is the hardware of the micro computer. The hardware used for the micro computer for EI is special as it deals with human safety, this in turn causes use of special software for operation of this hardware.

Entire hardware is in the modular form and is placed on a rack on which harp connectors inter-wired are plugged in to accommodate wired cards bearing various modules:

i) **Central processor module:** In this module application logic is loaded. This could be in the form of a Boolean equations based programme or a programme which is geographical database. The programme is loaded on EPROM/Flash Rom but for the sake of quicker operations this processor module uses RAM as its brain and also as notepad where it keeps the programme available for random access as well as read and write purposes also. Depending upon commands from the indication cum operation panel or the VDU and instructions from the programme, desired information is retrieved from the station yard, processed, analysed and if found feasible, commands are generated for operation of points and signals as the case may be.

ii) **Input Output interfacing module (I/O module):** It is the part of logic circuit which permits the CPU and memory to communicate with peripheral units. All data transfer from out side to inside and from inside to out side computer, passes through the I/O section. This section works as interface between the computer and all peripheral devices to convert application specific software commands into hardware compatible signals and vice versa. A keyboard is an input peripheral device for the CPU while a VDU or a printer is an output peripheral device. I/O modules are put mainly in two categories i.e. vital I/O and non vital I/O.

Vital input module receives data/status from the vital gears like point status (NWKR/RWKR), signal status (ECR inputs) track circuit status (occupied/clear), level crossing gate status etc. Vital output drives vital functions like operation of point machine, feeding power to signals etcetera.
Non-vital I/O performs non-vital function such as receiving panel commands (button relay contacts from Panel), sending output to panel indication LED’s etc.

Data transfer measurement units: Each such level low or high or zero or one, with reference to communication is known as a ‘Bit’. A set of 8 bits is known as a ‘Byte’. The rate of transfer of symbols per second is measured in terms of ‘Bauds’.

iii) Panel processor module: This module handles the tasks which are not critical to safety. This module interfaces with Control cum indication panel or VDU and other such devices. This module receives panel commands and sends to the processor as well as takes indication status from the processor and sends to the panel for display of indications etcetera on the panel.

iv) Diagnostic processor module: This module is accessible from the technician’s console also known as Maintainer’s terminal. It is attached with the memory module containing the diagnostic programme and a geographical data and is linked between the interlocking and the maintainer’s terminal. Diagnostic module is used mainly to carry out diagnostic check of the system. Checking the functioning of the system, downloading the events related with various functions carried out by interlocking. Diagnostic system is also used for changing and uploading the application software, for carry out yard alterations.

v) Power Supply Module: This module supplies power to various modules like processor modules, I/O Modules, Communication Modules etcetera. Normally redundancy is provided in the power supply system so that working of EI is not affected if a power supply module fails. Depending upon design of Electronic Interlocking, the system requires two or more potentials for the power supply. Microlok manufactured and marketed by M/s Ansaldo signals requires 12V and 24V DC power supply.

vi) Memory module: Memory, the essential part of the computer where the programme is loaded and instructions that are required by the processor to interact with the programme and other inputs and process data. Without memory computer cannot perform its operations. The memory is in form EPROM and (b) RAM.

7. Distributed Interlocking: Distributed Electronic Interlocking is provided at major yards to reduce the overall requirement of the signalling cable. In distributed Interlocking, at Central location i.e. ASM office Central Processor, power supply, communication modules & panel processors are provided. I/O modules connect to the field equipments are provided at the end goomties. I/O modules along with communication module provided in the field are called Object controller or Element controller. These object controllers drive field equipments like points & signals, and receive status information from track circuits etcetera. The object controllers are connected to main processor in Station Master’s office either on OFC or Quad cable. Various signalling information are exchanged between main processor & object controllers in the form of telegrams i.e. digital data format. The cable connection between Object controllers & Main processor is in the form of a ring arrangement to improve over all reliability of the system.

8. System Software: Software of the Electronic Interlocking system along with its hardware is designed to meet safety integrity level 4 (SIL 4) as per CENELEC standards.
Various CENELEC standards used for design & validation of Electronic Interlocking are:

i) EN 50126 Reliability Availability & Maintainability of Signalling system (RAMS)
ii) EN 50128 Software Developments and its Validation.
iii) EN 50129 Hardware Design & Validation.
iv) EN 50129 Part I & II Design of failsafe data communication system for railways.

System Software of the Electronic Interlocking can be categories in two main categories.  
i) Generic Software,  ii) Application Software.

8.1 **Generic Software:** Generic software is equivalent to Operating system and monitors the functioning of the Electronic Interlocking hardware. It continuously monitors the proper functioning of Electronic Interlocking hardware to ensure its fail safety. It is also responsible for acquiring data/inputs through I/O devices, communication controllers etcetera, and each and every component module of the system hardware is internally scanned by generic software and its health is checked. In case of any fault, entire system is forced to failsafe shutdown. Checking of health of the hardware & software of the system is called self-diagnostic. It is performed at a regular and pre-determined interval.

In Microlok system, the software works on a cyclic basis. Minimum, major cycle time is 608 milliseconds while the EI can work satisfactorily with major cycle duration up to 1000 ms. The major cycle determines the rate at which operated equipment viz. points and signals get fresh commands.

Minimum duration of minor cycle is 9.5 milliseconds which may extend up to 30 milliseconds. During the minor cycle the programme performs self test, error recovery procedures, updates system timers and exchanges data with peripheral devices such as panel processors. It also processes data associated with one outgoing command and incoming data with associated geographic block. If the data associated with a panel command takes processing time more than 20 milliseconds the system interprets the delay as data link fault and will drive the equipment to a safe state. Zeroeth cycle data are exchanged with the diagnostic processor.

8.2 **Application Software:** The application software contains information relating to particular yard layout. Based on the yard layout, table for various I/O ports connecting to field equipments are prepared. The application logic takes data either in the form of free wire i.e. complete logic equations which determines/calculates the outputs based on the panel commands and field status or in the form of simple control table data which is then internally interfaced by the generic software for controlling the field gears based on panel command and field status.

If complete wiring diagram for the yard is required to be made for the programming of the EI system then it is called **free wire programming**. If only control table is required by the system then it is called **geographic programming**. In the case of geographic programming system generic software includes the signalling rules of the railway.
9. **Geographic data preparation**: Refer yard layout plan figure 4.7.2 (A) placed amongst last pages of the book. Here route 18D starts from signal number S18 and leads up to signal number S6 with its overlap up to Level crossing gate number 415. Since the level crossing gate is clear of signal number S6 by 120 metres, this gate is not required to be locked for the purposes of keeping overlap clear. The route may be divided in sub-routes to read in down direction as T59adn, T55bdn, T55adn, and T04A/Bdn while in up direction to read T55aup, T55bup, T59aup, T59bup and T17up. Directly conflicting routes C18D and 18D, are not considered for the purpose of this illustration.

a) Selection table is prepared.

b) The geographical data is organised into a number of files each for a specific purpose. These files include list of all signalling functions by type. Only those functions which are specified are recognised by the system. The names of the files start with a code which may be EG for the sake of example. The function files are listed as:

- EG. TCS : Track Circuits
- EG. SIG : Signals
- EG. PTS : Points
- EG. ROU : Routes
- EG. FLG : Flags (Miscellaneous functions other than mentioned)
- EG. ELT : Elapsed timers
- EG. QST : Route setting requests/ commands
- EG. BUT : Panel controls
- EG. IND : Panel indications

c) These data files contain specific signalling conditions for each function. Routes and overlaps are subdivided into sub-routes and sub-overlaps for the purpose of sectional route release. Each sub-route is identified by a track section.

d) The data files for such functions are prepared to form conditions under which a point can be operated or a signal can be taken ‘Off’:

- EG. PFM : Points Free to Move - Defines the conditions for each point or turnout, under which the points can be moved from normal to reverse or reverse to normal.
- EG. MAP : Map Search- The data defines map of the station yard signalling. The availability of train in station area is searched to control aspect sequence of the signals. This data is also used for route cancellation and approach locking for the signals.
- EG. IPT : Input Telegram Processing – Directs messages carrying indications from yard and from other interlocking to the correct locations in the interlocking memory. The messages from monitoring units in the yard and commands from the interlocking are called telegrams.
- EG. PRR : Panel Route Requests – Defines actions required to set each route.
- EG. FOP : Flag Operations – Specifies conditions for route release and sectional route/sub-route release to allow utilisation of sub-routes for other movements on having been released by the route in question. It processing of miscellaneous functions available for a
wide range of usages, called as ‘Flags’, and giving flexibility to the system.

EG. OPT : Output Telegram Processing – Prepares control information ready to be sent to the devises to be operated in the yard such as points and signals.

e) There are some more files to define different indications on the panel:
EG. PSD : Panel display data
EG. PPD : Panel points display
EG. PTD : Panel track data
EG. POD : Panel other data
EG. PBK : Button data.

f) Contents of these files are:
i) PFM- files consist of the conditions for each point or turnout to be moved. Firstly all track circuits covering points are clear and for the points required to be set to - a) Normal: all sub-routes requiring points to be set to reverse are free and for the points required to be set to - b) Reverse: all sub routes requiring point in normal are free.

These conditions are put in the manner given below taking the example of point number 55 in the signalling plan figure 4.7.2(A) placed amongst lat pages of the book. The conditions for points required to be set or already in normal condition are given as *P55N and for points required to be set or already in reversed condition are given as *P55R.

*P55N          T55a c, T55b c, U55bDN f, U55bUP f, U55aUP f
*P55R          T55a c, T55b c, U55bDN f, U55bUP f

Here it may be seen that point number 55 is covered under track circuits 55aT and 55bT as such for movement of point from normal to reverse or from reverse to normal both track circuits shall be clear.

The conditions for point to be set to normal are given in *P55N. For this the sub-routes requiring point in reverse should be free. Point number 55 shall be required in reverse by the routes 18D, C18D & 40D in down direction represented by ‘DN’ and 11G & 31G in up direction represented by ‘UP’. Sub routes of these routes covered by the track circuits covering point number 55 shall be U55bDN and U55bUP & 55aUP for down & up directions respectively. 55a normal shall not be required for down direction movement (‘U’ is the universal notation for route).

Similarly, the conditions for point to be set to reverse are given in *P55R. For this, the sub-routes requiring point in reverse should be free. The point 55 shall be required in reverse by main routes 18C & C18C both down movements and
31G an Up movement. These shall form sub-routes U55bDN and U55bUP respectively and shall be required free.

It is pertinent to note that there is a possibility that the point operation might have been blocked from technician’s console in opposite direction. However this being an overriding flag available in point memory is accessible to the generic programme which restricts the system generally applicable to interlocking irrespective of the yard layout.

In case of track circuits letter ‘c’ indicates track clear and in case of routes, letter ‘f’ indicates free.

ii) PRR – file consists of conditions for setting signal route. The conditions stipulate that opposite and conflicting sub-routes should be free and the concerned point should be in set for the desired route or should be free to be set in required position. In case the conditions are satisfied the route is set by setting the points in required position and all sub-routes are locked.

Example for route initiation: When a signal is to be taken ‘Off’, a route request command is initiated at the control cum indication panel. In Geographical Data Language, the command is in the form of a statement. The statement is in two parts first starts with ‘if’ which checks the conditions and second part starts with ‘then’ which stipulates the command. The statement for signal number S 18 for route ‘D’, is as given below:

*Q18D if P59 cn f, P55 cr f, T59aup f, T55bup f, T 55aup f, T46up f, P46 cn f, then R18D s, P59 cn, P55 cr, T59adn 1, T55bdn 1, T55adn 1, P46 cn  

The Execution begins at label ‘*Q18’ which is treated as pointer into static data table, and continues up till the ‘dot’ (.). The statement starts with an ‘if’ which initiates testing for point number 59 which is, if the point is controlled normal or free to move to normal (P59 cn f), similarly point number 55 is reverse/controlled reverse or free to move reverse (P55 cr f) and point number 46 is normal/controlled normal or free to move normal (P46 cn f) (here point number 46 is not essentially required to be kept normal for reception of the train on route 18D but is proved normal to save multiple conflicting route interlocking); conflicting sub-routes are tested for being free (T59aup f, T55bup f, T55aup f and T46a f). After testing, if the points and sub-routes are found free, the points are controlled reverse or normal as per requirement to set the sub-routes and then the route and sub-routes are locked (‘l’) before the signal is taken ‘Off’ and the signal is taken ‘Off’ thereafter having checked for clearance of other track circuits, level crossing gates and any other conditions.

iii) Output Telegram Processing file (OPT) file- Clearing of signal: Conditions for clearing of the signal are in Output Telegram processing (OPT) file.
iv) Flag Operations (FOP) file- Route release: The route is normally locked as a whole while it is released in parts of sub-routes, with the passage of the train clearing sub-routes at the back of the train, occupied first by the train at the back of the signal, retaining rest of it, ahead of the train (see back locking & sectional route release, chapter V of this volume). These commands are executed during major cycles.

For example, with reference to signalling plan fig 4.7.2(A) placed amongst last pages of the book, the statement specifying data shall be as follows:

\[\text{T59aDN f if R18D xs, R18C xs, RC18D xs, RC18C xs, R40D xs, R40C xs, T59a c \ .}\]
\[\text{T55bDN f if T59aDN f, T55b c \ .}\]
\[\text{T55aDN f if T55bDN f, T55a c \ .}\]

The letters ‘s’ and ‘xs’ represent route set and unset respectively. Here it may be observed that first sub-route is released as soon as the main route has been unset and the track circuit of the sub-route T59aDN has been cleared. Next sub-routes in chain get cleared if the sub-route in rear has been released (‘f’) and its track circuit also has been cleared. These commands are executed during major cycles.

Start-up from technical console: When power is first applied, a mode -1 start up sets the internal state to a predefined safe configuration and gets all yard equipment to set to the safe state and disables all commands from the operating cum indication panel. The interlocking can then be enabled from the technical console only.

Restart in case of power failure: For short time much of the contents in RAM will have been preserved a mode 2 or mode 3 start up shall be appropriate. The mode 2 start up while resets the internal state to safe configuration, it preserves the restrictions applied through technical console. In this case signals are disabled for long period enough to bring all trains to come to stop and allow the system to restart automatically. In case of mode 3 start up, the status of the routes is also preserved and the system restarts immediately.

The details as discussed above are only for the sake of example and different vendors use different methods and the modus operandi may differ from vendor to vendor.

10. Free wire data preparation: Free wire programme is prepared using logic circuits converted to Boolean algebra equations, programmed and fed to the EPROM. The Programme is developed in stages:

i) Preparation of selection table.

ii) Preparation of circuit diagrams in the same manner as that for ‘Q’ series relay based interlocking except that in case of EI the circuit is prepared in two parts. One is the logic circuits and other is the interface circuits. In case of logic circuits preparation of wiring diagram is not required as there is no limit for number of relays for the sake of contacts, thereby requirement of repeating relays is eliminated.

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iii) The circuit diagram is converted into Boolean equations.

iv) The Boolean equations are simplified and are converted into a programme in computer language.

v) This programme is ‘Application Logic’ and is loaded on to the processor module one of the methods being through 29 pin connectors from the laptop.

vi) The geographical layout and signalling scheme i.e. station’s Signal and Interlocking plan is loaded on to the processor module for purpose.

For preparation of selection table and logic circuits Chapter V (Electrical Interlocking) of this book may referred to.

10.1 Boolean Algebra: For the purpose of conversion of the logic circuits into Boolean equations, Boolean algebra has to be understood first.

i) Mathematician George Boolean conceived an idea that logical operations can be performed and can be expressed in terms of mathematical expressions. He published a book “An Investigation of the Laws of Thought on Which Are Founded the Mathematical Theories of Logic and Probabilities” in 1854. He developed a mathematical system named as, Boolean algebra which is a set of theorems, laws and rules. E.V. Huntington formulated postulates in 1904 which differed with some of postulates of Boolean theory. C.E. Shannon introduced ‘two valued Boolean algebra’ also called as ‘switching algebra’ in which he demonstrated that properties of bistable electrical switching circuits can be represented by the algebra propounded by him (Digital logic and Computer Design by M. Morris Mano - page 37).

Binary functions have only two levels, one shall be ‘1’ and other shall be ‘0’. ‘1’ could be any voltage level while ‘0’ could be another voltage at a level different and lesser than the voltage at ‘1’ but in two valued Boolean algebra values of level ‘1’ and ‘0’ are a defined voltage ‘one’ and voltage ‘zero, respectively.

10.2 Two valued Boolean algebra: As the entire relay based circuits switch in level ‘1’ or ‘0’, the two valued algebra suited most for conversion of the logic circuits into two valued Boolean functions and there from into Boolean equations. Accordingly variables are assumed to take any one value either ‘0’ or ‘1’ representing a ‘false’ or ‘true’ logic or ‘low’ or ‘high’ voltage levels respectively.

i) Operators used with the two valued Boolean algebra: The operators used in Boolean algebra though resemble mathematical operators but carry different meaning. An ‘and’ operator is represented by a dot (.) while an OR operator is represented by plus (+) and an inverted function is represented by symbol similar to inverted comma (‘). Some times the dot is also eliminated and no operator in between two functions is treated as operator ‘and’. The inverted function is also represented by a bar over the function (‾).

A logic circuit howsoever small or large may be has i) power, ii) conditions and iii) output. A circuit for energising signal lighting relay HR shall require all track circuit relays ahead of the signal energised, approach stick relay (ASR) de-energised, LR relay for the route energised, crank handle proved locked, all points for the route on which train is scheduled to traverse are set and locked. (Refer Chapter V, Electrical system of Interlocking of this book).
For example, relay’s of which pick up contact is proved for energising HR are considered at level ‘1’ and those the back contact of which is proved to energise HR are considered at level ‘0’. A combination of these relays contacts extends power to energise HR which is the output of the circuit. It may be inferred that the set of relays forming conditions to energise HR may be at level ‘1’ or level ‘0’ but the output, i.e. the HR, has to be energised finally, which is at level ‘1’, invariably.

ii) Logic Gates and Binary Logic functions: Circuits may be designed and wired for typical application such that for one or more number of inputs a single desired out put is made available. Such tailor made circuits are called ‘Gates’. To meet with the requirement of application of Boolean logics i) AND, ii) OR and iii) NOT gates shall serve the purpose. However many more gates can be derived out of these gates such as iv) NAND, & v) NOR Gates. Each of these gates is represented by a unique symbol as shown with each such description.

While inputs to the gates may be more than one the output is invariably one which shall depend upon inputs and the characteristics of the Gate.

To examine various outputs of this Gate with different permutations of input levels, a table is prepared called as truth table. The inputs to the logic circuit are represented by ‘a’, ‘b’, ‘c’ and so on and output function by ‘X’ or ‘F’. For the sake of example ‘a’ & ‘b’ are taken as inputs and ‘x’ as output for following gates. All possible permutations are worked out and placed in associated truth table:

a) AND Logic: Under AND logic, out put is ‘1’ only when all the inputs are ‘1’.

The logic equation works out to be: 
\[ x = a \cdot b \]

The equation may be also read as
\[ x = ab \], without dot in between.

\[
\begin{array}{ccc}
\text{a} & \text{b} & \text{x} = a \cdot b \\
0 & 0 & 0 \\
0 & 1 & 0 \\
1 & 0 & 0 \\
1 & 1 & 1 \\
\end{array}
\]

b) OR Logic: Under OR logic, out put is ‘1’ only when any of the inputs is ‘1’.

The equation works out to be:
\[ x = a + b \]

\[
\begin{array}{ccc}
\text{a} & \text{b} & \text{x} = a + b \\
0 & 0 & 0 \\
0 & 1 & 1 \\
1 & 0 & 1 \\
1 & 1 & 1 \\
\end{array}
\]

c) NOT Logic: Under NOT logic, there can be only one input and one output while out put shall invariably be inverted i.e. if the input is ‘1’ the output shall be ‘0’ and if the input is ‘0’ the output shall be ‘1’.

The equation works out to be: \[ x = a' \]

\[
\begin{array}{cc}
\text{a} & \text{x} = a' \\
0 & 1 \\
1 & 0 \\
\end{array}
\]
A small circle represents the function ‘Inverter’. If the ‘inverter’ function is applied at the apex of the Gate’s symbol the output of the Gate shall be inverted with reference to the given Gate’s original characteristics as in case of a NOT gate. If the ‘inverter’ function is applied at the input, the input shall be applied to the gate as inverted. For example if both the inputs ‘a’ & ‘b’ are at level ‘1’ the input ‘a’ shall be applied to the gate as level ‘1’ and the input ‘b’ shall get inverted and be applied to the gate as level ‘0’ the output shall be level ‘0’ only due to properties of the AND gate. This is true for all type of Gates.

d) NAND Logic: Accordingly output of the NAND operation shall be inverted. If both the inputs are at level ‘1’ the output shall be level ‘0’.
The equation works out to be:
\[
x = (a \cdot b)'
\]

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>x = (a b)'</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

10.3 Formation & simplification of Boolean equations: About 900 to 1000 ‘Q’ series relays are used for a 5 line station. Here each logic circuit is defined by energisation of a relay. This works out to be 900 -1000 circuits some of which may be very small and some may be with a complicated network. To put all these circuits into one programme as many equations shall have to be prepared and used for preparation of a programme. It therefore is imperative that these equations are simplified to reduce the quantum, duplication and complication of the work. For the purpose of simplification of these Boolean equations Huntington, DeMorgan and Karnaugh set out certain postulates and theorems. A Postulate is the fundamental rule which is proven by itself while a theorem requires to be proved.

Postulates given by Huntington in the table number 10.3 set ‘a’ and set ‘b’ are interchangeable by replacement of AND operator by OR and ‘1’ by ‘0’. This property is called as duality principle. These postulates shall be helpful in simplification of the equations.
<table>
<thead>
<tr>
<th>Rule applied</th>
<th>Set ‘a’</th>
<th>Set ‘b’</th>
</tr>
</thead>
<tbody>
<tr>
<td>- -</td>
<td>Postulate $a + 0 = a$ (OR rule)</td>
<td>$a.1 = a$ (AND rule)</td>
</tr>
<tr>
<td>- -</td>
<td>Postulate $a + a’ = 1$ (OR rule)</td>
<td>$a.a’ = 0$ (AND rule)</td>
</tr>
<tr>
<td>- -</td>
<td>Theorem $a + a = a$ (OR rule)</td>
<td>$a.a = a$ (AND rule)</td>
</tr>
<tr>
<td>- -</td>
<td>Theorem $a + 1 = 1$ (OR rule)</td>
<td>$a.0 = 0$ (AND rule)</td>
</tr>
<tr>
<td>Complementation rule</td>
<td>Theorem $(a’)’ = a$</td>
<td></td>
</tr>
<tr>
<td>Commutative rule</td>
<td>Postulate $a + b = b + a$</td>
<td>$a. b = b . a$</td>
</tr>
<tr>
<td>Associative rule</td>
<td>Theorem $a + (b + c) = (a + b) + c$</td>
<td>$a . (b . c) = (a . b) . c$</td>
</tr>
<tr>
<td>Distributive rule</td>
<td>Postulate $a (b + c) = (a . b) + (a . c)$</td>
<td>$a + (b . c) = (a + b) . (a + c)$</td>
</tr>
</tbody>
</table>

**Table No 10.3.**

**Boolean Theorems and postulates given by Huntington**

10.4 **DeMorgan’s Theorem:**

**Theorem 1:** The theorem speaks that ‘The complement of product form of an expression is equal to the sum of complements’ i.e. $(a . b . c)’ = a’ + b’ + c’$.

Take the expression $f = [(a + b)’. c’]$ to be simplified, using DeMorgan’s theorem:

$f = (a + b)^' + c''$ - breaking brackets the expression is converted & applied to this theorem.

$f = (a + b) + c$ - Complementation theorem.

**Theorem 2:** ‘The complement of product form of an expression is equal to the sum of complements’ i.e. $(a + b + c)’ = a’ . b’ . c’$.

Take the expression $f = [(a + b)’ + c’]$ to simplify, using Demorgan’s theorem:

$f = (a + b)’. c''$ - breaking braces the expression is converted & applied to this theorem.

$f = (a + b). c$ - Complementation theorem.

10.5 **Simplification of switching functions:** A given equation derived out of logic circuits is simplified by use of the Postulates and theorems as discussed in preceding paragraphs and is translated into a programme.

For the sake of example simplification of the logic function $f = ab + a (b+ c) + b(b + c)$ using basic gates, Boolean postulates and theorems to realize the minimized function shall be:

$f = ab + a(b+ c) + b(b + c)$

$= ab + ab + ac + bb + bc$

$= ab + ac + b + bc$

$= ab + ac + b$

$= b + ac$

10.6 **Conversion of Logic Circuit into Boolean equations:** Using characteristics of logic gates as discussed in preceding paragraphs, the hard drawn logic circuits are converted into Boolean equations.

All the Boolean equations so formed are simplified and in turn are used to prepare a programme in computer language.
For example, take the circuit for energisation of 18ASR as given in figure 10.6a, the array of Gates depending on their functions with reference to logic circuits and the relay to be energised as final output as the function of the gate is placed at figure number 10.6b.

Taking A18HR as- a, A18HHR as- a1, A18DR as- a2, 18HECR as- b, 18DECR as- c, 18 HR as- d, 18D UHR as- d1, 18DR as- e, 18UCR as- e1, 18CLR as- g, 18DLR as- g1, EUYNR as- h, 18GNR as- j and 18ASR as- k while 18 ASR is also the output of the circuit as such taken as- f. The corresponding array of gates shall be as given in figure 7.2.6b. Here ‘f’ is the output of the system while ‘k’ is used symbol for ASR. These two shall be defined to connect each other.

\[ f_1 = g'.g1'.h.j \]

\[ f_2 = f_1 + k \]

\[ f = a'.a1'.a2'.b'.c'.d'.d1'.e'.e1'.f2 \]

The equivalent Gate array satisfies the circuit as i) in case of common limb of the circuit all relays back contacts are used which are at level zero. Accordingly inputs representing these dropped relay contacts are connected inverted as input to get level one as input to the AND gate (referred as first AND gate hence forth); ii) In the branched off upper part of the limb 18CLR and 18DR back contacts are also taken at level zero, as such connected as inverted input g & g1 to the second AND gate for the same reason; Pickup contacts of relays 18GNR and EUYNR are already at level one as such added as input to the same second AND gate directly.
without being inverted to get combined output as f1 at level one. Output f1 of second AND gate is fed to an OR gate to get output f2 which is connected as input to the first AND gate. F2 shall be at level one even if one of the inputs is at level one accordingly since f1 is at level one, f2 shall also be at level one which when added as input to the first AND gate the output of this gate shall also be one till the conditions as discussed so far prevail.

Since the output of first AND gate is level one, which is connected as input to the OR gate as k, the output of the OR gate shall not be affected even if the output of the second AND gate becomes level zero thereby continuing to set the output level of first AND gate at level one till any of the inverted inputs, except f2, to this first AND gate comes to level zero.

18ASR shall get energised on getting level ‘1’.

10.7 Preparation and execution of application programme: The programme is prepared based on different methods used by different vendors.

10.7.1 Preparation of application programme: Microlock II uses free wire system of programming. It supports Boolean bits and Numeric variables data.

Under free wire system, programme is written in text with NOT, AND, OR, XOR Boolean operators and ASSIGN, IF, INPUT, OUTPUT, END and many more operators reserved for not to be used as any part of the Boolean expressions. All equations in the programme are either i) vital or ii) non-vital. A vital equation cannot be assigned into non-vital section. An assignment statement shall be ‘ASSIGN <Boolean expressions> TO’.

All bits that are used fall in category i) Inputs, ii) outputs or, iii) internal variables. For execution of a command, inputs are received by the processor from the panel or the VDU. Equipment status from the yard is also received as inputs. As and when there is a change in the status received by the CPU, the information is processed and generated as output. The output bit drives the relay on interface rack and indications on the panel or VDU. Input and output bits are processed through interface I/O boards.

The application includes, in addition to the basic Boolean logic, tables processing and block processing with numeric variables and operations. A Boolean bit is akin to a relay coil which is affected by an input bit and thereupon delivers output bit.

Boolean statements are i) EVALUTE, ii) NV. EVALUATE, iii) IF THEN ELSE, iv) ASSIGN, and v) NV. ASSIGN while numeric statement is EVALUATE. Similar to ASSIGN for Boolean section of the programme Evaluation is for NUMERIC section. Special features of numeric statement are to define internal time source and other such numeric functions.

- Boolean bits are akin to relay contacts and as such appear as “18ASR, 3ASR, 18HR” etcetera.
- Timer bits are used for making the relay slow to pickup or slow to release which can be added to the Boolean bit to look as “18ASR SET 120: SECS CLEAR 0: SECS;”.
- Approach locking programme shall look like:
“ASSIGN \((\neg18CLR\star18DLR\star\neg18YU\star\neg18GNR)\oplus(18ASR))\star(\neg18HR\star18ASR\star\neg18DR\star\neg18HE\star\neg18DE\star\neg18HR\star\neg18DU\star\neg18DR\star\neg18UC)\) TO 18ASR”.

Operator symbols used here are: \(\neg\) for NOT, \(\star\) for AND and \(\oplus\) for OR.

Interface cards are defined for communication with yard through interface relay rack, panel or VDU and CPU.

The programme is converted by the Compiler, which is a 32 bit compatible programme, written in text, to machine language.

10.7.2 **Programme execution**: Execution of Boolean logic ASSIGN statements part of the programme is executed by those ASSIGN or NV-ASSIGN statements which are to be re-evaluated based on changes. As soon as an input changes its state the executive software shall list all those equations which are affected by such input bit.

Execution of the *Numeric blocks* portion of the programme takes place initiated by one or more Boolean bit which controls the numeric block’s execution. Whenever one of the concerned Boolean bits makes a transition from zero to one, the numeric block is marked for execution. Once the execution of the numeric block starts it shall continue till completion uninterrupted.

10.8 **Uploading the Application programme onto the CPU**: The programme is uploaded onto the CPU from a laptop through maintenance terminal using one of the laptop’s serial port. The programme is evaluated in factory for acceptance termed as Factory Acceptance Test (FAT) with the help of simulator panel or simulation by PC using Free Run variable Display (FRVD) submenu in maintenance tool. It is then tested at site before final application and bringing it to use by real operation up to cable termination racks. Simulation of field equipments such as point machines, signals and track circuits is done through a panel representing each equipment connected on the CT rack corresponding terminals. This testing is termed as Site Acceptance Test (SAT).

Each occasion of modification the programme, which shall require re-burning of the EPROM, shall require complete FAT & SAT to ensure that the change has not altered any of the existing feature.

11. **Methods of connecting field equipment with the EI**: Field equipments are normally connected to the field equipment through interface relays. Vital output modules provide feed to these relays which extends the power to field gears like points etcetera. Similarly status of field equipments is used to operate interface relays which are read by vital input modules. Panel is connected with non vital I/O modules.
11.1 Through interface relays:
(A) Relays to control the signal aspects (HR, HHR & DR), point operation (NWR & RWR), and locking or releasing level crossing gate relays and any other control such as Line Clear from adjacent station for departure of trains, Block section clearance by incoming trains etcetera, on independent rack provided in the same room and near to the rack on which CPU for EI is provided [Fig 11A], and;
(B) Relays to repeat the indications to EI: Lamp checking relays (ECRs) for Indications of signals, point indication relays (NWKR & RWKR) for normal and reverse setting and locking, relays proving closed or opened status of the level crossing gates, in the room on the same rack on which controlling relays are provided. The incoming status of the signals, points, track circuits and level crossing gates etcetera provided by repeating relays, is communicated to the CPU via Input processor module through Opto-couplers.[Fig 11B].

The optical coupling arrangement is to ensure that no power supply is fed to the input board directly but the light source is coupled to the receiver of input board. As the 18GECR relay is energised the 24V power supply extends through pick up contacts of the relay to energise the optical light source. This is designed to detect the closed contacts of the corresponding relay. Similar is the case with 55 NWKR.

With the availability of failsafe power switching devices, EI systems are available in which output modules directly drive Signal lamps and point motors.

![Figure 11B](image1)
*Interface circuits for input to the system*

![Figure 11 A](image2)
*Commands generated by the system for field*

11.2 Through Optical Fibre Cable (OFC): Huge amount of signalling copper cable is laid between central place where EI system is provided and entire length and breadth of the station yard for control of the operated equipment such as points and signals and transfer of status of various monitoring devices such as track circuits, signal lamps checking, status of points etcetera as discussed under preceding paragraph number 7, Distributed Interlocking system.

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In case of Automatic Block Signalling, the Logic of interlocking may be relay based or a **mini EI** based. Whenever Automatic Block signalling is provided in the block section adjacent to the station on which EI is provided, in any case the status of signals and track circuits in Automatic Block Section is required to be made available to the EI provided for the Station section for the purpose of departure and reception signal aspect control, for this the Automatic Block section is divided into two sections one being attached to one station and the other to the adjoining station. This is also required if Centralized Traffic Control (CTC) is contemplated in the section.

It makes transfer of the information easier and economical if a smaller EI is provided in the Automatic Block Section as in such a situation a relay hut which may be prefabricated steel or any other suitable structure installed on either end of the station yard. All such information of automatic block signalling section is transferred to the main SSSI system provided at the station.

The smaller EI meant for the Automatic Block Section may also be used for execution of commands received from the main EI from the station for operation of points, locking unlocking of the level crossing gates and crank handles an transferring status of the area in the portion of yard covered by it back to the main EI, thereby reducing huge copper cables laid between main EI at the station to the yard.

This serves the purpose for:

a) The smaller EI which shall be equipped with status of the signals and track circuits in the Automatic Block Section under its control, shall transfer all the information to main EI at the station,

b) Transferring status of the station section covering status of points set and locked in normal or reverse position, signal aspects illuminated red, yellow, double yellow or green, track circuits clear or occupied, crank handles locked or released and level crossing gates closed and locked or open. The failure of track circuits signal or points shall be decided by the system through logic and the information received from both ends of the station through the smaller EI to the main EI,

c) Transferring all commands for signal aspect control, point operation and level crossing control if any, from main EI of the station to both ends of station yard through smaller EIs.

d) Only derivation signalling copper cable is laid between the smaller EIs and corresponding signals, points, and level crossing gates on both ends of the station thereby saving huge quantities of main signalling copper cable to be run between centrally placed main EI and the associated operated equipment on both ends of station section.

In such situation the centrally provided IPS is split into two to be provided in relay huts where the smaller EI is provided, which in turn shall take care of the power supply requirements of half of the station section with associated half of the Automatic Block section.
11.3 **Through copper cable**: *Directly*, by connecting Input / Output processor module, through screened, twisted pair copper cable with 100 ohms characteristic impedance terminate on the equipment with matching impedance, which is duplicated to ensure that one link failure does not affect the system. The connection is for each link on individual cable.

The distance for connection is limited to 10 km due to attenuation losses and distortion of the data. For operation beyond such distance a bidirectional repeater, by providing two data link modules back to back, is required. Such connection can be provided up to a maximum distance of 40 km by using 4 repeaters placing them at a distance of 8 km. In case of area electrified with 25 KV AC traction isolation transformers shall be provided to safeguard against effects of induced e.m.f.

This practice however is not in use on Indian railways.

12. **Data logging**: the EI system is capable of logging data happenings inside the EI system. Any of the bits used in programme are logged as defined under the programme. Accordingly it does not log data which is outside the system such as health of power supply or cable etcetera necessitating provision of a data logger with analogue inputs for monitoring voltage variations and status of other power supply units, Earth leak detectors and digital inputs similar to cable cuts etcetera are provided in addition to the data logged by the EI system.

13. **EI installations on Indian Railways**: 374 EI systems as on 30.11.2009 have been brought into use on Indian railways by six international vendors as detailed below which is an indicator of future system of Interlocking.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>No. of Installations</th>
<th>Vendor</th>
<th>No. of Installations</th>
</tr>
</thead>
<tbody>
<tr>
<td>US &amp; S</td>
<td>300</td>
<td>Siemens</td>
<td>23</td>
</tr>
<tr>
<td>Westrace</td>
<td>11</td>
<td>G.E.</td>
<td>22</td>
</tr>
<tr>
<td><strong>Kyosan</strong></td>
<td><strong>07</strong></td>
<td><strong>AZD-Praha</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

****
1. **Multiple choice questions:**

1. SSI interlocking system is managed through:
   (a) Microprocessor.
   (b) Relays.
   (c) Application logic software.
   (d) All of above*  

2. The software for EI are loaded on:
   (a) EPROM.*
   (b) RAM.
   (c) ALU.
   (d) I/O of EI.

3. I/O of EI is used for:
   (a) Receipt of yard statues.
   (b) Receipt of commands from VDU.
   (c) Transmitting control to interface relay rack.
   (d) Transmitting indication on to VDU.
   (e) All of them.*

4. Logic Application Software is required for:
   (a) Operation and management of hardware.
   (b) Analysing commands & status of the station yard.*
   (c) Checking of the system performance.
   (d) All of them.

5. Railway Board has allowed provision of EI for routes:
   (a) Up to 200. *
   (b) More than 200.
   (c) Up to 50.
   (d) More than 50 but less than 200.

2. **Select the right answer (True/False)**

1. SSI system must meet SIL – 4 conforming to standards laid by European committee for Technical Standardization standards – True*/False

2. CENELEC is abbreviated form of European committee for Technical standardization standards – True*/False

3. The modification to software shall be loaded through maintenance terminal as such the control operation of the yard can also be done from maintenance terminal – True*/False

4. The only method to work EI system is Free wire system. - True*/False

5. Under free wire system Generic programme is to look after basic functions of interlocking and also to monitor function of the EI system – True*/False

6. With reference of transfer of electronic data each level station ‘low’ or ‘high’ is a ‘bit’ - True*/False
3. **Answer the following questions:**

1. Write short notes with reference to EI on:
   (a) Hardware architecture.
   (b) Basic difference between Warm & Hot standby.
   (c) Boolean algebra.

2. Discuss Application logic programme.

3. Discuss role of:
   (a) Operating system programme.
   (b) Application logic Programme.
   (c) Generic programme.

4. Describe architecture of EI system:

5. Describe how application logic programme shall be developed from a circuit diagram.

*****
CHAPTER-VII

MONITORING DEVICES

1. Monitoring devices are grouped as i) devices to monitor features related to safety, ii) monitoring correspondence between operating device and operated equipment and iii) safety against collisions.

1.1 Monitoring important safety functions of signalling system:
   a) Track vacancy detection: DC track circuits, AC Track circuits and Axle counters.
   b) Power supply health.
   c) Data logger: event monitoring.
   d) Cable health: Earth leak detector.

1.2 Monitor correspondence of operating device and operated equipment:
   a) Points set normal or reverse and locked detection.
   b) Illumination of signal indication: Lamp checking relay (ECR) [refer Chapter V of this book] & Arm & Light repeater.
   c) Locking and release of level crossing gate control.
   d) Locking and release of crank handle control.
   e) Lever lock [refer Chapter V of this book].

1.3 Anti Collision devices.

2. Track vacancy detection: With the increasing traffic density & speed of trains, monitoring track vacancy has become one of the most important safety feature requirement of the signalling system. Track vacancy detection is “Detection of a defined portion of the railway track for occupancy by a train or being clear”. The device for detection of track vacancy is, by convention, called as Track Circuit. As per clause 1.02(57) of Indian Government Railways General Rules 2006, the Track Circuit is defined as “an electrical circuit provided to detect the presence of a vehicle on a portion of track, the rails of the track forming part of the circuit”.

DC and Audio Frequency Track Circuits are one of the track vacancy monitoring devices in conformity to Indian Government Railways General Rules definition, besides Axle counter, which is another track vacancy monitoring device using different technique discussed in ensuing paragraphs.

2.1 Minimum length of track circuits: In this context it is very important to understand the meaning of a train. A train is defined under clause 1.02(58) of Indian Government Railways General Rules 2006 as “an engine with or without vehicles attached, or any self-propelled vehicle with or without a trailer, which cannot be readily lifted off the track”. It may be noted that the smallest vehicle under the definition is a motor trolley. The minimum length of a track circuit is designed keeping in view i) minimum and maximum distance between wheel bases of a vehicle attached or unattached to a train, time required for the track and repeater relay to de-energise and speed of fastest running train on the section [SEM part-II, 2001 clause17.2]. This minimum length of the track circuit is specified to be two standard rail lengths (13Mts. each).
The track vacancy detection is required for:

i) Track occupancy: To monitor presence of a train or a vehicle over a defined portion of the track to ensure that the signal is not attempted to be taken Off when the line on which the train is to be moved is occupied.

ii) Replacement of the signal: Provided just ahead of the signal concerned, such that as soon as the train occupies track ahead of the signal, it is replaced to On.

iii) Flank protection: As and where a point or crossover takes off from a line to divert the movement of the train to the line connected through the crossover or converges on to line to lead in the train from another line, both the lines foul with each other at a specified position called as 'Fouling Mark'(FM). The track vacancy detection boundaries are set in such a manner that it shall not possible to take a signal Off when a train or vehicle is occupying the portion of the track which fouls with the adjoining portion of the track. The distance between track circuit termination and the fouling mark shall not be less than 3.00 metres to ensure clearance of any portion of the vehicle extending beyond wheel contact with the rails [SEM Part-II, September 2001, clause17.11].

iv) Track locking: The track vacancy detection boundaries are made so as to ensure that it should not be possible to move the point or the crossover while any vehicle is occupying the point zone. The point zone is made to ensure flank protection also.

v) Defining Overlap & Block section limits: For receiving a train from block section, clear availability of the block overlap ahead of first stop signal of the station and for taking a signal Off in the station section clear availability of signal overlap ahead of next signal, is required to be ensured. The length of the track vacancy monitoring devise between signal and the measured distance is kept equal to overlap to enable the Station Master monitor that the desired length of track beyond the signal is not occupied to fulfil the conditions for taking the preceding signal Off.

vi) Ascertaining complete arrival of the train i.e. clearance of block section along with the block overlap.

vii) Establishing direction of the train movement.

viii) Assessing speed or speed control (Hump yard, catch siding).

ix) Trolley protection circuit for analogue axle counters.

These factors accordingly dictate to define the length of each track vacancy detection section. Some times when under compelling circum stances when Rail Insulation Joints on both rails of the track, at either end of the track circuit, are required to be staggered thereby crating a non-monitoring section of the track, the staggering between such rail insulation joints shall not exceed the minimum wheel base of the vehicles [SEM Part II September 2001 clause17.5.2].

2.2 Factors affecting performance of the track circuit: Track vacancy detection, when provided by using both rails of the track as two conductors of a circuit, should be sensitive enough to detect presence of the wheel over the rail. Multiple factors contribute in such monitoring.
2.2.1 **Resistance per 1000 metres of rails** including bonding them with each other by GI wire, or through CAD weld, should be not more than 0.5 Ohms for track circuit longer than 700 metres [SEM part-II, 2001 clause 17.10.03].

2.2.2 To maintain adequate **insulation between two rails** of the track, rails shall have to be laid on wooden sleepers but with the wood becoming scarce the track is laid on concrete sleepers. If track is laid on concrete sleepers the resistance of each sleeper shall not be less than 500 ohms between insert to insert [SEM Part-II, 2001 clause 17.5.10]. On concrete sleepers Glass Filled Nylon (GFN) liners are used instead of steel liners, between insert and Pendrol clip on the area of track provided with the track circuit [SEM Part II September 2001, clause 17.5.13], for insulation between insert and the rail. Availability of GFN liners shall be maintained to at least 97% [SEM Part II September 2001, clause 17.28].

2.2.3 **Lead cable** between track feed or track relay and the Track Lead Junction Box (TLJB) near track and between TLJB and the rail, shall preferably be 2.5 sq mm area of cross section copper conductor.

2.2.4 **Ballast resistance**: Ballast provides good insulation between two rails. However when mixed with the dust, other impurities and moisture and contact with the rails, insulation between two rails falls resulting in leakage of the current. Leakage of current also takes place through sleepers which varies with the moisture content in the atmosphere. All such leakage of current combined together, across two rails of the given track circuit, is inversely proportional to the total resistance across two rails. This resistance is called as ‘Ballast resistance’. The ballast resistance is prescribed to be not less than 2 ohms per kilometre in station yard and not less than 4 ohms per kilometres in block section [SEM Part-II, 2001 clause 17.28]. To maintain ballast resistance to the bare minimum, ballast shall be kept clean and should be clear of rails and rail fastenings at least by 50 mm from rail flange [SEM Part-II, 2001 clause 17.5.6].

2.2.5 **Train Shunt resistance (TSR)**: It is important that the track vacancy monitoring device which may be an electric circuit, does not fail in detection of presence of a train or a vehicle. This could happen if the wheel of a vehicle standing on siding for a long time gets rusted or the top of the rail of a loop line/siding, not used for a long time accumulates rust or dust or a combination of both and track is not shunted properly or over energisation of the track relay beyond prescribed limits, thereby voltage across track relay terminals not able to reach below a level to break front contacts of the Track relay. This is a highly unsafe situation to arrive. In order to ensure mitigate such a situation the track circuit is designed and adjusted such as that a resistance of 0.5 ohms between both the rails and corresponding all the wheels of a vehicle cumulatively do not offer resistance of more than 0.5 ohms [based on SEM Part-II, 2001 clause 17.31]. This resistance is called as ‘Train Shunt resistance’ (TSR). **TSR is defined as ‘that maximum value of resistance which when applied across both the rails of a track circuit shall cause the front contacts of the track relay to break’**.

The limits of TSR prescribed for track circuits is fixed as 0.5 ohms with the exception of AC track circuits on double rail track circuits where it is prescribed as 0.15 ohms.

Owing to the importance of the performance of the track circuit, TSR is required to be checked for each track circuit i) before bringing into use after installation, ii) after each adjustment to the track parameters and iii) on prescribed periodical schedule.
2.3 Direct Current (DC) Track circuits: Direct current track circuit is one of the most versatile, simple and reliable version of track circuits and is always the first choice amongst track circuits.

a) DC Track circuit provided in section where AC traction has not been provided:
Both rails of the track are used as the conductor laid on insulated sleepers wooden or Prestressed reinforcement Concrete (PSC) Sleepers. Once the track section is identified to be monitored for track vacancy, both ends of both the rails of the track section are electrically insulated from adjoining track whether there is a track circuit or not, by providing Rail Insulation on fish plated Joints (RIJ). The set of nylon plates and bushes is inserted between fish plate and rails and bushes on the fish plate bolts to insulate bolts with the fishplate. An End post of the same cross section and profile as that of rail end is inserted between to rails joining. To make the insulated joint as one monolithic block, one steel ferule is provided between fish plate bolt and the rail web to protect from ill affects of the creep in rails. Owing to heavy stresses on the insulated joint in the block section, the insulating material gets occasionally crushed as such the entire joint is provided in the work shop with rail pieces of minimum 6 metre length on both ends of the joint made as monolithic block fixed with the glue. This arrangement is conventionally known as ‘Glued Joint’. The life of such a joint is considerably high and turns out to be a great maintenance relief.

The relay is connected to the rails through a cable near the insulation joint of the track circuit which is on approaching end of the signalled move and the power supply is connected through the adjustable ‘Limiting resistance’ in series with the power supply circuit near the RIJ on other end of the track section. A choke is provided in series of the relay when the track circuit is provided in area electrified with 25 KV AC [Figure 2.3a].

This limiting resistance has very important role in the function of the track circuit.

![Figure 2.3a](image)

**Schematic DC track circuit arrangement**

**Function:** The circuit as simple as shown in figure 2.3a functions in a bit complex manner, maintaining TSR as low as possible but in any case less than 0.5 ohms with worst ballast and rail resistance while at the same time the system has to be steady and reliable.
It is pertinent to note that when the wheels of a train shunt across both the rails of a track circuit, the current through the limiting resistance increases increasing voltage drop across itself such that voltage across the track relay decreases to maintain sum total of drop in voltage across rail resistance + limiting resistance + across the relay, equal to the feeder voltage which is 6 Volts. The variable limiting resistance is adjusted such that when the train occupies the track, voltage drop across limiting resistance is enough to reduce the voltage across track relay below its drop away value.

For the example if we take worst ballast resistance as 2 ohms, the rail resistance as 0.5 ohms per 1000 meters for a track of 350 meters and power supply to feed the track circuit as 6V the Track circuit shall be represented in terms of a circuit with different parameters permissible limits, as given in the figure 2.3b.

Consider ‘E’ to be power supply voltage for the track circuit, ‘Erc’ to be the voltage across rails when track is clear of a vehicle, ‘Erd’ to be the voltage across rails when the front contact of the relay are just opened, Rtsr to be Train Shunt Resistance, ‘Rb’ to be the ballast resistance, ‘Rr’ to be the relay resistance and ‘Rl’ to be the limiting resistance including rail resistance which is of negligible value [Figure 2.3c].
Also let the resistances so taken to be represented by conductance \((g)\) for corresponding resistances, for the sake of convenience of calculation, the equation\( g_{TSR} = (E_{RC}/E_{RD} - 1)(g_B + g_R + g_L)\) shall give the value of TSR under different set of track conditions.

If worst values of all the known parameters is filled in the given equation \(E_{RC} = 3.5\text{V} (250\% of 1.4\text{V, the pick up value of QT1 relay}), E_{RD} = 0.711\text{V} (taking minimum percent release as 68\% of 0.117 A, the maximum operating current of the relay working out to be 0.079A \times \text{relay coil resistance 9 Ohms})\), \(g_B = 1/0.5\text{ i.e. 2.0 mho, } g_R = 1/9\text{ i.e. 0.111 mho}\) and \(g_L\) (to be worked out). Putting the figures into the equation \(2.0 = \{(3.5/0.71)-1\} (0.5 + 0.11 + g_L)\), \(g_L\) works out to be \((-) 0.099 \text{ mho i.e. limiting resistance as(-) 10 Ohms}.\) Since the output is negative, the available TSR shall be about 4 Ohms under given parameters.

Effect on TSR: The TSR is the most sensitive parameter of any track circuit irrespective the type of the circuit used. With specific reference to a DC track circuit it is pertinent to examine affect on TSR of variation of different parameters:

a) Variation in percentage release.

b) Variation in ballast resistance.

c) Variation in relay resistance.

c) Variation in limiting resistance.

Effect of variation in percentage release on TSR: To keep the track relay sensitive to better TSR, high percentage release is required. However at the onset of monsoon and at the time of first shower when the ballast is covered with fine dust the ballast resistance goes down due to multiple parallel paths. Although the dust gets washed away with the continued downpour, the track relay with high percent release shall drop requiring the track circuit current to be readjusted affecting TSR adversely. With this reason the percentage release of the track relay is kept at the best compromise between better TSR and track circuit failure.

Effect of variation in ballast resistance on TSR: Keeping the limiting resistance fixed the voltage across track relay increases with the increase in ballast resistance and decreases with the decrease in ballast resistance. Since the TSR is inversely proportional to the voltage on track relay, thereby TSR is adversely affected with the increase in ballast resistance and vice-versa. It is a paradox since ballast resistance is always required high for efficient performance of the track circuit. The limiting resistance has therefore to be adjusted such as the track circuit functions optimally with increase and decrease in ballast resistance.

Ballast resistance is one of the most unreliable components of the track circuit demanding frequent adjustment to the limiting resistance. However this neither is practicable nor desirable as doing so may result in failure of track circuit if limiting resistance goes down to near minimum with rain or TSR crossing the prescribed limit when limiting resistance is adjusted to cater for low ballast resistance but the ballast resistance goes high with sun since thereby creating unsafe conditions.

Ballast resistance is one of the most unreliable components of the track circuit demanding frequent adjustment to the limiting resistance. However this neither is practicable nor desirable as doing so may result in failure of track circuit if limiting resistance goes down to near minimum with rain or TSR crossing the prescribed limit when limiting resistance is adjusted to cater for low ballast resistance but the ballast resistance goes high with sun since thereby creating unsafe conditions.
Berthing tracks on railway stations, placed on washable apron surrounded by drains, usually showing low ballast resistance, are adjusted normally to cater for low ballast resistance.

**Effect of variation in relay resistance & Limiting resistance on TSR:** Looking at the equation to work out $g_{TSR}$ as discussed in preceding paragraph it may be appreciated that $g_{TSR}$ is directly proportional to $[g_R \text{ (Relay conductance)} + g_B \text{ (ballast conductance)} + g_L \text{ (limiting conductance)}]$. With the increase in relay resistance the pickup voltage shall increase correspondingly, thereby decreasing operating current as well as decreasing limiting resistance. In terms of conductance the $g_L$ increases with the increase in $g_R$. It may further be noticed that with the decrease in limiting resistance tending towards zero, the track circuit shall become non-functional at zero limiting resistance with the TSR falling to zero ohms.

With the increase in relay resistance the pickup voltage of the relay also increases demanding a higher voltage battery charger and corresponding battery bank without corresponding gain in the efficiency in the functioning of track circuit.

**Staggering of polarity:** All adjoining track circuits which butt each other are provided with staggered polarity i.e. the negative polarity rail of track circuit shall invariably butt with positive polarity rail of the adjoining track circuit to avoid extension of the track circuit to the other in case of Insulation Rail Joint getting crushed and loosing insulation, making both track circuits as one operating with two different power sources, creating undesirable conditions.

b) **DC Track circuit provided in 25 KV AC traction section:** The electric motor of the loco is fed through Over Head Catenary at 25 KV AC via pantograph and the return current flows through both the rails. About 300amps current flows through the rails due to one loco. In one feeder section two locos may be available at any one stretch of time there by doubling the amount of the current to 600 Amps. The rails are earthed at each feeder post, thereby giving a return path to the loco return current through the earth. Accordingly, for provision of a DC track circuit in such area, one rail is essentially required to be kept free to carry traction return current. Since the DC track circuit requires two rails to complete the circuit, the rail used for traction return current is also used to share DC track circuit return current.

![Figure 2.3d](image)

*Figure 2.3d DC Track circuit staggering of polarity in area provided with 25KV AC traction*
The DC track circuit is conventionally called as single rail track circuit in such areas though it is not a single rail track circuit in effect. Since the loco permits the return current to pass through both the rails, current is diverted to flow through rail giving continuity to the return current up to earth connection provided at the feeder post. However the return current may always find a path through Relay coil to the traction return rail creating unsafe conditions due energisation of track relay under heavy current as well as burning the relay coils. To avoid such a situation a high impedance choke is provided in series with the relay. For arrangement of the DC track circuit proved in AC traction area see figure 2.3.d.

Here also all track circuits butting each other are provided with staggered polarity. Due the staggering of polarity the traction return rail also gets staggered and is connected with Mild Steel (MS) flat traction bonds to maintain connectivity to the traction return rails till the last track circuit in the station section ends whereupon both the rails of the track are bonded together to share further flow of current up to earth connection.

2.3.1 Limiting resistance: Limiting resistance is the variable resistance provided at the feed end in series with the power supply to the track circuit adjusted to cause a voltage drop across itself in such a way that minimum and maximum energisation of the track relay remains within prescribed limits taking into account the current leakage through ballast and maintaining TSR not higher than 0.5 ohms.

2.3.2 Track Relay, its resistance and excitation limits: In sections provided with 25 AC traction, plug-in type track relays of 9 ohm resistance shall be used in all future installations. In non-electrified section the resistance of the shelf type relay shall be 9 ohms except for track circuit of more than 100 metres laid on wooden sleepers it shall be 2.5 ohms. [SEM Part-II, 2001 clause 17.15.2]

2.3.3 Excitation limits: The track relay shall be over energised minimum to 125% and maximum 250% of its rated pickup voltages for shelf type relays while the maximum over energisation for plug-in type relay can be done up to 300% [SEM Part-II, 2001 clause 17.15.4]. The minimum excitation of track relay to 125% of its pickup voltage is to cater for varying ballast resistance and maximum over energisation is to take care of TSR and to avoid saturation of the core of the track relay coil.

2.3.4 Maximum permissible length of a DC track circuit under different conditions is tabulated as below [SEM Part-II, September, 2001 clause 17.15.5]:

<table>
<thead>
<tr>
<th>SN</th>
<th>Area</th>
<th>Sleeper Type</th>
<th>Section Yard/ Auto Block</th>
<th>Minimum ballast resistance</th>
<th>Maximum permissible length of</th>
<th>Type of track relay to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-RE</td>
<td>Wooden/ PSC</td>
<td>Block/ Station</td>
<td>4/2 Ohms</td>
<td>100 mts.</td>
<td>QT type 4 or 9 ohms</td>
</tr>
<tr>
<td>2</td>
<td>Non-RE</td>
<td>Wooden</td>
<td>Block</td>
<td>4 Ohms</td>
<td>1000 mts.</td>
<td>Shelf type 2.5 ohms</td>
</tr>
<tr>
<td>3</td>
<td>Non-RE</td>
<td>Wooden/ PSC</td>
<td>Yard</td>
<td>2 Ohms</td>
<td>670 mts.</td>
<td>-do as 1 &amp; 2 above.</td>
</tr>
<tr>
<td>4</td>
<td>RE</td>
<td>Block</td>
<td></td>
<td>4 Ohms</td>
<td>450 mts.</td>
<td>QT or shelf type 9 ohms ACI</td>
</tr>
<tr>
<td>5</td>
<td>RE</td>
<td>Wooden</td>
<td>Yard</td>
<td>2 Ohms</td>
<td>450 mts.</td>
<td>-do-</td>
</tr>
<tr>
<td>6</td>
<td>RE</td>
<td>Wooden</td>
<td>Block</td>
<td>4 Ohms</td>
<td>450 mts.</td>
<td>-do-</td>
</tr>
</tbody>
</table>
2.4 Alternating Current (AC) track circuits: In area electrified on DC traction or where a DC track circuit does not work due to interference by stray currents caused by a factory in vicinity or any reason whatsoever, alternating current track circuit is used. Three phase supply at 110V AC is required to operate the track circuit.

The AC track circuit works on two independent phases so as to create a torque on the vane of the relay. Track feed is connected with power supply through 110:6-12 V transformer. The secondary winding of the transformer is connected to the rails through, i) resistance, ii) reactance or iii) capacitance as regulating device for the track circuit.

In area electrified with AC traction, either single rail track circuits are used where one of the rails is used by the track circuit and the other rail is shared by the track circuit with the traction return current. In case a two rail track circuit is required to be used essentially, the impedance bond is provided for facilitating free flow of traction return current.

2.4.1 Resistance fed AC track circuit: The track circuit may be used with single phase also with the restriction that only short length track circuits can be used. The relay de-energises due to reduction in phase angle with the occupation of the track circuit by train. Variable resistance is provided in between the feeding transformer and the rail at feed end of the track circuit. At relay end the rail is connected to the control winding of the relay. The local winding of the relay is fed from the same phase of AC as that of at the feed end [Figure 2.4.1]. The resistance fed track circuit suffers from a poor phase angle and constant loss of power.

![Figure 2.4.1](image-url)

*Schematic resistance fed single phase two rail AC track circuit.*

With three phase supply, power to local coil of the relay is fed from one of the three phases other than the one used for control coil fed through the track. In such a case the resistance fed track circuit gives a good phase angle.

2.4.2 Reactance fed AC track circuit: The track circuit arrangement is similar to resistance fed track circuit except that the variable resistance is replaced by a variable reactance at the
feed end. As the ballast resistance falls, there is a drop in voltage across rails. To make good this drop the regulating reactance has to be decreased resulting in decrease of the operating phase angle. A corresponding increase is, accordingly, required to be done in power supply voltage. A balance between reactance and power supply voltage is therefore required to be maintained to obtain a good operating phase angle.

2.4.3 Capacitance fed AC track circuit: The track circuit arrangement is similar to resistance fed track circuit except that the variable resistance is replaced by a variable capacitor at the feed end. In order to avoid the capacitor of a large capacity 1:1 transformer is used at the feed end. In case track relay used is non-resonated the phase angle improves when the train shunt is applied however with the use of resonated relay the phase angle remains 90° throughout (figure 2.4.3 tuned AC track relay).

2.5 Audio Frequency Track circuit (AFTC): Issue of making an Rail Insulation Joint (RIJ) has always been a cause of concern more for Permanent Way Engineers and also for Signal Engineers, the RIJ being the weakest link with a view of maintenance of track geometry as well as with a view of performance of the track circuit, respectively. The AFTC becomes of the greatest advantage being a joint less track circuit.

Like any other track circuit, each AFTC shall have its boundaries to define the area to be monitored. The boundary, in case of Audio Frequency Track Circuit, is defined by an Electric Separation Joint.

AFTC has few more advantages over DC track circuit, i) of not getting affected by the stray currents, ii) monitoring rail continuity by default though not reliably established, iii) uses both rails in 25KV AC traction area also thereby allowing both rails to be used for traction return path, iv) increased length of each track circuit section extending up to 1000 metres, thereby reducing number of track sections especially in Automatic Block Signalling section on PSC sleepers.

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency band (Hz)</th>
<th>Nominal frequency (Hz)</th>
<th>Type</th>
<th>Frequency band (Hz)</th>
<th>Nominal frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1682-1716</td>
<td>1699</td>
<td>E</td>
<td>1532-1566</td>
<td>1549</td>
</tr>
<tr>
<td>B</td>
<td>2279-2313</td>
<td>2296</td>
<td>F</td>
<td>2129-2163</td>
<td>2146</td>
</tr>
<tr>
<td>C</td>
<td>1979-2013</td>
<td>1996</td>
<td>G</td>
<td>1831-1865</td>
<td>1848</td>
</tr>
<tr>
<td>D</td>
<td>2576-2610</td>
<td>2593</td>
<td>H</td>
<td>2428-2462</td>
<td>2445</td>
</tr>
</tbody>
</table>

These frequencies are modulated by 2.2Hz, 2.9Hz, 3.7Hz, 4.8 Hz, 6.3Hz & 8.0Hz.

While a DC track circuit detects broken rail at least the one with positive potential, the rail common to Traction return current and negative limb of the track circuits often remains un-
detected being connected parallel through earth. AFTC is used in large scale on Automatic Block Sections where high number of track circuits of longer lengths is used. In Absolute Block signalling section proving of track clearance for entire block section between two stations is preferred to be done by use of Axle Counters. Out of the three, the broken rail detection is best achieved on straight tracks by AFTC.

As is implied by its name, one of the audio frequencies is fed on to both the rails of the track. A set of eight frequencies is used in such a way that in no case adjoining track circuit frequency is same. The various audio frequencies used & typically identified by alphabets are shown in the table under table 2.5a.

Frequency plan for single and double rail sections is shown in Fig 2.5b.

Audio Frequency Track circuits are of Normal mode and Low mode.

2.5.1 Audio frequency track circuit components and their function: A transmitter 'TX' is provided at the feed end to transmit audio frequency at a given level, depending upon manufacturer’s design, through a Tuning Unit ‘TU’. Tuning unit is inserted between TX as well as RX and the rails to work as a selective band pass filter as well as to match the rail impedance with the TX/RX unit.

A receiver ’RX’ is provided at the other boundary end of the track circuit through the tuning unit for similar purpose. A relay is connected to the receiver, which is energised when the track is clear. The system is fed with a power supply unit at transmitting end as well as at the receiving end.

A termination unit is provided at the end of the track circuit adjacent to which there is no AFTC.

This arrangement is for end fed AFTC, i.e. with a TX unit at one end and a RX unit at the other end of the track zone [Figure 2.5.1a].

The AFTC may also be centrally fed with a TX unit at a point some where in between end points of the track boundary, where RX is provided. A length longer to the end fed AFTC may be achieved by providing centrally fed AFTC [Figure 2.5.1b].
Figure 2.5.1b  Schematic diagram of Centrally fed track circuit frequency ‘A’ with an adjoining AFTC of frequency ‘B’

i) **Transmitter:** Transmitter ‘TX’ is a unit to feed Audio frequency at a given level of voltage to the track through ‘TU’. It is provided at one end of the track boundary. A relaxation oscillator generates signal at 9.6 HZ frequency which is converted to square wave by a bi-stable multi-vibrator at the rate of 4.8 Hz and thereupon fed to a modulator. An oscillator generates the desired carrier frequency which is modulated by the modulator on Frequency Shift Keying (FKS) principle to create signal with frequency band of +17Hz & -17 Hz on either side of the carrier frequency at a rate of 48 Hz. The modulated signal is fed to an amplifier and is further forwarded to the tuning unit. Schematic diagram may be seen at Fig 2.5.1(i).These two frequencies are detected by the receiver as two different frequencies.

![Schematic diagram of transmitter unit](image)

**Figure 2.5.1(i)**

*Schematic diagram of transmitter unit*

ii) **Tuning unit:** At the transmitter end the tuning unit is connected between transmitter and the track i) to match the characteristic impedance of the rails with the transmitter to offer low impedance to the frequency band for which the TU is tuned resulting in smooth transfer of the energy from TX unit to the rails, ii) to work as band pass filter to ensure that only the given frequency specified for the track circuit is allowed to pass to the rails and iii) to stop passage of direct current to the rails. On receiving end also it functions the same way to match the characteristic impedance of rails with the RX unit to facilitate smooth transfer of energy from rail to RX, as band pass filter to ensure that the frequency prescribe for this specific track
circuit only is allowed to pass to the RX unit and to block passage of Direct Current to the RX unit.

iii) **Power supply:** power supply is required at both ends TX as well as RX units. 110 V AC is used to convert the power to a voltage required to operated TX, RX and Relay attached to RX, depending upon manufacturer’s system design. Usually transmitter unit of one track is placed adjacent to the receiver unit of adjacent track. In such a situation one Power supply unit can be used for both track circuits i.e. transmitter of one and receiver of the other.

iv) **Receiver:** The signal transmitted is received from the rails through the ‘TU’ and is passed on to the RX. Receiver has two parallel limbs one limb ‘A’ deals with the frequency higher to the carrier frequency i.e. +17f and the limb ‘B’ deals with the frequency lower to carrier frequency i.e. -17f passing through a filter, amplifier, again through filter and then demodulator. The demodulated signal from both the limbs is compared and if the frequencies so received through both the limbs are found to be at phase 180° opposite to each other for two seconds continuously, the relay is energised.

1350 ohms 50V DC line relay is connected to the receiver through a driver [figure 2.5.1 (iv)].

![Schematic diagram of receiver unit](image)

v) **End Termination Unit:** As and when two AFTCs are placed adjoining to each other these are separated by an Electrical Separation Joint using tuning unit. End termination unit is similar to a tuning unit and is used when there is either no track circuit by the side of an AFTC or there is a track circuit other than AFTC. When there is no track circuit adjoining to an AFTC the boundary of the track circuit is made by providing **End Termination Unit** and joining both rails by an aluminium cable at a distance of 18 metres from the point where the End Termination Unit is provided [Figure 2.5.1(v)(a)]. However if there is any track circuit other than AFTC, adjoining it, End Termination Unit shall be provided at the boundary of the AFTC with a physical Rail Insulation Joint at a distance of less than 1 metre from the point where End Termination Unit has been provided [Figure 2.5.1(v)(b)]. The End Termination Unit shall be used as Tuning Unit and connected to The TX or RX depending upon configuration of the AFTC.

End Termination unit for frequencies A, C, E & G are designed with three parallel limbs of the circuit while it is designed with two parallel limbs of circuit for frequencies B, D, F & H.
The End Termination Unit may also be used for centrally fed AFTC however in this case Rail Insulation Joint is not required.

vi) **Electrical Separation Joint:** The portion of the track between two Tuning Units is called ‘Tuned Length’. In case of end fed track circuit the tuned length varies between eighteen and twenty two meters for a normal mode track circuit depending upon ballast resistance. In this part of the tuned length Boundary of the track circuits is formed at the centre line between the two tuning units varying between ± five metres maximum from centre of the tuned area. This part of the tuned length is ‘overlap signalling zone, and in this part either of the track circuit may get shunted while in rest of the tuned length the track circuit with the nearest tuning unit shall get shunted positively. This phenomenon causes the length of Electrical separation joint to vary. Tuned lengths in case of centre fed track circuit and track circuit on different point zones are shown in figure 2.5.1b and for end fed AFTC in figure 2.5.2 (vi).

2.5.2 **Orientations of AFTC:** Audio frequency Track Circuits may have different orientations viz.:

a) **End fed:** TX & RX units are provided at the ends of the track circuit boundary of the track circuit used for short lengths.

b) **Centre fed:** The TX unit is provided almost in the middle of the track circuit and two RX units are provided at the outer ends of the boundary of the track circuit used for longer lengths.

c) **Both of these type of track circuits are fed either i) Locally meaning thereby the TX and RX units provided by the side of railway track along with TU and power supply and ii) remote fed where the power supply, TX and RX units are kept in a centralised place such as a cabin or a prefabricated shelter in block section, while TU is kept at
site. This system has an overriding advantage of being secured against thefts and is most suited in Automatic Block Signalling section.

2.5.3 Typical layout arrangements are given of AFTC at turnout with RIJ and adjoining AFTCs is given in figure 2.5.3a, arrangement with two AFTCs on a crossover with RIJ in between figure 2.5.3b, AFTC with adjoining track circuit (R) other than AFTC figure 2.5.3c and AFTC at turnout without RIJ and adjoining AFTCs figure 2.5.3d.

2.5.4 Lengths and corresponding power modes of AFTC: Output power of AFTC transmitter decides the mode of the track circuit. Forty watt output power of the transmitter is the `Normal mode while three watt output is Low mode. The length of the track circuit vis-à-vis power mode for

i) end fed AFTC works up to 250 metres on low power mode, ii) while such end fed track circuits of length between 250 metres and 1000 metres work on normal power mode and iii) each half of centre fed AFTC works between 300 and 900 metres.

2.5.5 AFTC in area electrified with 25 KV AC traction: In area provided with 25KV AC traction the return current passes through both the rails of the track. When AFTC is provided in such area, it becomes imperative to ensure that equal amount of traction return current passes through both the rails of the track to ensure that a potential difference between both the rails does not develop. To ensure this, both the rails are bonded to earth through an especially designed electric circuit, the unit called as Impedance Bond.
In area electrified with AC traction, OHE masts are connected to the rail to earth the mast as a safeguard against high voltage on the mast caused due to damage to insulator or any other reason. Even though the masts are grouted with cement into the ground partial leakage to earth is not ruled out, thereby with the provision of double rail AFTC connecting the OHE masts may be avoided by providing a separate bus connecting OHE masts in manageable groups and earthing them. However in Kanpur- Ghaziabad section where AFTC is being provided in automatic block sections in a big way, OHE masts have been allowed to be connected to the rails by railways.

2.6 Impedance bond: In the area electrified with 25 KV AC traction, traction return heavy current to the tune of 300 amps, flows through rails to be earthed at the Feeder Post. With the provision of PSC sleepers entire current has to pass through rails only as such it is of utmost importance to make arrangement for suitable path to the traction return current. This is managed by i) providing track circuits using one rail dedicated to the track circuit and the other rail shared by the traction return current and the track circuit and ii) under certain compelling circumstances when it comes to use a double rail track circuit, the traction return current is made to share the double rail track circuit current in both the rails. In case the traction return current flowing through both the rails becomes unequal, for any reason whatsoever it shall create imbalance and as such potential difference between the two rails affecting performance of the track circuit. This an undesirable feature. To mitigate such a situation when both rails are made to share traction return current with the track circuit current, impedance bond is used.

Impedance bond is a device to maintain equal distribution of traction return current in both the rails, where a track circuit is used on the same pair of rails. Read through the SEM Part-II September 2001 paragraph number 17.19.7.13, “Impedance bond within track circuit shall be tuned with correct resonating capacitor across the auxiliary coil and this tuning shall match with the frequency of the track circuit”.

2.6.1 Impedance Bond design: Impedance Bond consists of two copper windings wound in opposite direction on a laminated iron core. These windings are of wide copper strips offering little, to the tune of 0.0003 ohms, impedance to the traction return current. One end of each of these windings is connected on to both the rails and other end jointed together is either earthed [figure 2.6.1 a] or connected to the rail adjoining the rail insulation joint if no track circuit is contiguously placed or with a traction bond connected to the centre point of adjoining track circuit’s impedance bond [figure 2.6.1 b]. As the current passes through both the windings net affect on the iron core becomes zero both fluxes being equal and opposite, having being wound in direction opposite to each other. This results in non-saturation of the iron core, thereby offering no impedance to the traction return current. As and when an imbalance of current is experienced through the coils of the impedance bond, corresponding impedance is generated in the winding due to imbalanced creation of flux across iron core which results in equalising of the current bringing the system back to normal. Alternating current of the track circuit, while trying to short circuit across both the coils of the impedance bond in series, generate small flux through the iron core of the bond which prevents the flow of current to short circuit the track circuit. However certain amount of current has to pass through the coils of the impedance bond as leakage current. Accordingly it may be observed that the DC track circuit shall not work with the use of impedance bond.

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The impedance offered by the bonds at 50Hz AC track circuit supply is 0.4 to 0.5 ohms as such 83 \( \frac{1}{2} \) cycles per second track circuits or AFTC are used. However 83 \( \frac{1}{2} \) Hz track circuits have been stopped from being used in future installations [SEM Part-II, September 2001 paragraph 17.16.2].

Under certain conditions when the imbalance of current passing through the coils of the bond becomes as much as to create saturation of the iron core, there shall be no affect of the track circuit current on the core and the track circuit shall get short circuited and fail. To avoid this, an air gap is provided in the iron core thereby introducing high reluctance to the core.

2.6.2 **Resonated Impedance bond**: To reduce the track circuit current loss, the impedance of the bond coils is increased by resonating the bond.

![Figure 2.6.2a](image)

*Vector diagram showing reduction of current in resonated bond due tuned by capacitor*

![Figure 2.6.2b](image)

*Track circuit arrangement with tuned impedance bond*
A step up transformer is coupled to the impedance bond coils which work as primary coil. A capacitor is provided across the step up transformer. The leading current in the condenser causes an overall reduction in the current flow through resonated bond which in turn results in increased impedance across the impedance bond [Figure 2.6.2a].

Accordingly the feed to the track circuit is applied across impedance bond winding in series coupled with the windings of a step up transformer across which the capacitor of suitable capacity is provided. At the relay end the relay element winding is provided across the impedance coil in series to which the step up transformer is coupled [Figure 2.6.2 b].

2.7 **High voltage impulse track circuit**: With the advent of PRS sleepers replacing wooden sleepers, incidences are there when the DC track relay got energised by the stray currents in local area developing eddy currents onto the metal bars of the sleepers transmitted to the rails thereby making the DC track circuit defunct.

![Figure 2.7 a](Jeumont track circuit transmitter)

The area electrified on to the 25 KV AC traction also restricted use of AC track circuit. Under the circumstances where spurious voltage is observed or where the track is used less, causing formation of rust or grease impairing the train shunt, high voltage impulse uneven wave form track circuit known as **Jeumont Schneider Track Circuit** is found to be useful. The track circuit works on single as well as two rails. When used in area electrified with AC traction on double rails, an impedance bond is used along with it. Due to high voltage output of the transmitter the train shunt resistance is considerably reduced.

SEM specifies that: i) These track circuits shall operate on 220V, 50Hz AC or 110V 50Hz AC supply [SEM Part II September 2001, clause 17.20.2], ii) The high voltage track circuit shall consist of a transmitter which generates impulse with a given shape, amplitude & recurrence frequency, injected into the track by means of a matching isolation transformer and a receiver
which detects, at the other end of track section, the specific signal and operates the fail safe relay if specific signal responds to the correct positive & negative amplitudes. Whenever the specific signal is not received, is deformed or is too weak, the track circuit fail safe relay shall remain de-energised. Transmitter and the receiver shall be located either near the track or in a centralised room. Transformers and impedance bonds shall always be located near the track [SEM part-II 2001, paragraph 17.20.3], iii) for single rail high voltage impulse track circuit, maximum length shall be 400 metres and for double rail track circuits this shall be 5000 metres [SEM Part-II 2001 paragraph 17.20.4].

**Track Circuit components and working:** The track circuit arrangement has i) Power supply, ii) Transmitter, iii) Receiver and iv) Relay [Figures 2.7a and 2.7b].

**Power supply:** 115V 50 Hz AC is fed to the transmitter.

**Transmitter:** The transmitter delivers a high voltage pulse through a relaxation oscillator, rising to about 110V and then going negative while receding. The negative part of the pulse is prolonged to about 12 milliseconds. The output is delivered at terminals C- and C+ of the transmitter and connected to the rails [figure 2.7c].

**Receiver:** The receiver terminals C1- or C2- depending upon site requirement and C+ are connected to the rails. The input positive part of the uneven wave form is rectified and delivered across receiver output terminals V & V2 and negative part of the wave form across V1 and one of the terminal numbers 1, 2, 3 or 4 such that the resultant flux generated in the relay coil is able to attract the armature [Figure 2.7d].

**Relay:** Relay is specially designed to work on two different outputs of the receiver unit such that the armature gets attracted only with the given uneven wave form.

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**Figure 2.7 d**  
Special relay schematic

**Figure 2.7 b**  
Jeumont track circuit receiver
2.8 **Axle counters**: While DC track circuit requires provision of rail insulation joints (RIJ) at desired positions of the rail, audio frequency track circuits came as a big respite being jointless track circuits. However both type of track circuits are essentially superimposed on the rails becoming an integral part of such rails on which the system is superimposed. These track circuits have to share the adversities born by rails such as low ballast resistance, damage to RIJs, breakage of jumpers connecting rails to power supply at one end and relay at other end, breakage of connectivity bonds, sharing with flow of traction return current etcetera. These track circuits, as such, have to be designed to be compatible to the railway line on which these are provided. Signal engineers always have been striving for independence of track while the track vacancy could not be monitored without independence; Axle counter device has been able to achieve the purpose to a large extent.

Axle counters shall conform to IRS specification S-42 unless otherwise approved, in terms of paragraph 17.41 of SEM Part-II, September, 2001.

2.8.1 **Advantages of axle counters over track circuits superimposed on the rails**: Axle counter monitors track vacancy without interfering with the track geometry. The principle being counting of the wheels passing over the axle counter track detection device at the entry end of the track zone then counting wheels out going out of the same track zone, comparing and declaring track zone clear if comparator finds in-count and out-count equal. Axle counters have advantages over a track circuits on account of:

i) Not being affected by type of sleepers used,
ii) Not being affected by Ballast resistance,
iii) Not required to make holes in the rails,
iv) Not affected by electrification,
v) Not affected by train shunt value,
vi) No bonding required to maintain rail continuity.
vii) No rail insulation joints required.
viii) No restriction on the length of the track zone vacancy to be monitored except for cable losses and data distortion.
ix) Used to prove block clearance.

2.8.2 **Analogue system of axle counters**: Axle counters used in India have been manufactured by Central Electronics Limited (CEL), Standard Electronic Lorenz (SEL), and M/s Siemens. All use their own designs.
Axle counter system main ingredients are [Figure 2.8.2a(i)]:

i) Electronic junction box,

ii) Rail fixtures i.e. transducers and deflectors,

iii) Evaluator,

iv) Transmission media, i.e. cable,

v) Power supply for Evaluator,

vi) Power supply for Electronic junction box.

vii) Trolley suppression track circuit.

Figure 2.8.2a(i)

Schematic axle counter system (analogue)

a) **Transducers**: Entire station yard, if track circuited, is divided into as many track sections as are required for monitoring of track vacancy depending upon requirements of interlocking. The length of each such track sections is also decided accordingly. In case of DC or AC track circuit, each such section gets defined by rail insulation joints on either side of the track circuit. However in case of Axle counters, transducers/axle detectors are clamped with the rails at each end of the track zone to be monitored defining track section boundary.

These transducers are fixed on the rail flange between two sleepers, though a high tensile steel bolts, spring washers and nuts so as to ensure that these transducers once adjusted do not get disturbed by the vibrations caused by the running trains.
Transducer is a set of a transmitter and a receiver [Figure 2.8.2a(ii)]. An oscillator housed in electronic junction box continuously sends 5KHz sine wave power to the transmitter through a cable of fixed length. The receiver is a passive device which gets linked with magnetic flux generated by the transmitter. This linkage of flux generates an induced e.m.f. in the receiver coil which in turn is connected to the receiver amplifier housed inside the electronic junction box. The cable connecting electronic junction box and the transmitter is an integral part of the oscillator circuit as such any variation in the length of the cable shall affect the frequency generated.

In earlier versions of axle counters the transducers measured through centre lines were used to be fixed on both the rails of the track staggered by 150mm to 200mm, to establish direction of traffic which decides the count to be in or out. However owing to the problem of maintenance of staggered distance between the two transducers, both the transducers are mounted on a single base which in turn is fixed on the same rail flange.

![Arrangement of axle counter rail fixtures](image)

**Figure 2.8.2a(ii)**

*Arrangement of axle counter rail fixtures*

To safeguard the transducers from being hit by a hanging part of the running trains, **deflectors** are clamped on the rail flange through nuts and bolts on both sides of each transducer on single line and on approaching end on the double line section.

b) **Counting of wheels**: The 5KHz frequency fed to the transmitter is pure sine wave. The same is induced into receiver. The signal generated in the receiver is modulated by the wheel passing over the transducer.

As may be seen in figure 2.8.2b the flux lines F1 & F2 pass through air as well as through rails. The resultant flux is adjusted by moving the transmitter up and down about semicircular toothed base on which it is fixed to obtain signal of maximum strength and of suitably optimum waveform [Figure 2.8.2c] in receiver coil. The receiver coil signal level is influenced by the passing train wheel due to wheel diameter and metal density. As the wheel of the train passes over first transducer while entering into the track circuit zone, the signal in the receiver coil drops and the waveform changes. This is called as ‘Wheel Dip’.
In order to obtain an optimum wheel dip, the transmitter may again be required to be adjusted by moving a wheel simulator called as ‘Dummy wheel’ which is a metal sheet, to create wheel like conditions when moved to and fro along the rail top across the transducer. The adjustment has to be as such to obtain signal of maximum strength when there is no wheel over the transducer and best wheel dip when the wheel is over the centre line of the transducer. The wheel dip is observed on Cathode Ray Oscilloscope or any other similar instrument operable at site with low power considered best with broad bottom.

c) **Wheel dip**: The dip of the shape as shown in figure 2.8.2c (i) is inadequate and may miss the counts, the dip in figure 2.8.2c (ii) has two sharp dips which may result in counting two dips for one wheel, figure 2.8.2c (iii) shows single sharp dip and is nearest best while the dip in figure 2.8.2c (iv) the sharp single dip has been widened which is the optimally best.

![Profiles of wheel dip](image)

**Figure 2.8.2c** Profiles of wheel dip

d) **In & out count**: The dip received from receiver amplifier into the evaluator is converted into a square wave when the trolley suppression track circuit is de-energised. The square wave has either level one or level zero. The adjustment of the transducers is such that when the wheel dip is transmitted to evaluator card from one of the receiver amplifier the wheel dip or rise of level of other receiver takes place almost midway of the wheel dip of first receiver. **It is pertinent to note that a count takes place only when one of the Receiver’s level is low and the other receiver’s level is falling to low or rising to high.**

As the wheel dip from transducer ‘A’ is received by the evaluator card, the waveform is converted to square wave, level of which drops down to zero. This shall make no count. As the wheel reaches transducer ‘B’, the wheel dip at ‘B’ takes place. This is registered as ‘one’ in-count by the evaluator. As the train moves on and the transducer receiver ‘A’ is cleared and its output acquires level-1 while level of transducer receiver ‘B’ is still at level zero which starts rising back to level-1. As the level of receiver ‘B’ also acquires level-1, another in-count is registered by the evaluator.
This means that two in-counts are generated for every occupation and clearance of transducers ‘A’ & ‘B’ in one sequence to count one IN. This means that the train has entered into the track zone being monitored for track vacancy. At the same end when the train moving in opposite direction is leaving out the same track zone, first transducer faced by it is ‘B’ as such the level of receiver ‘B’ goes down to zero first and then level of receiver ‘A’ drops to zero while the level of receiver ‘B’ is already zero. This is counted as ‘Out count’, process being same as that of in count. See figure 2.8.2d and associated table. The arrows in the table show transition of level as rising to level one or falling to level zero.

It is pertinent to note that the count takes place when the level of one of the transducers is high or low and the level of other transducer is rising or falling.

e) **Electronic junction box:** One electronic junction box, placed in location box, is provided near and for a set of two transducers such that the cable connecting both does neither fall short nor it is required to be put in the form of coil. In case the cable between electronic junction box is required to be stored in the location box, it should be kept bunched in zigzag formation and not in the form of a ring to avoid formation of coil disturbing inductance of the circuit. 12Volt power supply is fed directly through an independent power cable or through the quad cable connecting the evaluator to the electronic junction box, superimposed on the quad carrying the amplified receiver output. This power is used for energising the i) oscillator and the ii) receiver amplifier, which are housed in junction box.

Output of both the transducer-receivers is fed to two receive amplifiers provided in the electronic junction box, separately. The tuned frequency is 5KHz with a 3db bandwidth of ±250Hz. Any noise picked up due to AC traction is suppressed at this stage. The output of the amplifier is fed to the evaluator through a line matching transformer to quad cable. It has to be ensured that the output impedance matches with the characteristic impedance of the cable which is 470 Ohms for PET quad cable. The wave shape from the receiver output is pure sine wave, free of any noise.
f) **Evaluator**: Major components of Evaluator are i) power supply, ii) supervisory, evaluator and comparator modules, iii) display unit, iv) relays and v) resetting box.

  i) **Power to the evaluator**: The power supply to the DC-DC converter is provided from a 12V battery bank charged by a battery charger with ripple voltage less than 2 V. Ripple free 10V DC and 5V DC power supply is provided to the Evaluator through DC-DC converter.

  Power supply for the indication lamps is taken separately not from DC-DC converter.

  ii) **Input to evaluator from receiver amplifier**: In area electrified with 25 KV AC traction, one pair of polyethylene insulated star quad cable is used to connect the output of the receiver amplifier of channels ‘A’, ‘B’, ‘C’ ‘D’ (Electronic junction box) to the evaluator to avoid inducted noise. In non RE area, twisted pair or star quad cable may be used.

  iii) **Evaluator modules**: The input from four receiver amplifiers out of two electronic junction boxes is connected on the evaluator. The analogue processing circuits of the evaluator, on evaluator cards, convert the modulated carrier into digital pulses. These circuits include logic, counting and supervision functions. The in counts are stored and compared with corresponding out counts by a comparator. In case the in-counts and out counts compared are found to be equal, the evaluator relay is energised.

  In case of loss of signal from any of the receiver amplifier the system shall show track zone occupied condition.

  iv) **Display unit**: A display unit is provided on the evaluator box for stored counts, fault location, initial and periodical adjustments.

  v) **Relays**: The output of the Evaluator is fed to Supervisory and Evaluator relays using shielded cable. The supervisory relay is to prove that the system is working properly while evaluator relay proves equal in & out- counts. These relays shall be of 4front / 4back contact configuration of class ‘A’ with percentage release better than 65%. These relays along with both the trolley suppression track circuit repeater relays are put on the same rack that of evaluator to keep the cable connecting them to be of minimum length. Another relay to prove the track zone monitored by the axle counter is energised proving both trolley suppression track circuit repeater relays, supervisory relay and the evaluator relay in series. This final relay is designated as AZTR with the prefix of the given track number.

  vi) **Resetting Box**: For any reason whatsoever in case there is a mismatch in in-counts and out-counts, the system shall not show the track zone as cleared and the mismatch shall continue to occur with every train movement. To discontinue with the mismatch the system is required to be rest to zero state by using a reset box which contains a key to ensure that any person not authorised to handle the resetting uses the box and a press button by pressing of which the system shall get reset.

  Since resetting can be done at any stage even with the train being inside the zone of the track being monitored, this process attains a high order safety risk. The resetting is therefore done in cooperation with another person who also shall verify that the track zone is clear before the axle counter is reset. Each resetting is counted. The signalling
circuit is so designed that first train shall be piloted to pass over the concerned axle counter zone while the next train shall pass over the said zone of track on proper signals.

Axle counter track zone clear and occupied indications are provided on the axle counter resetting box also.

g) **Trolley suppression**: Movement of push trolleys is an integral part of the maintenance of railway systems. However since the trolleys are not controlled by signals, their occupation of track circuits or axle counters is undesirable as it may raise a signal, taken Off, back to On when occupy the track circuited zone or axle counters. To prevent this to happen the axles of all trolleys are insulated so that the trolley does not short the DC track circuit or any other track circuit which is superimposed on the rails. Since in case of axle counters the counting takes place with the passage of a train wheel, the trolley wheel causes disturbance to the axle counter system being partially sensed by the transducers. To avoid such a situation, the transducers are invariably fixed (not in case of digital axle counters) in the zone of a track circuit zone dedicated for the purpose. This track circuit is called as ‘Trolley Suppression track circuit’.

+10V power supply is provided at the input of the card which counts the input from electronic junction box receiver amplifier through trolley suppression track circuit relay energised contact. As the level remains high at the input point where dip is sensed, the depression of the wave form is not sensed resulting in signal being not registered and count not taking place. As the track circuit of the zone of which the transducers are provided is de-energised, the +10V power supply is disconnected and counting starts. It takes some time for the track relay to de-energise after having been occupied by the train as such the transducer is provided at a distance enough from the rail insulation joint of the track circuit on approaching end to allow time to de-energise the track relay before first wheel of the train reaches in the sensing zone of the transducer between cut-off of the +10V DC supply on the evaluator and start of counting. A distance between rail insulation joint on approaching end of the track circuit and the first transducer, adequate enough for allowing the track relay to de-energise before the first wheel of the train interacts with the transducer depending upon type of track relay used and the permitted maximum speed of the section, as mentioned in the table 2.8.2g, shall be provided [Paragraph 17.43.5 of SEM Part-II, September 2001].

<table>
<thead>
<tr>
<th>Speed in Kmph</th>
<th>Minimum distance in case of shelf type relay</th>
<th>Minimum distance in case of Q style relay</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>5.4 m</td>
<td>1.0 m</td>
</tr>
<tr>
<td>50</td>
<td>16.2 m</td>
<td>6.3 m</td>
</tr>
<tr>
<td>90</td>
<td>32.5 m</td>
<td>12.5 m</td>
</tr>
<tr>
<td>100</td>
<td>36.1 m</td>
<td>13.8 m</td>
</tr>
<tr>
<td>120</td>
<td>43.3 m</td>
<td>16.6 m</td>
</tr>
<tr>
<td>140</td>
<td>50.6 m</td>
<td>19.5 m</td>
</tr>
<tr>
<td>160</td>
<td>57.8 m</td>
<td>22.2 m</td>
</tr>
<tr>
<td>200</td>
<td>72.2 m</td>
<td>27.6 m</td>
</tr>
</tbody>
</table>

Table 2.8.2g

Minimum distance between first RIJ and the transducer

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Accordingly a trolley suppression track circuit of minimum 3 rail lengths on double line section and minimum 5 rail length of single line section is provided as on double line section the movement is unidirectional and on single line section it is in both the directions. The transducer is paced at distance of 2.5 metres (32.5 metres) from the entry end rail insulation joint to allow the trolley suppression track circuit relay to de-energise before the counting of axles starts.

On double line section where shunting movements are frequent in opposite direction, track circuit length shall be such that even during the opposite shunt move the track repeater relay de-energises before the first wheel comes within the influence of track devices at the maximum shunting speed. [Paragraph 17.43.4 of SEM Part-II, September 2001].

All analogue axle counters are for single section.

2.8.3 Digital axle counters: A single section axle counter has one set of Axle detector at entry end and another at exit end dedicated to the zone of the track to be monitored for single zone of track vacancy. Digital axle counters are for single section as well as multi-section. Basic difference between Analogue and digital axle counters is that the digital axle counter evaluation system is software based.

A single section Digital Axle counter requires two Axle detectors placed at the ends of the track monitoring zone. These detection points are capable to work without evaluator. An evaluator is required to work Multi section digital axle counter.

a) Requirements to be fulfilled by digital axle counters:
   i) Detect, count and determine direction of the wheels passing over the axle detector.
   ii) Shall be actuated by wheel flange only.
   iii) Any damaged or missing subassembly of the axle counter shall reflect in showing track zone occupied.
   iv) Track zone clear indication shall be available only when the in-count and out-counts are equal and the health of axle counter system is working normal.
   v) In case of restoration of power after failure, fluctuation of voltage beyond prescribed upper and lower limits, removal of any printed circuit card or occurrence of out count before any in count, the system shall not come to its original or normal condition.
   vi) To discontinue with the mismatch in in-count and out-count, the system is required to be reset to zero state by reset box which contains a key to ensure that any person not authorised to handle the resetting uses the box and a press button by pressing of which the system shall get reset. In this case the axle counter shall continue to show occupied. This state is known as ‘normal and preparatory’. The system shall become normal only after passage of the first train over the track zone monitored, if in-count and the out-count becomes equal again.
   vii) Free and occupied indication shall be available at each axle detector through relay contacts.
   ix) The axle counter is designed such as that wheels of insulated trolleys, or rail dolly are not counted. Accordingly provision of trolley suppression track circuit covering axle detectors shall not be required.
   x) Transmission of data between two axle detectors may be done through copper cable, OFC or radio including GSM.
xi) Axle detector will adopt two out of two architecture.
x) The axle counter is capable of monitoring trains running at the speed up to 250 kmph.
xii) Both hardware and software functions have to be partitioned to ensure that integrity of certified design is not be compromised through routine software and hardware upgrades.

A) Single section Digital Axle counters: Single section digital axle counters are designed, manufactured and procured in conformity to specifications RDSO/SPN/177/2003. The system has axle detectors at both ends of the zone of the track to be monitored, interconnected through a media of communication.

i) Axle detector: Axle detectors is a set of axle detecting unit fixed on the rail and an ‘electronic assembly’ kept in an apparatus case near the axle detectors. The electronic assembly is meant for detecting wheels passing over the axle detectors, determination of the direction of movement of the wheel and also contains count comparator, supervision relay driver and vital relay for both of the two detection points to perform additional function of counting, comparing and energising track relay when count comparison is equal similar to an evaluator as such a separate central evaluator is not required.

ii) Media of communication: Both axle detectors are interconnected to form a single section and is capable to transmit axle counts, health status and other information between the two units. The communication media may be ½ quad copper cable, one voice channel of optical fibre or radio.

iii) Connectivity to evaluator: It is possible to connect two detection points of the axle counter to a central evaluator by making suitable modifications.

iv) Power supply: The track side axle detectors work on 24V DC power or 110V 50Hz single phase AC. The evaluator works on 24V DC.

B) Multi section digital axle counter: Multi Section Digital Axle Counter (MSDAC) is designed, manufactured and procured in conformity to specification number RDSO SPN 176-2002. The ingredients of the MSDAC are:

i) Axle Detector: The axle detectors in case of multi section digital axle counter are different as these do not have an electronic assembly to carry out count comparison, relay drive and relay, at the axle detectors.

Figure 2.8.3B Multi section Digital Axle Counters Detection points in yard

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ii) **Track side Digital axle counter field unit:** This unit is placed to energise the Axle Detector, monitor direction of movement and keep count of wheels, placed nearby Axle Detector and transmit the count and health information to the Central Evaluator.

iii) **Central Evaluator:** The system has an independent evaluator to which all the axle detection units are connected through ½ quad cable. It:
   a) is capable of accepting inputs from at least 40 axle detection points.
   b) is capable of receiving counts and data from axle detection points of different track sections simultaneously and also giving decisions simultaneously.
   c) shall be based on 2 out of three logic.
   d) shall communicate with field units at 1200 Baud.
   e) Will provide one vital relay for each track section.

iv) **Media of transmission:** The axle detectors to axle detectors or axle detectors to evaluator shall be connected through quad copper cable, Optical fibre, radio or GSM.

v) **Resetting:** Resetting arrangement shall be similar to as given in case of single section axle counter in preceding paragraphs. The resetting box has a key, a button, and indication for preparatory resetting and indication for track clear or occupied. After resetting axle counter shall continue to show occupied until count balancing is achieved by the first train having traversed the section. This condition is termed as Preparatory reset.

vi) **Power supply:** The track side axle detectors work on 24V DC power or 110V 50Hz single phase AC. The evaluator works on 24V DC.

vii) **System of working:** Axle detectors are provided at each Detection Point ‘DP’ at the entry and exit ends of each track zone to be monitored. Since the track zones are contiguous, the DP falling in between two track zones becomes common and is used as such without any addition or alteration to the axle detector. See figure 2.8.3B where track monitoring zone numbered as 59aXT is monitored by DP-A and DP-B. Track monitoring zone 55bXT covers point number 55b. The zone is covered by DP-B, DP-C & DP-D. Here the DP-B is common to track zone numbers 59aXT and 55bXT. Accordingly in entire yard only 18DP are required to monitor 12 track zones as against requirement of 24 in case of single section axle counters.

Central Evaluator which is of a modular structure has 5 set of cards. Each set of cards can be connected to minimum 2 and maximum 8 field units. Accordingly the complete system with all the 5 sets of cards can be connected to maximum 40 number of the field units therefore the system has the provision for scaling up or down according to the requirement at the station.

MSDAC system provides individual vital relay output for each monitoring track zone based on the principal of counting of axles. The axle detector works on 21 KHz & 23 KHz frequencies according to the proven method of electromagnetic wheel detection. When a train wheel enters between the Axle detectors it influences the electromagnetic field and the wheel is detected. The Axle Detector and electronics Associated with it is working on the principal of phase Modulation by wheels. The detected wheels of a train are converted into digital pulses which are counted and stored at the entry and exit field units of the track section. The stored counts as well as the health status from the field units are continuously transmitted by means of telegram packets to Central Evaluator on ½ quad cable. After evaluation of counts received from entry and exit field units of each track section, the track "Clear" decision is arrived in Central
Evaluator, if the evaluation of counts is equal and the Vital Relay (VR) is energized. The contacts of VR are provided into the signalling circuits of the station. The VR for point zone is picked up after evaluating counts from all the field units of that particular section.

3 Data Logger: It is an electronic system to log events with reference to time for i) predictive and proactive maintenance, ii) Diagnosing failures and iii) Establishing facts in case of accidents. Data loggers are manufactured and procured under specification number IRS - S-99/2001.

The events to be monitored by the data logger are in i) binary form i.e. Signal’s status as Off or On at a given time, status of track circuit as energised or de-energised at a given time, status of the level crossing gate closed or open at given time and, ii) In analogue form i.e. variation in voltages of the different power supplies such as 230V AC, 110V AC, 60V DC, 12 V DC, current levels of point machine’s etcetera. Many more such binary and analogue events as may be deemed fit may be planned to be logged such as emergency cancellation of route, emergency crank handle release, emergency point operation, cancellation of line clear, reception of train on calling on signal used for detailed analysis leading to a mishap.

The Data logger is also able to analyse these events to enable signal engineers reach at conclusive decision. It is marketed to monitor in units of 512 binary and 32 analogue ports which is found to be adequate for a way side station. Data loggers are used now as an integral part of signal and interlocking system, while the oldest installation is at Itarsi station installed in the year 1994.

3.1 Data logger system & design: It is processor based equipment designed for Indian Railway signalling system and is in two parts i) Central Monitoring Unit equipped (CMU) with a VDU, key board and a printer, kept in Divisional Head Quarters if railway, usually in a room conventionally known as 'Test Room' and ii) Unit provided at the stations in the relay room to enable it monitor binary and analogue events. In case the station has two or more cabins the Remote terminal unit data logger unit is provided in each such relay room which are connected serially, to Master Data logger which in turn is connected to the OFC hut for transfer of information to Central Monitoring Unit at Divisional head quarters. It also transmits data recorded to Central Monitoring Unit for generation of reports, graphical display of station functions and other information.

The connection of CMU to way side station Data loggers may also be through dedicated 4W serial communication link.

Data logger at station relay room stores changes in status of various field functions along with exact time of occurrence and analyses the data for making immediate announcement of any fault. In addition to logging the events it also:

i) Generates fault alarm, identifying the gear at fault & thus reduces rectification time.
ii) Predicts certain faults & generates the alarm so that equipment is attended before fault occurs & thus avoiding repercussion on train movement.
Data logger system consists of hardware components i) Station data logger, ii) Central Monitoring Unit, iii) Communication media between the two and iv) application software specific to requirements.

3.1.1 **Connectivity**: Data loggers of all the stations are connected through an omnibus circuit with the Test room at divisional or sub divisional headquarters through a copper cable or OFC as well as a wireless link such as Microwave or radio is also provided as an alternative means of connection.

3.1.2 **Station data Logger**: The equipment is provided with a front panel display & a printer interface to observe the status of the events/alarms or to takeout hard copy of the event/alarms. Station data logger equipment works on 24V DC power supply. Equipment has facility to record over 100000 events using battery back up RAM/Flash RAM. It consists of following modules:

i) **Digital input module**: Potential free contacts terminated at the tag block from various relays are connected to input card. Each module can read 256 or more digital input through separate opto-isolators. This module contains multiplexers for addressing the inputs and opto-couplers for input isolation. Contact number D1 of each Q series relay dedicated for the purpose is used by NC Railway as convention.

ii) **Analogue input module**: Measurement of analogue voltage is based on voltage to frequency conversion & counting (or by using 10 bit ADC). The frequency which is proportional to input voltage is counted by micro controller. All analogue input cards are connected to the data logger processor card through serial communication.

iii) **Processor module**: this module controls all the activities and performs the entire logical decision-making, serial communication interface for external communication, display driver and keypad interface and all the local input functions. The card continuously scans all the digital inputs at the rate of 20 ms. and analogue inputs for every 1 sec. Any change in the status of input, the processor records change along with the time and date and stores in a battery backed memory.

iv) **Remote terminal unit (RTU)**: The RTU is a mini data logger placed at distance from the main data logger. It transfers status as scanned by it to the main data logger, while main data logger transfers entire information to the Central Monitoring Unit through copper, OFC or microwave link. The RTU is provided to monitor events which are away from a data logger by more than 50Mts and can be placed up to a distance of 3Km from main data logger. RTU has also facility to store up to 10,000 events.
v) **Signal conditioning module**: this module translates analogue signal levels to specified range and does impedance matching before feeding the signal to analogue input module.

vi) **Communication module**: In this processor card, six serial communication ports are provided. Modem can be connected to transfer data to central monitoring unit or front-end processor through any of these ports.

vii) **Printer module**: The printer if provided is connected to the processor card through parallel communication port. Display and keyboard facility has been provided in front of data logger to select printer on line and off-line.

viii) **Power supply module**: The power supply card consists of DC-DC converter to cater for the power supply requirements of data logger equipment. The system works on 24V DC +20% -10% input supply.

3.1.3 **Central monitoring unit (CMU)**: Central monitoring unit consists of a commercial PC and a Front End Processor (FEP).

i) **Commercial PC** required shall be Pentium based system to retrieve data from FEP. It stores data in standard data base file. It is capable of analyzing the data and generates audio-visual alarm on unusual conditions. It displays the status of signalling gears at any selected time in graphic form for any selected station yard. It also can simulate train movement as per station yard lay out.

ii) **Front End Processor (FEP)**: The main function of the FEP is to receive the data from data logger and store in its memory and transfer the same to the computer on request from it. The FEP has two communication (COM) ports. COM1 provides the serial communication between FEP and CMU and COM2 provides the communication between FEP and data logger through modem.

iii) **Communication media**: For proper functioning of the data logger and retrieval of the events recorded, reliable communication is made in ring main arrangement provided such that any single interruption in the communication does not affect the transmission of the data from station data logger to the Central Monitoring Unit. Besides connecting stations on an omnibus circuit drawn through copper or Optical Fibre cables, an alternative wireless link is also made.

iv) **Software**: The software used are i) **System software**, which supports all the functions in the data logger and reads & interrupts the application software to enable the CMU to perform the appropriate functions and ii) **Application software** generates Log of Entries Report, Fault Report, Graph Report of analogue voltage, Train simulation Report, to generate train movement simulation.


v) **Fault generation logic**: Fault alarms are generation using logic by comparing the status of various relays and their sequence of operation with the pre-determined sequence. In case of analogue signals, level of the analogue signal is used for generating the alarm. Example of some such logics generated are i) point failure: If both NWKR & RWKR relays are dropped for more than a specified time, point failure alarm is generated, ii) point flashing under wheel: Such condition arises due to loose
packing of the points, improper adjustment of the point etc. If both NWKR & RWKR relays are dropped when concerned track circuit relay is also dropped, a point under wheel flashing alarm is generated, iii) passing signal at danger: de-energisation of track circuit time before the signal is Off and after the signal is On along with the status of RECR is taken to decide the overshooting of the signals. If track circuit before the signal is occupied and RECR is UP followed by occupation of track circuit beyond the signal, it generates alarm indicating overshooting of the signal, iv) delayed start of train: If a signal is cleared, tracks circuit before the signal is occupied & next track circuit does not show occupied with in a certain time, it generates late start alarm, v) speed at turnouts: The speed of train is calculated from the duration for which concerned track is occupied & its length. This helps in monitoring the speed at the turnouts and thus pinpointing the driver who exceeds the speed limit over turnout, vi) train simulation: The information can be used for automatic plotting of the control chart and help the controller in planning precedence/crossings of the trains by using forecasting technique, vii) passenger-information system: The information available in the data logger can be used for passenger information system by providing real time information to platform display boards and IVRS system.

4 Anti Collision Device: Signal is the only interface between the Loco pilot and safety of the train. If the signal is On and skips attention of the Loco pilot due to any of the unforeseen reasons the repercussion is serious. Indian Railway has been continuously striving for improving safety with the outcome for provision of i) Train Protection Warning System (TPWS) and ii) Anti Collision Device (ACD) also known as Raksha Kavach

4.1 Automatic Warning System: The system came a long way from Automatic Train Control (ATC), Automatic Warning System (AWS) to Train Protection & Warning System (TPWS). ATC was proposed to be used in suburban section of Bombay, and some sections of railways where permissible speed was 120Kmph. However AWS subsequently provided in Howrah –Mughalsaria section with a magnet based track device could not succeed due to thefts of track device. Subsequently later when provided in suburban sections could survive due to high frequency of local trains not giving adequate margin for stealing.

The system ingredients in Loco are i) AWS processing equipment with an indication panel ii) Taco generator, and iii) Loco magnet, while in the field, track magnet, which is passive device tuned for electromagnetic coupling is connected with ground signal aspect controlling relays through opto-couplers.

The track magnet placed 200 meters in rear of each signal, mounted on sleepers between two rails of the track, is connected with the ground signal aspect controlling relays through opto-couplers to transfer 21 combinations of the desired information to the loco. The loco magnet consisting of 2 coils for 50Hz & 60 Hz picks up the information from track magnet. The information so received is evaluated by micro processor based AWS processing equipment provided in the loco and the indication on the indication panel and the action to be taken is generated. The Loco pilot of the suburban loco on getting indication on the panel about having passed the signal at an indication other than double yellow or green has to acknowledge the same within 4 seconds. If Loco pilot does not take action in time, service (normal) brakes and
then emergency brakes shall be applied by the system. Taco generator keeps train speed informed to the system. Automatic Approach Warning System (AAWS) with the track magnet with two frequencies placed at a distance of 1.8 Kilometres from Home signal was installed in Tuglakabad – Agra section where the maximum permissible speed is 140 Kilometres. Two coupling coils mounted under the loco detect track magnet and gives warning to the Loco pilot about approaching Distant signal. If the driver did not acknowledge the warning the speed is reduced to 110 Kilometres. The system could not function owing to the thefts of ground magnet.

In order to be able to combat the theft problem finally, is replaced by Balise based system replacing the field magnet by the software chip, of no use to thieves.

The system stands further upgraded with more features as Train Protection & Warning System.

4.2 **Train Protection & Warning System**: The Train Protection & Warning system (TPWS) is manufactured and procured under specification number RDSO SPN 183-2004.

The system comprising of i) track side sub system and ii) computer based system evaluator with an indication panel and a taco meter, installed in loco. The passive track devise, electromagnet of AWS is replaced by the Blias, a sealed microprocessor chip mounted on the sleepers. This track device is an interface between interlocking system and the loco computer.

The computer works on two out of three selection. It evaluates the information gathered from the track device and odometer. A warning is given to the Loco pilot to enable him to react within 5 seconds of the warning. If the loco pilot does not react in time, and the train exceeds more than 10 kilometre of permissible speed the service brakes are applied till the train is brought down to the permitted speed and if the train is not likely to stop at the given point emergency brakes are applied.

The system is for complete control of the train by monitoring i) speed of the train, ii) signal indications in the Loco cab, iii) automatic application of brakes when required and application of temporary speed restrictions en-route.

4.3 **Raksha Kavach**: Designed under the name of Raksha Kavach is for continuous protection of the trains in station and Block section. It functions by i) detecting situations when two trains are not maintaining a given minimum distance creating situation for collision, under such a situation ii) it applies brakes, iii) Door Dristi (Distant vision) of 3 Kilometres under all weather conditions, iv) covering loco pilots timely inaction and v) extending to level crossing gates. The system is provided in Locos, SLRs for Guard, Level crossing gates and stations.

4.3.1 The system detects presence of other train on which the ACD has been provided, by exchanging information with each other through radio when come within 3 kilometres range of communication. Control command unit (CCU) receives inputs from GPS and other ACDs, processes the data so received and transmits the data to other ACD.
The trains are tracked by Global Positioning System (GPS) via loco where the ACD is provided, which is satellite based. The loco is connected with GPS through antenna fixed on its top. The system positions the train by locating the train by its latitude, longitude, date, time and speed of the train. ACD, while interacting with each other through radio communication exchange data and commands with each other, analyses the situation on real time basis and applies brakes as and when required. In case of failure of the system an audio visual indication.

4.3.2 Situations and corresponding action taken by the system: Raksh Kavach shall protect the trains under situations, i) No action when two trains are moving on different lines, ii) Train moves at a cautious speed when one train is stationary and other is approaching it, iii) in case of fouling of other tract by a derailed train and Loco pilot presses Save Our Sole (SOS) button, the approaching train shall apply brakes, iv) in case of one train following the other, speed of the following train shall be regulated stopping if the leading train stops, v) acts as Train Actuated Warning device (TAWD) as and when approaching level crossing gate provided with ACD, by initiating hooter at the level crossing gate warning road traffic of the approaching train. The status of the level crossing gate shall also be communicated to the loco pilot enabling him to regulate speed of the train.

4.4 **Train Actuated Warning Device for level crossing gates (TAWD):** Level crossings are always a cause of concern for Indian railways be it on account of road/train accidents or detentions due to heavy road traffic. The situation could be eased out by giving advanced information to the gateman of an approaching train as well as by back locking the gate by the train once the gate is closed and locked. An audiovisual warning by way of a hooter and gate signals for road traffic is also extended to the road users while the gate is scheduled to be and is being closed.

TAWD is manufactured and procured under specification RDSO/SPN/179/2003, using digital axle counters eliminating disturbance due to push trolleys and provision of trolley suppression track circuits and rail insulation joints.

4.4.1 **System design and features:**

a) **System design:** The system consists of i) approach Axle Detector located at 2 Kms in rear of the level crossing for detecting approaching train on double line section and also in the direction of the train on single line section, ii) clearing Axle Detector at the level crossing for detecting level crossing clearance, by the train, iii) decision box located at level crossing connected to approach axle detector and clearing axle detector through ½ quad cable or on radio link, iv) two audio-visual alarm units including gate signals for road traffic, v) monitoring equipment at station, which is connected to decision boxes at level crossings on ½ quad copper cable or radio as required and vi) power supply.

b) **System features:** i) Normal aspect of road signal will be flashing yellow. (1 sec on and 2 seconds off), ii) warning will start as soon first axle is counted in and road signal will change to steady red indication, ii) audio warning will stop as soon as train first wheel is counted out of level crossing and visual warning will stop as soon as last axle is counted out, iii) if train does not pass within ten minutes after counting in first axle, warning will stop automatically, iv) Health of the units will be continuously monitored and working status of the gate such as failure of speaker or road signal, low battery condition alarm will be available at the controlling
station, v) system will be shut down after voltage drops below set limit to avoid permanent damage to battery, vi) all gates in a block section will be covered on one quad cable, vii) in case of failure of communication link between axle detectors, road signals shall extinguish, viii) gate closed condition will also be available at station, ix) Tx/Rx coils at the exit unit will remain in sleep mode until first axle is counted at entry unit, x) as and when train, after entry into the entry end units returns back without crossing the LC gate, counter will reset after ten minutes, xi) in case of a failure due to count mismatch counts will reset after ten minutes xii) equipment is fit for environmental temperature ranging from –10 to 70°C and xiii) system will operate at 24 V DC.

5. **Devises for monitoring correspondence**: When crossover points are given command to set normal and one point moves and other does nor or there is any discrepancy in faithful compliance of the command the consequences shall be serious. Electrically operated device to monitor compliance for points is electric point detector.

5.1 **Electric Point & Lock Detector (EPD)**: Any amount of efficiency in setting of facing points shall be infructuous if the point is not set in desired position and then is not locked properly or when the set of two points making a crossover is set for different routes. Even if the point is set but not locked the chances of encountering two road condition, under a running train, remain very high as such not only proper setting of point is required to be detected but full travel of lock plunger is also required to be detected.

When points are rod operated or in case of out type point machine where detection of point and lock is not an integral part of the point machine, an electric point detector is provided at the point. These detectors are suitable to be put on i) single set of points and lock plunger with IN and OUT movement, ii) single set of points and lock with straight through movement of the lock plunger, and on iii) double slips.

5.1.1 **Construction details**: The detector assembly is housed in a cast iron box with a cover with pad locking and sealing arrangement. The groove in the cover is filled with asbestos rope which sets over the rim of the EPD box to make the assembly dust and water proof.

Opening for rectangular slides to pass across the cast iron box is provided on both opposite faces of the box with spacers to facilitate the slides to be interchangeable. The spacers are screwed with body of the box. A cable inlet to the box through a hose is provided.

i) Contacts terminal plate is mounted on the upper portion of the box. The contacts are fixed and the terminal plate may be moved to & fro for fine adjustment of the contacts. Besides, these contacts are in ‘U’ shape with the facility of accurate adjustment, ii) one bridging contact for normal setting of point and one for reverse setting of point is provided on the fixed contact plate for cross protection when the points are midway and neither normal nor reverse contact is making, ii) Moving contacts are mounted on a trolley loaded with helical springs. iii) One slide connected with each tongue rail with extension piece at tongue rail end using solid pin and with a link coupled with washer & nuts at the threaded end of the slide and the connecting rod, iv) one slide is connected with the roller and cam bracket using solid pin, of the economical facing point lock plunger, this way three slides are passed through the detector box under the detector
trolley pressing against slides through rollers attached to the trolley. Since the trolley is fixed with the box through a fulcrum rod, these rollers allow smooth movement of the slides.

Both the point slides are identical in design with one small depression on one position to correspond the closed position of the switch and a larger longitudinal depression for open switch. Accordingly the slides are connected to the tongue rail in such a way that the small depression of the slide falls below trolley roller only when the tongue rail is in closed position. This is required to ensure adjustment of the detection such that the contacts do not make when an obstruction piece of 3mm thickness causing a gap of 3 mm between closed switch rail and the stock rail is put. This is not necessary in case of open switch as such the longer depression falls below the trolley roller of the other switch which is open when the first switch is closed.

The lock slide has only one depression on it to allow fall of the roller when lock has been plunged in and the point detection slides are already in normal or reverse position.

There are two sets of bridging contacts in each electric point detector. Each set is in two parts. One having a ‘U’ shaped metal projection plate to counteract with the projected reed of the trolley moving underneath, riveted to the bridging contact, is screwed on the extreme end of the fixed terminal strip to make normal relay contacts, with the counterpart of the bridging contact screwed onto the terminal plate fixed opposite to make reverse relay contacts with the trolley. Another similar set of bridging contacts is screwed onto the other extreme ends of the fixed terminal strips, keeping bridging contact with the ‘U’ shaped metal projection plate riveted placed on the plate opposite to the first one.

It is pertinent to note that it is the trolley which tilts either side, depending upon point set for normal or reverse, makes contact with the terminal contacts screwed on the fixed terminal strip, to prove respective setting of the point. The tilt of the trolley is exponentially proportional to the gap between switch rail and stock rail which determines making or breaking of detection contacts.

Under conditions when the points are set for normal or reverse the reed on the trolley butts against the counter projection riveted with the bridging contact to raise the bridging contact up disconnecting, and continue to be so till the trolley is tilted, with the counterpart of the bridging contact thereby keeping the NWKR and RWKR, R1&R2 terminals un-bridged and consequently allow either of them to be energised if detection contacts are made. As the point is operated the trolley becomes vertically aligned, making the reed on the trolley to shift its position away under the bridging contact ‘U’ shaped projection allowing it to come down and to rest on its counterpart making the bridging contact short circuiting NWKR and RWKR coils.

These bridging contacts work as cross protection, one set connected with R1 and R2 of point normal indication relay NWKR as well as second set of bridging contact with R1 and R2 of the point reverse indication relay RWKR, to ensure that none of these relays get energised when points are not set in either position and gets disconnected, before the normal or reverse detection contacts is made, with the tilting of the trolley either way for.
5.1.2 **Mounting of the EPD**: i) The EPD is fixed onto a shoe which is rigidly fastened with the stock rail through a solid rod with a but end, tightened with bolts and nuts so as to ensure that there is no variation in distance between the EPD and the stock rail. Any inter-se movement between the two shall effect the adjustments resulting in failure or creation of unsafe situation. The EPD assembly is put on a cast iron foundation cast in-situ with cement concrete, between two angle channels fixed on the foundation top. ii) The other method is to fix the EPD on the same sleepers as on to which the point is placed, since the dimension of the detector does not match with the sleeper spacing, two angle iron bars are fixed with the sleepers on which the EPD is bolted. The arrangement is comparatively better with reference to creeping points, which adversely affects performance when the detector is fixed on cast iron foundation due to rods connecting the EPD as well as point and lock slides getting skewed, disturbing entire adjustment.

Electric point detectors are used under electro mechanical signalling where with out-type point machines where the point detection is not inbuilt with the point machine as well as these are used where points are operated with rods and signals are colour light, requiring electrical detection of points. By and large similar arrangement for point detection is made within the casing of the electric point machine.

6. **Monitoring cable health**: A damaged signalling cable is one of the biggest safety hazards. Rightly so it has been prescribed to test all conductors of signalling cable for insulation every year in dry weather. Progressive test results should be monitored for insulation status and as a sudden fall in insulation is observed the cause shall be investigated and immediate steps shall be taken to repair or replace the cable. In addition it also has been provided that in addition to the regular testing in dry weather, random tests should also be conducted in wet weather where considered necessary, to localise any sudden deterioration in insulation of the cable. [Signal Engineering Manual Part II, September 2001, clause 15.23.1 & 15.23.2].

The seriousness of the situation warrants rather continuous monitoring of the signalling cable health. The device for the purpose is Earth Leakage Detector (ELD).

The one or more spare cores of the signalling cable are fed with electric power. As and when the insulation of the conductors fall below safe level and the conductor current is leaked to earth, the current flows through ELD system earth provided on a conspicuous place, where the signal maintainer is available round the clock, displays audible and visual indication. The cable needs immediate attention.

7. **Arm & Light repeater**: Under electro mechanical arrangement for checking of status of the signal arm and burning of a kerosene oil lamp for Semaphore signals, arm and light repeater is used which is an exact parallel of ECRs of colour light signals.
It is a small glass fronted box with two indicators one for representing status of signal arm and other to represent the status of the signal lamp lighting. The signal indicator is operated to simulate signal arm’s Off and On positions depending upon direction of the current passing through electromagnet coil. The current direction is inverted through circuit controller attached with the signal arm. The electromagnet coil for lamp moves only in one direction to show ON when lamp is burning and OFF when not. A thermostat which is bypassed with a high resistance is placed on the top of the signal lamp burner makes a contact when heated by the burner bypassing the resistance and gets disconnected when the lamp is not burning. The impedance of the lamp indication coil is such that the current is not enough for creating torque for turning indication needle to OFF position when thermostat contact is not made and the resistance bypassing the thermostat contact is in the circuit. The lamp and signal arm indication coils are put in series keeping the signal arm indication coil impedance to be such that it works in both the situations of full as well as reduced current.

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Chapter VII  
Self assessment

1. **Multiple choice questions.**
   1. Minimum length of any track circuit shall be:
      (a) 13 metre* (b) 16 metre (c) 39 metre (d) 65 metre
   2. Train shunt resistance for D.C. Track circuit shall not be more than:
      (a) 1 Ohm (b) 0.1 Ohm (c) 0.5 Ohm* (d) 10 Ohm
   3. Minimum permissible ballast resistance in the block section is:
      (a) 4 Ohm* (b) 2 Ohm (c) 6 Ohm (d) 8 Ohm
   4. Number of frequency bands used for AFTC are specified as:
      (a) 4 (b) 6 (c) 8* (d) 10.
   5. Impedance bond is required to be used with
      (a) Single rail track circuit (d) double rail track circuit (c) both of them (d) none of them

2. **Select right answer- (True/False):**
   1. In case of D.C. track circuit the wheel of the train short circuits the battery.- True/False*
   2. Track magnet of Approach warning system is a passive device. - True*/False
   3. Analogue axle counter can also be used as multi-section axle counter. - True*/False*
   4. No evaluator is required in case of single section digital axle counter. - True*/False
   5. In case of analogue axle counter, count takes place only when one of the channel’s level is low and other channel’s level is in transition. - True*/False

3. **Answer the following questions:**
   1. Discuss train shunt resistance with reference to D.C. track circuits.
   2. Compare AWS, TPWS and Raksha Kawatch.
   3. Compare single section digital axle counter with Analogue Axle counter.
   4. Discuss electrical separation joint of an end fed AFTC, with specific reference to overlap signalling zone.
   5. Write short notes on:
      (a) Transmitter of AFTC
      (b) Receiver of AFTC
      (c) Tuner of AFTC
      (d) Receiver and relay of Jeomont T.C.
      (e) Impedance bond.

*****
1. **Power Supply for signalling system:** Power supply is an integral part of any signalling system be it semaphore or colour light. In rudimentary signalling system where there are no track circuits, reversers, indicators the power is still required for telephone communication.

110 V AC power is used predominantly for Signalling system on Indian Railways. 110V for reasons of this voltage being safe for humans and shall not be fatal in normal course and AC being easily transformable to any required potential for use of different equipments and systems of signalling.

2. **Power supply requirement:** Power supply is required for - A) Semaphore signalling system for, i) illuminating indication of semaphore signals, ii) motor operation of signals, iii) controlling reversers, iv) electrically operated indicators; B) Electrical system of signalling for i) illuminating signal lamps and their indication in the cabin, ii) Solid State Interlocking (SSI) system, iii) panel indications, iv) computerized system of operation for SSI; and C) common to both and hybrid signalling system for, i) electrical interlocking using switching relays, flasher & time element relays, ii) Audio Frequency Tack Circuits, digital track circuits, or any other track vacancy monitoring devise such as Axle counters, iii) operation of point machines, iv) electrically illuminated independent indications, v) Intermediate Block Signalling, vi) power operation of lifting barriers on level crossing gates and for D) Automatic Block signalling System E) for block signalling under Absolute Block system F) for telephonic communication between Station Master and cabins, adjoining station attached to Block Instruments and other telephonic communication such as with IBS post, Crank handle, in location boxes for manual operation of points, level grossing gate goomties and Axle Counter resetting box for resetting of axle counters where provided for Block Proving etcetera.

2.1 There is huge variation for requirements of power supply for similar equipment depending upon product manufactures design and technological developments [Table 2.1].

All these power supply requirements and many more, need a battery bank with a battery charger to feed the circuit and charge simultaneously the battery bank needed to provide the system a stable power supply and backup when there is no power.

<table>
<thead>
<tr>
<th>SN</th>
<th>Equipment</th>
<th>Power supply required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interlocking Q series relay based</td>
<td>24V DC</td>
</tr>
<tr>
<td>2</td>
<td>Interlocking Siemens</td>
<td>24V DC or 60 V DC</td>
</tr>
<tr>
<td>3</td>
<td>Interlocking SSI</td>
<td>24VDC &amp; 12V DC (Microlock II)</td>
</tr>
<tr>
<td>4</td>
<td>Track circuits, Shelf type relay</td>
<td>4V DC</td>
</tr>
<tr>
<td>5</td>
<td>Track circuit Q series 4 &amp; 9 ohm relay</td>
<td>4-6 V DC</td>
</tr>
<tr>
<td>6</td>
<td>Track circuit Q series ACI, QTA-2, 9 ohm relay</td>
<td>4 V for TC up to 100m &amp; 6V for TC up to 450m.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Power requirement</td>
</tr>
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<td>-----------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Track circuit Q series ACI, QBAT, 9 ohm relay</td>
<td>4 V for TC up to 100m, 6V for TC up to 450m &amp; 8V for TC up to 750m.</td>
</tr>
<tr>
<td>8</td>
<td>Input for DC track circuit feed battery chargers</td>
<td>110V AC</td>
</tr>
<tr>
<td>9</td>
<td>Audio frequency track circuit</td>
<td>24V DC</td>
</tr>
<tr>
<td>10</td>
<td>Axle counters (Block proving)</td>
<td>24V DC 80AH battery bank with 220-240VAC/24VDC battery charger less than 10 mv rms and 50 mv PP.*</td>
</tr>
<tr>
<td>11</td>
<td>Point machine DC operated</td>
<td>110V DC</td>
</tr>
<tr>
<td>12</td>
<td>Point machine AC operated</td>
<td>450V AC three phase</td>
</tr>
<tr>
<td>13</td>
<td>Block instrument SGE double line (line circuit)</td>
<td>24-40V ripple free DC with dual bank battery charger*</td>
</tr>
<tr>
<td>14</td>
<td>Block Instrument single line token.</td>
<td>12-24V DC, 1A*</td>
</tr>
<tr>
<td>15</td>
<td>Block Instrument single line token-less</td>
<td>40-60 DC, 1A*</td>
</tr>
<tr>
<td>16</td>
<td>Block bell circuit</td>
<td>12V DC</td>
</tr>
<tr>
<td>17</td>
<td>Signal lighting (incandescent lamp)</td>
<td>110VAC transformed at site to 12V AC</td>
</tr>
<tr>
<td>18</td>
<td>LED signals</td>
<td>110 V AC or 110 V DC</td>
</tr>
<tr>
<td>19</td>
<td>i) Different set of same voltage power supply shall be needed for indoor &amp; outdoor circuits in area electrified with 25KV AC. ii) Signal lighting shall be provided with inverter backup to ensure uninterrupted power supply for signal indication.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>All kinds of battery chargers for charging different battery banks as mentioned above except DC track circuits.</td>
<td>Ferro resonant, 220-240V AC input with capacity and output as per requirement of battery bank.</td>
</tr>
<tr>
<td>21</td>
<td>Speech circuit for point to point or group telephone.</td>
<td>3 V DC (ripple free); 6-I Rail road cells or any other cell in conformity to RDSO specifications IRS S-95/96.*</td>
</tr>
<tr>
<td>22</td>
<td>Motor operated signals, Key transmitters &amp; signal reversers</td>
<td>12V DC.</td>
</tr>
<tr>
<td>23</td>
<td>Independent indications of signal aspect and track circuit.</td>
<td>12V AC through 230V AC/12V AC transformer of 250VA.</td>
</tr>
<tr>
<td>24</td>
<td>Incandescent Indication on Panel.</td>
<td>24 V AC through 230/24V 500 VA transformer fed through inverter for signal supply.*</td>
</tr>
<tr>
<td>25</td>
<td>LED based Indication on Panel</td>
<td>24V DC with 80AH battery bank and a 230V AC/24 DC battery charger.*</td>
</tr>
</tbody>
</table>

* Railway Signalling Installation & Quality Hand Book (SIQH), issued by Railway Board

Table 2.1

Power supply requirements
3. **Sources of power supply:** Power supply sources are categorised as **primary** and **secondary**. Primary sources are those which are commercially available while secondary sources are for power at different voltage levels, DC or AC and for storage and other usage, as created by railways as backup & supporting arrangement.

3.1 **Primary sources of power supply:** Primary sources of power supply for signalling system are i) Commercial supply from local state electricity board directly or through overhead equipment in the area electrified for traction, ii) Solar power panel, iii) Diesel generators.

3.1.1 **Power supply through OHE:** In the area where 25KV AC traction has been provided, traction Over Head Equipment (OHE) is charged at 25KV AC. The power is drawn from OHE after transforming it to 230V AC through Auxiliary transformer (AT). The traction return current finds its return path through earth via rails after passing through eclectic loco motor and wheel of the loco. One limb of primary coil of the AT is connected to overhead Catenary and other end is earthed. The secondary output winding of AT provides 230V AC. This is terminated in the Station Master’s room as the primary supply point for signalling system and for battery chargers which are commercially manufactured to work on 230V AC input, with an exception to track feed battery chargers which are designed to work on input of 110V AC as these chargers are provided by the side of the track circuit feed, spread over entire yard where carrying 220-240 V AC supply is not considered appropriate for safety considerations.

3.2 **Secondary source of power supply:** Stable signalling system is required for trains running at high speed as bobbing signal or track circuit or a signal going blank, shall result in disastrous consequences, as such the power supply is provided with a storage system of back up. **Secondary source is a battery bank** in an array of 2V low maintenance lead acid cells of desired capacity, arranged in series to get the desired voltage and enable the system to sustain about 6 hours non-availability of primary source of power supply, with a **battery charger** capable to trickle and quick charge. This is required in all cases whether primary source of power supply is from state electricity board, Solar panel, 25KV AC or Diesel Generator.

Low maintenance lead acid battery banks are used for signalling system while maintenance free Valve Regulated Lead Acid (VRLA) cells which are sensitive to ambient temperature working at its best at around 27°C, loosing efficiency adversely with the change in temperature, as such, are suitable only for indoor usage and as such are used for telecommunication system.

Line circuits of block instruments where three position polarised relays are used in block line circuit, ripple free power supply is required. In such case either primary cells or a lead acid battery bank to which charger is not connected, is used. Two sets of battery bank are connected one being on the circuit and the other on charging through a duel bank battery charger. Duel bank battery charger is especially designed to facilitate switching over charging onto the battery bank which was connected on the circuit and the one which was being charged is connected to the line circuit. The switching over s done manually as a regular maintenance programme on a periodicity based on consumption of power.

3.2.1 **Battery charger:** For storage of power supply, the battery bank is charged through a battery charger. The battery chargers are self regulating type as well as controlled manually.
also. All battery chargers are worked on 230V AC designed to charge a battery bank of capacity and voltage required for the equipment except for track feed battery chargers which work at 110V AC input. The battery chargers for electronic equipment such as axle counters and SSI are with inbuilt rectifiers to maintain ripple component below specified limits.

4. **Power supply arrangement:**

4.1 **Primary power supply arrangement:** Available sources of power supply are used as an alternative to each other in order of priority. The priorities depend upon availability of sources of power supply at the given station/site. i) power supply from local State Electricity Board (SEB) is the main and first source of power for signalling system, ii) In case the SEB power supply is erratic as such unreliable, electrical system of signalling is usually not provided but however if it becomes imperative to provide electrical system of signalling for operational or technical considerations, solar power supply is used in support to the local state centrality power supply occasionally supported by Diesel Generators, iii) In areas electrified with 25KV AC traction, main source of power supply is from OHE supported by State Electricity Board power supply. iv) A diesel generator of suitable capacity is used as the last alternative such as in case of single line section electrified with 25KV AC traction, two DG sets are used to work alternately when OHE as well as state electricity board’s supply is not available or where solar panel is used as an alternative to State Electricity Board’s supply.

First priority power supply for signalling system is brought into Station Master’s room and terminated on a distribution panel with changeover switch. All other available power supply systems scheduled to be used for signalling system are also brought in the Station Masters room and terminated on the same distribution panel with a changeover switch. The changeover switch is manipulated for selection of one of the sources of the power supply. Onwards distribution to i) cabins if there are cabins for operation of signalling system or ii) to equipment room if signalling system is operated centrally, is connected to the output of the changeover switch. The distribution panel is provided with illuminated indicators for availability of power, as Station Master being the person available round the clock and also the person in the helm of affairs of running rail traffic at site knows best when to switch over to the available power supply to avoid blanking out of the signals or collapse of interlocking system.

Equipment room is the accommodation to keep transformers, battery chargers and voltage stabilizers. Batteries shall be kept in separate room.

First source of power is used besides onwards distribution to signalling system and also for general lighting of the station area. Arrangement of power supply at a road side station provided in area electrified to 25 KV AC traction, equipped with multi aspect colour light signalling is shown in the figure 4.1. This does not cater for supply for Indication cum operation panel.
Figure 4.1
General power supply arrangement for MACL signalling system on a road side station electrified with AC traction
4.1.2 **Arrangement for power supply in area electrified with 25KV AC traction:** Circular number 82/RE/205/1 dated 13.09.2002, issued by Railway Board, lays down detailed guidelines on use of different sources of power supply for signalling & telecommunication installations in area provided with 25VAC traction. The salient features of the circular are:

<table>
<thead>
<tr>
<th>SN</th>
<th>Installation</th>
<th>Requirement</th>
</tr>
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</table>
| 1  | Way side station/ BH /IBS on double line section. | i) Two ATs of 10KVA each connected to up & down Catenary.  
   ii) Local supply shall be alternative source. |
| 2  | Way side station/ BH/ IBS on single line section. | i) One AT of 10KVA connected to the Catenary.  
   ii) Local supply shall be alternative source.  
   iii) One DG set of adequate capacity will be provided. |
| 3  | Station situated within 350m from Traction Switching Post (TSP). | i) 240V supply for station situated within 350m from the TSP will be extended from the AT provided at the TSP.  
   ii) Second AT of suitable capacity will also be connected to the other Catenary on double line section. |
| 4  | Big yards with Multiple cabins. | i) 2-3 cabins, depending upon load, shall be grouped and power shall be extended from a set of two ATs one each connected to up & down Catenary on double line section. One such AT shall be provided, at convenient location to feed each such group.  
   ii) Local supply shall be alternative source.  
   iii) DG sets as required will be provided. |
| 5  | RRI installations. | i) Main source of supply will be three phase local power supply.  
   ii) Second source of supply will be provided by three numbers of 10/25/50 KVA ATs as per load requirement.  
   iii) Two sets of DG sets of adequate capacity will also be provided as stand by.  
   iv) For relay-huts located less than 2Kms from the RRI cabin, supply will be extended from the cabin. In case local power supply is also available at the relay hut, an automatic change over switch of suitable capacity will also be provided by S&T department.  
   v) For relay-huts located beyond 2Kms from the RRI cabin, a separate set of ATs will be provided along with one local power supply. Where load requirement so warrant, two relay huts may be grouped. |
| 6  | End Panel Stations, | i) Main source of power supply will be through two ATs in case of double line section and one AT in case of single line section with capacity of the AT as 10/20 KW depending upon requirement.  
   ii) Local power supply shall be second source.  
   iii) One DG set of adequate capacity will be provided for single
<p>| | |</p>
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<tbody>
<tr>
<td><strong>7</strong></td>
<td>Interlocked level crossing gates.</td>
</tr>
<tr>
<td>i)</td>
<td>Two ATs of 5 KVA each shall be provided and in case of single line section, one AT of 5 KVA shall be provided at each interlocked level crossing gate located at a distance of more than two Kms away from the station. Wherever interlocked level crossing gate is locate within 2 Kms of a station or other interlocked level crossing gate, where a set of ATs has been provided, the power supply from one of the ATs will be extended to these level crossing gates.</td>
</tr>
<tr>
<td>ii)</td>
<td>Local supply shall be standby source at level crossing gates in block section.</td>
</tr>
<tr>
<td><strong>8</strong></td>
<td>Automatic Block signalling installations.</td>
</tr>
<tr>
<td>i)</td>
<td>Power supply for all signals within 2 Kms from RRI cabin or station shall be extended through signalling cable.</td>
</tr>
<tr>
<td>ii)</td>
<td>Power supply for signals located beyond 2 Kms, a set of ATs will be provided connected with up and down lines in case of double line section and one AT for single line section.</td>
</tr>
<tr>
<td><strong>9</strong></td>
<td>Main/standby supplies.</td>
</tr>
<tr>
<td>i)</td>
<td>Power supply from ATs will be the main source for all way side stations, multi-cabin stations, end panel stations, level crossing gate, IBH, IBS, Automatic signalling relay huts, while local supply shall be the standby source.</td>
</tr>
<tr>
<td>ii)</td>
<td>In case of RRI if local supply is reliable it shall be main source of power supply while supply from ATs shall be the standby source of power supply.</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Power supply distribution and arrangements for way side stations, IBS, BH, Multi-cabin stations, LC gates, end panel stations &amp; Automatic block signalling sections.</td>
</tr>
<tr>
<td>i)</td>
<td>ATs, local supply, supply from inverter or supply from DG sets as the case may be, will be terminated on an automatic changeover switch/panel provided by electrical department in conformity to RDSO specifications.</td>
</tr>
<tr>
<td>ii)</td>
<td>Power supply will be extended from auto changeover panel to cabins or where Signalling equipments are installed through a cable of suitable capacity.</td>
</tr>
<tr>
<td>iii)</td>
<td>Normally the changeover will be automatic.</td>
</tr>
<tr>
<td><strong>11</strong></td>
<td>Power supply distribution and arrangements for RRI installation including relay huts.</td>
</tr>
<tr>
<td>i)</td>
<td>Three phase local supply shall be extended to RRI power supply room and terminated on a distribution board.</td>
</tr>
<tr>
<td>ii)</td>
<td>Power supply from all ATs shall also be terminated on distribution board.</td>
</tr>
<tr>
<td>iii)</td>
<td>Local power Supply, supply from ATs and supply from DG set shall be extended to power panel of RRI.</td>
</tr>
<tr>
<td>iv)</td>
<td>Power panel shall have facility for automatic changeover for three sources of power supply.</td>
</tr>
</tbody>
</table>

**Table 4.1.2**

*Power supply arrangement in 25KV AC area*
It is pertinent to note that power supply from ATs and local power supply from state electricity boards shall be provided by Electrical department of railways at a given point which is usually Station Master’s room which shall be extended to the desired location by S&T department of railways. For this, power cable of 1100V grade, armoured, PVC insulated and PVC sheathed Aluminium conductor in conformity to IS specification 1554 Pt.-I shall be laid with configuration as laid down by RDSO as per their letter number TI/PSI/PROTCT/ CLS/03 dated 21.02.2003 detailed in Chapter IV (transmission media) of this book.

4.1.3 **Power supply distribution on area electrified with 25KV AC traction:** Owing to development of induced e.m.f. on unscreened cable conductors due to parallelism, i) all circuits leading power out of and leading power in from & to confines of the relay room, double conductors with double cutting of relay contacts is used, ii) in case of signal lighting circuits the limit of 200 metres between controlling relay and the signal is imposed, iii) maximum distance between source of power supply and the place of signal controlled has to be restricted to 2.8 Kilometres on double line section for QNA1 relay used due to 400V limit (including 1.5 safety factor) of AC immunisation of the line relay and iv) circuits wired within relay room with single cutting;

a) External and internal circuits are isolated with each other.

b) Power supply sources for circuits leading up to a distance of 200 metres from relay room are kept isolated from all other circuits.

c) Power supply sources for circuits leading up to a distance of 2.8 Kilometres on double line section, from the relay room are kept isolated from all other circuits.

Accordingly three power supply sources isolated with each other are used in such area.

For further details refer Indian Railway Signal Engineering Volume –I by the same author.

4.2 **Capacity of primary source of power supply required and fundamental principles of distribution:** Before requesting electrical department for arranging power supply for use of signalling system, the total signalling system load has to be worked out. For working out the load of signalling equipment has to be taken into account along with efficiency of transformers and battery chargers and calculated backwards to reach up to primary source.

4.2.1 Fundamental principles for working out primary load requirement [Table 4.2.1]:

240
Table 4.2.1

<table>
<thead>
<tr>
<th>SN</th>
<th>The principle</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The power supply shall be of 1.2 times higher than required at site. Such as if a track circuit requiring 400ma at 6 volts i.e. its energy requirement is ( 400 \times 6/1000 = 2.4 ) watts. In this case the source of power supply shall be ( 1.2 \times 2.4 = 2.88 ) watts.</td>
<td>Clause1.2.3 SIQH*</td>
</tr>
<tr>
<td>2.</td>
<td>All power supply equipments such as battery chargers, transformers, inverters, stabilizers &amp; IPS shall be kept in one room called as equipment room and all battery banks shall be kept in separate room to avoid damage to equipment due to acid fumes emanated from secondary cells.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>To ensure continuous power supply to the signal aspects to avoid blanking off of the signals, 220/110 V AC signal transformers shall be supported by inverters. Direct AC supply from primary source for signal transformers shall also be provided through Voltage Regulators (VR) to avoid voltage fluctuations.</td>
<td></td>
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<tr>
<td>4</td>
<td>Separate transformers shall feed signals and track circuits.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Efficiency of each equipment between primary sources of power supply up to the last equipment shall be taken into account. Efficiency of battery chargers and transformers usually range between 0.6 &amp; 0.9 which shall be checked from the manufacturer.</td>
<td></td>
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</tbody>
</table>

4.2.2 Calculate power requirement at primary source of power supply:

i) List down all equipment at the station with their power requirement in terms of Watts,

ii) The equipment load shall be shared with battery charger and the battery bank.

iii) Check up efficiency of the transformer if the equipment works on AC or that of Battery Charger if equipment works on DC.

iv) Sum up total requirement of each equipment.

v) Sum up total requirement of all equipments of each type such as signals as one group, points as another group and internal relay wiring as one group etcetera.

vi) Multiply sum total of all groups and multiply by a factor of 1.2 [Railway Signalling Installation and Quality Handbook paragraph 1.2.3]

For example take a four line station on double line section provided with central panel with incandescent lamp indication, colour light signals provided with incandescent lamps, complete yard between Home signal and Advanced starter signal with loop lines provided with DC track circuits. Station provided with two distant signals Inner Distant and Distant and also three independent shunt signals. While calculating power requirement, the maximum load at any stretch of time is considered. Equipments which are fed with power through a battery bank and a charger, the load is shared by battery charger and the battery.

a) Maximum signal lamps lit at any one time: Advanced starter signal one \( = 33W \), mainline and loop line starter signals one each i.e. two \( 33 \times 2 = 66W \), home signal one \( = 33W \) with junction type route indicator i.e. \( 5 \times 25 = 125W \), Inner Distant i.e. two \( 33 \times 2 = 66W \) and distant signal i.e. 241
2x33=66 W in one direction total power required =33+66+33+125+66=223W; Total power required for signals in both, up & down directions=223x2=446W. Taking efficiency of 110V AC:12VAC signal transformer as 0.9 the power required at 110V AC side of signal transformer = 446/.9=495. Power required for shunt signals, two lamps each independent signal lighted at 110V AC, 25W each. The power required by each shunt signal shall be 50W and for three shunt signals it shall be 50x3=150W. Total power required for all Stop signals and the Shunt signals at 110V AC works out to be 495+150=645W; considering efficiency of 230:110 V transformer as 0.7, total power required at 230V AC side = 645/0.7=921W multiplying with factor of 1.2 it works out to be 921x1.2=1105W.

Accordingly total power required for lighting signals at the station on primary source of power supply shall be 1105W.

b) **All DC track circuits** at the station yard may be taken as 24 in numbers. Each track circuit works with QTA2 relay drawing 148 ma normal current at 1.4V normal voltage.

Power to DC track circuit is provided with a battery bank of 6V comprising of three secondary cells of 80AH capacity each. The 9 Ohm track relay can be over energised to 2.5 times of its normal operating voltage which works out to be 1.4x2.5=3.5V. The current drawn by the relay at this voltage shall be 0.389 A. The current leakage across ballast and sleepers may be taken as 0.1A in addition to 0.389, (the voltage drop across track feed resistance fills in the gap between 6V battery bank), thus the load at battery charger shall be 0.489x6=2.93W. Taking efficiency of the track feed battery charger 110V AC/ 6V DC, as 0.8, the load at 110 V AC side works out to be 2.93/0.8=3.66W. Taking into account the efficiency of 220V:110V transformer as 0.7, the total load at primary power supply, on account of each track circuit, works out to be 5.23W (3.66/0.7). The net load due to all track circuits in the yard shall be 5.23x24= 125W.

Multiplying this with factor of 1.2 the net load on primary power supply 230V AC due to all track circuits shall be 125x1.2=150W.

c) **Power supply for internal circuits using QN1 relays.** The nominal working volt of QN1 relay is 24 V DC with 350 Ohm coil resistance the operating current for each relay works out to be 68ma. Accordingly each relay consumes 0.068x24= 1.632W. Approximately 500 Q series relays are used in indoor circuits on station yard taken for example. Considering at an average of maximum 250 relays energised at any one stretch of time the net power works out to be 250x1.632= 408W. Taking efficiency of the charger as 0.8 the net wattage required at 230V AC shall be 408/0.8=510 W.

Multiplying with factor of 1.2 total power required for internal load shall be 510x1.2= 612 W.

d) **Power supply for external circuit using QNA1 relays** (in area electrified on 25KV AC traction): The nominal working volt of QNA1 relay is 24 V DC with 208 Ohm coil resistance the operating current for each relay works out to be 115ma. Accordingly each relay consumes 0.115x24= 2.76W. Out of approximately 200 relays, considering at an average of maximum 60 relays energised at any one stretch of time the net power works out to be 60x2.76=165W. Multiplying with factor of 1.2 the net load on primary power supply 230V AC due to all external relays shall be 165x1.2=198 W.
e) **Point machine operation:** 110V DC operated point machines take 6A initial current to operate. Three machines may be required to move at one stretch of time, thereby consuming 18A at 110V. This works out to be 110x18=1980W. Considering efficiency of the battery charger to be 0.8, the load on 230V AC shall be 1980/0.8=2475W.

Multiplying by a factor of 1.2 the net load on primary source of power supply works out to be 2475x1.2=2970W

f) **The Indication cum operating panel** provided with incandescent indication lamps or LEDs. The incandescent lamps lit by 24 AC transformed from 230V AC source derived from the same inverter which is provided for signal illumination or through 24 DC through a low maintenance battery bank with a suitable charger. The intention is to ensure that panel indications shall not go blank under any circumstances as it shall bring entire operation of signalling system at the station.

In present example the panel indications provided with 24V DC, 1.2 W incandescent lamps is taken. Here maximum lamps lit at any stage of time shall be about 110 numbers covering indication for i) signal aspects-21, taken same number as that of signals as taken in preceding paragraph, ii) independent shunt signals-3, iii) route lights-54, iv) flasher relay-1, v) point lock indications-10, vi) route lock indications-2, vi) crank handle locked/released-10, vii) level crossing gate locked/released-1, viii) power supply health-2, ix) train entering section with buzzer- 2, x) 120NJKE-1, xi) Signal lamp fused-1, xii) train entering block section indications- 2, xiii) train entering block section buzzers-2 (20W). This may very depending upon requirement such as x) IBS passed at On, where IBS has been provided, y) panel PC switch, z) SSI system working/ failed and many more.

Accordingly total power required for panel indications shall work out to be 110x1.2=132W+20W for buzzers. Thus total power for indication panel required shall be 152W at 24V DC. Considering efficiency of the battery charger to be 0.8 net load at 230V AC power supply shall be 152/0.8=190W.

Multiplied with a factor of 1.2, the net load on Primary supply of power shall be 190x1.2=228W.

g) **Block line circuit:** Block instrument line circuit is fed either through a set of primary cells or a battery bank charged with dual bank battery charger. Associated to the block instrument an independent set of power supply for block bell is provided. A dedicated telephone is also provided which normally works with 6-I Rail Road cells as such does not load the primary power supply.

In present example block line supply is taken from a battery bank of 12AH capacity which varies between 24V & 40V DC depending upon distance between two block stations to enable 150ma current through line circuit in case of double line SGE block instrument. Consider that the distance between two block stations is such that to maintain 150ma line current, a battery bank of 30VDC is required. However this shall be insignificant since this load is not passed on
to the primary supply source as this battery bank is not connected to the battery charger when connected to the Block line circuit. The battery charger shall charge this discharged battery bank when the other battery bank is put on line circuit and this battery bank is connected to the charger for charging, on 10% of battery capacity which workout to be 1.2A. Accordingly the load at the charger shall workout to be 30x1.2=36W. Taking efficiency of the charger as 0.8 the load on 230V AC shall be 36/0.8=45W. For two Block instruments at the station it shall be 90W.

Multiplying with a factor of 1.2 the load at primary supply shall be 90x1.2= 108W.

h) **Load of Block bell**: Block bell works on 12V DC battery bank. The load of block bell is momentary, average load on battery charger may be taken as 0.5W. Considering efficiency of the battery charger as 0.8 the net load on 230V AC shall be 0.5/0.8=0.62 W. For both sides this shall be 1.24W.

Multiplying with a factor of 1.2 the net load on primary supply shall be 1.24x1.2=1.49W say 1.5W.

j) **Sundry loads**: Telecommunication equipment, equipment room & relay room lighting is also considered for working out power supply for S&T equipment. This may be taken on lump-sum basis as 500W.

Accordingly total load on primary supply, which should be advised to electrical department, works out to a+b+c+d+e+f+g+h+j=5872.5W, say 6KW.

5. **Power from Solar cells**: [Figure 5] Solar energy i.e. energy from sunlight is converted to electrical energy using Photo Voltaic cells (PV Cells). Each Silicon solar cell when exposed to sunlight, photons generates 100ma at 0.45 Volts which works out to be 45 miliwatts DC from each cell measuring 2 inchesx0.5 inches (6.45 sq cm). PV cells can be arranged in parallel & series in such a way, on a panel, so as to generate desired DC power. Each such arrangement is Solar Photo Voltaic (SPV) system. The panel is mounted on the roof of a building or on a post by itself facing South and inclined at an angle such that the sunrays fall at right angles to the panel, a point sufficiently high to give a clear exposure to the trajectory of sun moving in South for longer period of the day while at the same time to make its reach conveniently accessible for maintenance, repairs and cleaning its surface. The accumulation of dust over the surface of the Solar Panel reduces the efficiency of the system, requiring periodic cleaning of its surface.

Accordingly for a station provided with central panel with MACLS which may require about 3 Kilo watts of power shall need a panel of [(.000645x3000)/.045= 43] 43 Sq. meters. The length works out to be 21.5 metres. However the SVP shall have to cater for additional capacity for battery charging to the extent of at least 3 no-sunny days calling for increased size of the panel.
In view of the fact that solar panel shall be able to generate power during the availability of sun, the power so generated shall have to be stored also which can be done by storing it into a low maintenance battery bank of lead acid cells, which is used to run the signalling system through DC TO DC converters of desired voltage depending upon equipment requirement and inverter to provided power supply for lighting of signals. In case the local power supply is also available even for short periods, it can be made use of for charging the battery bank to the extent possible [Figure 4.4]. The system is further supported by a Diesel Generator to charge the battery in case of more than three non-sunny days (not shown in the figure).

Solar power supply arrangement could not become popular despite of being pollution free and free primary source, because of high initial costs.

First generation solar cells were of crystalline silicon, costing fairly high being manufactured in comparatively smaller quantities. The second generation cells had higher efficiency, made of thin wafers of silicon. The third generation has more complex integrated devices that can reduce reflection thereby able to capture more of solar spectrum by using one or more combination of optical methods having wide range.

There are two systems of distribution one is on-grid and other is off-grid. On-grid is the commercial arrangement in which the energy generated by PV cells is sent to grid where it is converted to AC and sold, during the night, back to the supplier. However under off-grid arrangement the power is stored directly to the batteries. Germany has adopted solar power energy big way making solar power cheaper due to market economics. (Curtsey TOI dated 21st Jan, 2009, interview of Stuart Irvie Director for Solar energy Research, North Wales). Off-grid arrangement is used in railway signalling system in India.

6. **Integrated Power Supply (IPS), System:** Under conventional system of power supply arrangement for signalling system, as many assorted sets of battery banks of capacity, ranging between 12AH & 120AH or more, are required to be housed in a separate battery room to
Switch Mode Power Supply (SMPS) based Integrated Power Supply (IPS) has been introduced suitable for way side stations up to six lines without AFTC or up to 7 KVA total signalling load covering relay based interlocking operated by panel as well as SSI, to specification number RDSO/SPN/165/2004.

The system is designed with the objective of i) unifying entire power supply system at one place, ii) eliminating all verity of battery chargers and battery banks replaced by one single battery bank for one signalling system and iii) to ensure that the signals do not go blank when primary source of power supply is not available.

IPS System is designed in i) Cabinet ,ii) Float Rectifier cum Boost Charger (FRBC), iii) battery Bank, iv) Inverter, v) Constant Voltage Transformer(CVT), vi) Transformers and vi) DC-DC converters for different power requirements of signalling system and communication.

DC track circuit chargers are provided at site near the feed end of the concerned track circuit.

Salient features are:

i) Entire power supply arrangement has been compacted into one system in three panels each of fixed size viz. 2000mm maximum height, 750mm maximum depth and 750mm maximum width. One panel accommodates AC distribution system, other DC distribution system and one SMPS based Float Rectifier cum Boost Charger (FRBC). Front of the panel is equipped with switches and meters.

ii) Single battery bank of required capacity.

iii) SMPS based FRB Charger with auto boost charge, supplies power to battery bank till battery terminal voltage reaches 2.3V per cell in case of Valve Regulated Lead Acid (VRLA) cells and 2.42V per cell in case of low maintenance Lead Acid cells and shall then change over to Auto Float mode after the period as defined by battery manufacturer. The condition of the battery shall be sensed by switching/control unit.

iv) Inverter of suitable capacity is also fed by output of FRBC or from the battery bank when main primary power is not available.

v) DC-DC converters with 110 V DC input from FRBC and in absence of main power supply from battery bank, are easy to replace by sliding in from front, modular arrangement designed for typical requirement of each equipment separately to cater for voltage and capacity for working entire signalling system at the station.

vi) Adjustment to limit the input current adjustable between 50 to 100% of full load input current with provision for full utilisation of power when DG set is operated. [clause 4.1.16 of specifications of IPS]

The provision is to ensure that under deep discharge conditions of battery bank, when mains power is resumed, heavy current shall be drawn by the battery along with current drawn by normal load. In this case if the capacity of the source of power supply or that...
of the cable provided between source of supply and the IPS is less than the current
drawn by the IPS it shall damage the source or the cable. As such the input current shall
be set to limit in accordance to capacity of cable or source which ever is less.

Setting of input current shall also take care that the supply from Diesel Generator is not
under utilised i.e. if the diesel generator of 7KVA is provided to supply 220V AC the
maximum current which can be drawn from the generator shall be 31.88Amps. Keeping a factor of 1.2, maximum current that can be drawn from the generator shall
be 25.51 Amps. Accordingly if the input current is regulated to limit less than 25.51,
the generator output shall be under utilised. The current regulation shall also depend on
capacities of power supply transformer and cable’s current carrying capacity.

vii) Battery path current shall automatically be controlled by the input current in such a way
that input current shall not exceed the set limit. [clause 4.1.16 of specifications] The
current which is allowed to be in, shall be distributed to load and the battery bank in
such a way that signalling system is not deprived of the required input diverting the rest
to charging of battery.

It is pertinent to note that the input current setting has repercussion on the health of
i) main source of power supply, ii) cable between main source of power supply, iii) IPS
battery bank and , iv) signalling system.

In many cases malfunctioning of IPS is attributable to input current adjustment done
without appropriate considerations of all factors.

viii) Meter: AC volt/ampere meter to read AC input voltage and current, DC volt/Ampere
meter to read system voltage, battery voltage, system total current and battery current is
provided on the IPS panel. In case of failure of primary supply, battery discharge
current on DC ampere meter with negative sign shall automatically be displayed.

ix) The IPS is protected against lightening and transient surges in three stages. Stage 1)
power line class ‘B’ protection at distribution level against lightening, electromagnetic
impulse & other high surges, stage 2) power line ‘C’ class protection of equipment
level against low voltage surges and stage 3) protection for all external data line/AC-
DC signalling lines using class ‘D’ devices.

6.1 **Arrangement of power supply through IPS:** It shall be ensured that the feeder is
capable of feeding 30A at 230V AC to IPS. 230V AC supplied from the feeder into IPS is
distributed to i) SMPS based Float Rectifier cum Boost Charger (FRBC) panel, ii) Ferro
resonant Automatic Voltage Regulator (AVR) for power supply to signal transformers and to
iii) AVR for power supply to transformers for track feed supply [Figure 6 a].

The **DC output from FRBC** which is sine wave, is further divided in three limbs, one, to all DC
to DC converters, one to battery bank for charging in parallel and other to inverter. FRBC is
provided in n+ 1 configuration with a cold standby. The cold standby is not connected in circuit
but wired for insertion as and when required. Each module of the charger is capable of giving
20A at 110V DC with > 90% efficiency at nominal input and full rated load & > 85%
efficiency at 150-275 input and 25 to 100% load.
110V DC power supply from output of FRBC connected in parallel with battery bank is connected as input to inverter which in turn delivers 230 (± 2%) V AC sine wave form for input voltage variation of 98V to 138V DC and is connected to 230V AC/110VAC signal transformers. It is switched on automatically on non-availability of power from FRBC. The overall watt efficiency of the inverter is not less than 85% at full load for the input voltage range of 98V to 138V DC.

Primary power supply is connected to two AVRs provided in the IPS. The output of one AVR is connected to the output of inverter thereby providing two input sources to 230V AC/110V AC signal transformers to provide stabilised power supply for signal lighting. In normal course 230V AC main supply through AVR is fed to the transformer. As and when the primary supply is not available, the battery bank supplies 110V DC to the inverter, which takes over the output supply from AVR to the output of the inverter continuing uninterrupted power supply to 230V AC/110 V AC signal transformer.

Output of other AVR is connected to 230V AC/110V AC transformer meant for feeding power to track feed battery chargers. In case of non-availability of primary power supply the battery bank provided at the feed end of the DC track circuits sustains feed to the track circuit.

The Output voltage of the AVR is maintained at 230V (+/-1%) AC at rated load within range of 160V to 270V AC input. The efficiency of the AVR is not less than 85%.

DC to DC converters are fed power directly from FRBC and in absence of non-availability of 230V AC primary power supply, through battery bank. It becomes very convenient to provide power supply required to meet with different needs of voltage levels and capacities of power supply, by using DC to DC converters.

a) **Equipment fed with DC power and DC-DC converters:** i) DC power source is required for relays used in logic circuits. In case of stations provided with 25KV AC traction, it is required separately for internal and external circuits, ii) panel indication, iii) Axle counters, iv) line circuit for block instrument separately for either side, v) Block bell circuit, vi) Telephone attached to Block instrument separately for either side, vii) group telephone, viii) Data logger, ix) SSI system, x) point machine operation and for any other equipment provided at the station for signalling system.

DC to DC converters are housed in one or more cabinets of the IPS, each fed by 110V DC through the battery bank and output of FRBC connected in parallel, with output voltage and capacity to suit individual requirement of each equipment. DC-DC converters are designed and manufactured for a given capacity/current rating of 5 or 10 A and are grouped in parallel to cater for total current requirement of the equipment in addition to which two DC to DC converters are added as backup to withstand the load requirements in case of failure of any module till the same is replaced. The provision of additional 2 modules of DC to DC converters is represented as n+2 where ‘n’ is the required number of DC to DC converters. Overall

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Figure 6a
Schematic arrangement of Integrated Power Supply (IPS) System

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efficiency is not less than 75% for converters of 50VA -150VA rating and not less than 80% for converters of rating of 150VA and more at rated load.

No DC to DC converter is used for supply of power for point machines, which is extended directly by FRBC and through 110V battery bank in absence of primary source of power supply to the IPS.

Additional power supply is provided for charging sick cells which may require boost charging having gone low during usage.

IPS shall generally not be provided for RRI installation/big yards having more than 6 lines. [Railway Signalling Installation and Quality Hand book para1.5.6.2 (B) d].

b) **Working principle of DC to DC converter**: Transformation of voltage from higher to lower or vice-versa is easily possible with the use of AC with minimum losses and stability of supply, using transformer, while DC supply can only be stepped down but not transformed. This stepped down voltage is dependent on fixed power supply load as the output voltage shall vary with varying current of the load, voltage drop being ‘current x resistance’ (I x R). This is practically not possible and also causes loss of power. Accordingly the main DC supply is converted to alternating current through an oscillator, transformed to desired voltage level using transformer and rectified to convert to DC at the output. This combination is packed in one box and called DC to DC converter [Figure 6 b].

c) **Equipment fed with AC power**: AC power is needed for operation of i) Incandescent lamps fed with 12V AC and LED signals fed by 110V AC. In addition ii) 110V AC is required to run all along the yard to feed each track feed battery charger of DC track circuit.

For illuminating signal lamp, the primary power supply fed to the IPS is extended to 230VAC/110V AC transformer through an Automatic Voltage Regulator (AVR) of suitable capacity, to illuminate signal lamp. This supply has to be stable to ensure steady lamp illumination as well as for lower rate of fusing of Incandescent lamps. This transformer is also fed through an 110V DC/ 230V AC inverter connected to output of FRBC and the 110V DC battery bank in parallel, to ensure uninterrupted power supply to the signal lamps in case of failure of main source of power supply to the IPS.

110 VAC power to feed power to all battery chargers in the yard is derived from 230V AC/110V AC transformer, which is directly fed through the primary power supply source through another AVR to ensure stable voltage. Each feed end of the DC track circuit has its own independent set of battery charger as the battery bank to provide designed back up.
Required **capacity** of FRBC, AVR, Inverter, DC to DC converter, transformer of sorts and battery bank shall be worked out taking into account its efficiency, on lines as discussed in preceding paragraphs.

6.2 **Status monitoring panel:** An IPS status monitoring panel is provided in Station Master’s room with following indications and alarms [Table 6.3]: [clause 4.10 of specification 165/2004]

<table>
<thead>
<tr>
<th>SN</th>
<th>Indication &amp; status</th>
<th>Condition</th>
<th>Instruction to the SM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Red LED with audio alarm</td>
<td>50% DOD</td>
<td>Run DG set</td>
</tr>
<tr>
<td>2</td>
<td>Red LED with audio alarm</td>
<td>60% DOD</td>
<td>Emergent start</td>
</tr>
<tr>
<td>3</td>
<td>Red LED with audio alarm, Signal feed cut off and DC-DC converters to work</td>
<td>70% DOD</td>
<td>System shut down</td>
</tr>
<tr>
<td>4</td>
<td>Red LED with audio alarm</td>
<td>Equipment fault</td>
<td>Call S&amp;T staff</td>
</tr>
<tr>
<td>5</td>
<td>Green LED with audio alarm</td>
<td>FRBC changeover to float charge mode</td>
<td>Stop Generator.</td>
</tr>
</tbody>
</table>

1. Under conditions 1, 2 & 4 the audio alarm shall stop with its acknowledgement and in case of condition 3 the alarm shall continue till generator is started.
2. DOD represents Depth of Discharge

*Table 6.2*

*Indications on status monitoring panel*

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Chapter VIII   Self assessment

1. Multiple choice questions:

1. In area electrified with 25kv AC traction:
   (a) Internal and external sources of power supply shall be through battery bank or separate DC-DC converter.
   (b) Separate battery bank with separate battery chargers shall be used for internal & external sources of power supply.
   (c) Power supply for block bell shall be derived from internal source.
   (d) All of the above.*.

2. Primary sources of power supply for RRI installation shall be from:
   (a) Three phase local power supply.
   (b) All ATs.
   (c) Both of them.*

3. DC-DC converter is a device to:
   (a) Convert DC power source to DC power output by stepping down through resistances.
   (b) Convert DC power source to DC power output by stepping down through transformer.
   (c) Invert DC power source to AC power & than converts to DC power out put.*
   (d) All of them.

4. IPS caters for 110 AC power supply besides battery charging for:
   (a) Track circuits.
   (b) Signal lighting.
   (c) Level crossing gate.
   (d) All of them.*

5. Current regular is provided with the IPS to:
   (a) Limit current input to the IPS.
   (b) Regulate current for battery charging.
   (c) Ensure regular power supply to signal & all DC-DC converters.
   (d) All of them.*

2. Select the right answer (True/False):

1. Dual battery being charged by a battery charge is used for supply of power to line Circuit of Block instrument - True/False*

2. Power supply from the primary source shall be extended us to 2Km for signalling requirement beyond which another source of power supply shall be provide.- True*/False

3. N+2th DC-DC converter is not put on load in IPS- True/False*

4. IN area electrified with 25 KV AC traction, power supply for internal & external usage shall not be isolated if load is less –True/False*

5. Power supply for Block Instrument line circuit shall not have AC ripples as the polarised relay is sensitive to AC –True*/False
3. **Answer the following questions:**

1. Describe IPS with specific reference to DC-DC converters & indication panel placed in the Station Master’s room.

2. Write short notes:
   (a) Secondary source of power supply.
   (b) Primary source of power supply.
   (c) Current regulator in IPS.

3. Calculate power supply requirement at primary source so as to apply for power connection to State Electricity Board, for a three line station provided with Central control cum indication panel. Assume figures of Signals, track circuits, point machines etcetera realistically.

4. What is a solar cell? Can it be used for multiple aspect colour light signal operated by Control cum Indication panel? How the power supply from solar panel is used and why solar panel could not take on Indian Railways on large scale.

5. Compare general power supply arrangement for a four line station MACLS installation operated by central Control cum Indication Panel, with IPS.

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CHAPTER-IX
BLOCK WORKING

1. Systems of train working on Indian railways: Six systems for working of trains on Indian railways have been prescribed by Indian Government Railway General Rules 2006 out of which two systems viz. Absolute Block System and Automatic Block Systems have been permitted for regular use. Remaining can be used by railways under special approval. For details refer Indian Railway Signal Engineering Volume-I by the same author.

2. Station Section and Block Section: The entire area of track over which a train traverses is sectionalized into two main segments viz. (i) Station section and (ii) Block section.
   2.1 Station: Station is that part of track where passenger & goods traffic is dealt with to stop, despatch, make trains run-through, perform shunting, loading unloading of goods, watering of coaches, maintenance and many other activities for a goods or passenger trains. As per Indian Government Railways General Rules 2006 clause 1.02. (51), the station is defined as “any place on a line of railway at which traffic is dealt with, or at which an authority to proceed is given under the system of working”. The station is sectionalised in two parts i.e. Station section and Station limits.
   2.2 Station Section: Station section is that part of Station Limits which is not covered by Block Section. The area of station section varies with the class of station, situated on a double line or single line section.
   2.3 Block Section: As per Indian Government Railways General Rules 2006, clause 2.01(10), Block section is that portion of running line between two block stations on to which no running train may enter until Line clear has been received from the Block station at the other end of the block section.

For further details refer Indian Railway Signal Engineering Volume-I by same author.

3. Running of trains under Absolute Block System: Under absolute block system the space between two Block stations is required to be clear before a train can be allowed to enter into the block section. This is ‘Space Interval’ between the following trains.

In terms of definition of station as mentioned above, the authority to proceed has to be given to despatch a train from the station. Taking Off the last stop signal at the station works as authority to proceed and enter into the block section for the Loco Pilot. Prior to the year 1875, the Block working was maintained through telegraph without interconnection between block working and points & signals (IRISET notes). Over the period it was realised that it was not humanly possible to maintain absolute block clearance always in absence of any interlocking between block system and the signalling system at the station as well as there were no indications available to remind the person on job. This called for the ‘Lock and Block working’. Accordingly the last stop signal is required to be interlocked with an instrument which is responsible to maintain integrity of the block section. Such instrument is known as Block Instrument.
3.1 **Block instruments and associated system for block working**: Block instruments and associated system for block working shall essentially have:

Commutator or press buttons to operate the instrument.

i) A plunger or a press button to transmit single stroke bell signal when pressed.

ii) Indicator to apprise the operator about status of the block section. Two indicators shall be required for double line block instrument, one for up and other for down line. This indicator shall also function to indicate correspondence with the operation.

iii) Arrangement to lock the block instrument cover, by a key, to ensure inaccessibility of any one, inside the instrument without opening the cover.

iv) Arrangement to seal the instrument cover.

v) Independent dedicated telephone communication shall be provided between each pair of block instruments, designated as Block telephone. The power supply to the Block telephone be it primary or secondary cells, shall also be dedicated to the telephone and no other equipment or telephone shall be connected to it.

vi) Audiovisual indicator when the train clears block section including overlap.

vii) Audiovisual indicator when the train clears last stop signal.

viii) Interlocking of last stop signal with ‘Line Clear’ from the adjoining station.

ix) Means to replace the reception signal back to normal as soon as the train passes the signal.

x) Means to replace the Last stop signal back to normal as soon as the train passes the signal.

xi) It shall not be possible to take the last stop signal Off until the last train has reached the next block station and fresh line clear has been granted by the station in advance.

xii) Conductors connecting block instrument lines at either end of the block section may run overhead if the section is not provided with 25 KV AC traction. However if the section is provided with 25 KV AC traction covering stations at both the ends, the line shall be connected through PET quad underground cable. In case station falls in the area provided with 25 KV AC traction and other station is in the area not proved with AC traction then the conductors connecting line shall be under ground PET quad cable from the point where from the traction starts at the station up to a distance of two kilometres into the section not provided with AC traction. Thereafter the line and associated phone and block bell conductors may run overhead if required.

xiii) “The **line wires** of the block instrument, from the point where the lines of two adjacent block sections meet to the terminating point on or near the building shall either be insulated or be so erected as to be not less than 150mm away from any other wire. The provision of insulated wires should be preferred.

xiv) The insulated line wires must be terminated on pothead insulators. The line wires must not be easily accessible. Alternatively, a separate cable, suitably protected, may be use, for each circuit. The insulated line wires must be led in sloping upwards to the building, otherwise a drip loop be provided.” [SEM September 2001 paragraph 18.3.1]

xv) “The **wires leading into the building** from the terminating point shall be adequately separated from wires of other circuits and shall be single, braided or metal sheathed, run in one length from the pothead insulator to the test panel. Alternatively, a cable, suitably protected, may be used, but a separate cable should be provided for each block instrument circuit.” [SEM Part-II, September 2001 paragraph 18.3.2]
xvi) “Indoor wires must be run in trough or other suitable form of trunking which provides protection from interference and separation from the wires of any other circuits”. [SEM Part-II, September 2001 paragraph 18.3.3]

xvii) “It shall be ensured that induced voltage due to power line parallelism does not exceed 150V and short circuit fault current does not exceed 440 V as prescribed by CCITT.” [SEM Part-II, September 2001 paragraph 18.5.1]

xviii) “If the induced voltage goes beyond these limits (as mentioned in preceding paragraph), overhead block circuit shall be transferred to an underground telecommunication PET quad cable/OFc/radio, so as to bring the induced voltage within the prescribed limits.” [SEM Part-II, September 2001 paragraph 18.5.2]

xix) The block instruments work on earth return circuit, in area electrified with AC traction or not, with a three position polarised relay in series with the line circuit, to change polarity on the line circuit.

xx) “Since the immunity of Polarised relay is only up to 10 V (AC) only, block filters shall be used in all block instruments using this relay where this limit is exceeded”. [SEM Part-II, September 2001 paragraph 18.5.4]

xxi) “Use of single line push button token less block instruments is permitted in sections where length of parallelism does not exceed 1.5 KM, so as to ensure that the DC coding used in these block instruments is not mutilated.” [SEM Part-II, September 2001 paragraph 18.5.5]

xxii) A separate earth shall be provided for each block instrument. The distance of this earth shall not be less than 2.5 meters from any other earth. The resistance of the earth shall not be more than 10 Ohms. [SEM Part-II, September 2001 paragraph 18.6.1].

xxiii) The length of earth wire shall be as short as possible. The cross-section of the wire connecting the return circuit shall not be less than the dimension of line conductor but in any case not less than 4mm diameter. Connection to the earth pipe shall be well soldered. [SEM Part-II, September 2001 paragraph 18.6.2].

xxiv) Whenever radio or OFC is used as media to connect two block instruments in lieu of copper wires, a block interface shall be provided.

xxv) Each block instrument circuit shall be provided with lightening arrestor. The lightening arrestor shall not be provided within block instrument.

xxvi) Quick acting relays shall not be used for stick circuits of the block instrument. Shelf type relays or alternatively two (AC) immunised plug-in type ‘Q’ series relays connected in tandem or one ‘Q’ series slow to pickup AC immunised relay shall only be used. The total pickup time shall not be less than 300 milliseconds. DC, 3- position polarised line relay of approved type shall only be used in the line circuit for block working. [SEM Part-II, September 2001 paragraph 18.14].

xxvii) Block instrument provided in area electrified on 25 KV AC traction: On section provided with 25 KV AC traction only SGE type Double line block instrument shall be used [SEM September 2001 paragraph 22.9.1];

a. Filter unit to filter out the induced e.m.f. on the line circuit is required to be provided to safe guard against erratic behaviour due to AC, of three position polarised relay designated as BCR, damage to other needle circuit and safety of staff.
b. Underground Poly Ethylene Tetrachloride (PET) insulated quad cable is used connected with impedance matching transformers at both the ends of the section for reducing affects of induced e.m.f.

c. Line circuit is derived out of centre tapping on primary side of the transformers for up & down lines. The secondary tapping of one transformer is used for Block bell circuit and that of other transformer for train wire which has since been abandoned. The line circuit so derived is called as phantom circuit because no extra conductor is used for the purpose of these circuits.

3.2 Block instruments and other means for maintaining integrity of the block section are different for double line and single line track:

i) Double line Block Instrument.

ii) Single line Token Block Instrument.

iii) Single line token less Block instrument.

iv) Axle Counter Block Instrument.

v) Solid State block system.

vi) Block clearance proving by axle counters or track circuits.

vii) Automatic Block Signalling.

3.2.1 Double line Block Instrument: Besides Siemens & General Electric (SGE), non cooperative type double line lock and block single wire Block Instrument, which is used by and large on most of the double line sections, other double line block instruments are Syke’s Electric lock & Block Instrument Style ‘L’ Type ‘B’, required only one instrument to be used between two stations to control both up and down lines; Tyer’s 1-wire 3-positon sequence block instrument; Tyer’s 3-wire 3-positon sequence block instrument with free commutator; Pryce & Ferretra 3-wire 3 position Electric Block Instrument identical to SGE; Carsen 1 -wire 3-positin Block Instrument once extensively used instrument on Northern Railway, are not taken up here.

3.2.2 Siemens & General Electric (SGE) Block Instrument: The front of the instrument can be grouped in three parts i) Upper needle, indication of the status of block section for despatch of train, ii) Lower needle, indication of the status of block section for reception of train and iii) Commutator handle and the plunger.

Other integral ingredients of the Block instrument are i) Block telephone, ii) Block bell and iii) power supply. The inner arrangement of the block instrument is in consonance to the operation and indications as detailed below:

A) Indication Needles: Two indication needles are provided at the face of the block instrument.

Upper needle: positioned on the upper front segment of the Block instrument facing the Station Master, corresponds to the station to which the line clear is granted.

The needle has three positions displaying status of the block section on the track for which line clear is granted by the station in advance where the train is destined to reach, i) central position designated as Line closed, meaning thereby no train is in the block
section, ii) turned to right designated as Line Clear granted and iii) turned to left designated as Train on Line (TOL).

Lower needle: positioned on the lower front segment of the Block instrument facing the Station Master, corresponds to the station granting line clear.

The needle displays status of the block section on the track for which line clear is granted by the station where the Block Instrument is placed and where the train is scheduled to arrive. The indications displayed by the lower needle are same as that of upper needle.

The Indication needle is mounted on a spindle with a permanent magnet fitted to it. A coil is fixed with, in side the body of the Block instrument with its iron core poles around the permanent magnet of the needle to keep the needle in perfectly vertical position when no current is passing through the coil. As the commutator is turned to line clear, current made through by Commutator segments, with negative polarity, passes through the lower needle coil on to the line. The line at adjoining station is connected to the upper needle of the Block Instrument there and then connected to earth through three position polarised relay coil. Accordingly the poles of the needle coil get magnetised creating a torque to turn the needle towards line clear position and the contact of the polarised relay is made for Line Clear. As the commutator is turned to Train On Line position the Commutator segment makes spring contacts such that the polarity of the circuit on line is reversed and changed to positive. This results in a) turning of indication needles to TOL position from line Clear position at Block Instruments at both the stations and change of contact in Polarised relay at adjoining station to TOL.

B) Commutator & Plunger assembly: Commutator handle can be rotated right for granting line clear, centre for closing line and left for Acknowledging Train On Line, corresponding to the needle positions.

Inside instrument the commutator assembly consists of:

a) Commutator segment bearing plate on to which commutator segments are fixed for line & block release circuits.
b) Plunger with a pin and bell circuit contact.
c) Door lock assembly & the circular metal disk attached to Commutator shaft.
d) Spring contact assembly i) Set of six springs for line circuit, ii) set of two springs for block release circuit and iii) set of three springs for bell circuit.

i) Commutator assembly (inside) & spring contacts for line circuit: A circular metal Disk is held fastened to the commutator handle inside instrument. The assembly rests in the given any one of the three positions by a spring loaded ball pressing against the corresponding groove in the commutator assembly circular Disk at the lower side of the plate. This Disk is also provided with a lock assembly screwed on its upper side. A butterfly shaped bakelite commutator segment bearing plate bearing commutator segments made of brass embedded to it is screwed to this circular metallic commutator plate.
Two sets of commutator spring contacts are fixed onto the base of the instrument to make contact through the Commutator segments. One set of six spring contacts is placed in front, and other set of two spring contacts at the back of the Commutator segment bearing plate, when viewed from the back of the block instrument. The front spring contacts are connected to the block instrument line circuit. When the Commutator handle is normal i.e. in the centre position, none of these spring contacts make any circuit connection. When the commutator is turned towards line clear position, these spring contacts, two out of three on either side of the Commutator segment bearing plate, extend negative polarity of the battery on line. This set of the spring contacts is duplicated for safety reasons on double cutting of contacts basis. When the commutator is turned to Train On Line position the other set of two springs out of same set is connected through the contact segments such as that the polarity on line is reversed to positive.

**Spring contacts for block release circuit:** The set of two springs mounted on the back side of commutator segment bearing plate make contact with the commutator segments riveted on the back side of the plate, only when the commutator is turned to train on line position to prepare system for block release.

ii) **Plunger with pin and Block bell circuit:** The plunger is spring loaded and moves to and fro through the commutator shaft. It moves forward when pressed compressing the spring and comes back to its original position when released. A pin assembly is attached with the plunger which houses itself in hole in commutator disk. It is not possible to move the commutator to any position without pressing the plunger. Another assembly with three contact springs is fixed onto the base of the instrument for block bell. When the plunger is not pressed it completes the circuit through the longer spring contact for energising local bell through metal ring fixed at the plunger end when the plunger at the other station is pressed. As and when the plunger is pressed it makes
the contacts through to energise relay which in-turn activates bell circuit for bell at the adjoining station disconnecting the incoming bell circuit. The circuit works on an independent single conductor line through earth return.

It is may be observed that the circular metal disk is fixed with commutator shaft onto which the butterfly commutator segment bearing plate and door lock assembly is fixed while bell contact is made by plunger when pressed as the plunger can move to and fro only, while it rotates along with commutator handle.

iii) **Door Lock:** [Figure 3.2.2 (B)(iii)] The assembly for locking the commutator in TOL position is designated as ‘Door Lock’.

Door lock is in parts i) Door lock assembly fixed with the metal Disk attached to the commutator handle, ii) the pin attached to the plunger, iii) a set of two latch and one assembly of two Latch levers, one release lever and a stud pin provided on the longer latch lever, mounted on the body of the Block instrument and iv) Door coil with an armature.

The Door Coil is an electromagnet with an armature fixed on the body of the block instrument with its one end pivoted with the door coil assembly bearing plate in such away that the other, loose end, of the armature rests on the commutator lock assembly screwed with circular metal plate. As the power is supplied to the coil it gets energised and attracts the armature up [Figure 3.2.2(B) (iv)].

Commutator can be turned to Line clear side freely if there is no train in the block section, previous train has arrived and the block instrument has been normalised with commutator put to line closed position. While turning the commutator to line clear position the longer latch lever, on which the door coil armature rests in normal position, gets engaged with the pin attached with the plunger and moves along with it there by releasing the support to the door coil armature allowing it to drop on the recesses top of the lever lock assembly fixed to the commutator metal plate and continues to be there till next operation of commutator.
The smaller latch lever which is suspended on a pin provided on the Releasing lever and was so far resting on the door coil armature, also drops along with moving away of the longer latch lever. With the longer latch lever moving away, the Releasing lever which was resting on the stud pin of the longer latch lever looses its support and drops along with the door coil armature and lowers down along with the smaller latch lever and buts against the stud pin on longer latch lever to hold the longer latch lever away even when the commutator is moved to line closed or TOL position.

As the train leaves the station, to which line clear was granted, the station gives prescribed bell code intimating to the station granting line clear that the train had entered into the block section. This situation is Train On Line. At this juncture the station granting line clear shall turn his commutator to TOL position. By doing so the Door coil armature which was resting on the Lever Lock assembly recess top so far, drops into the notch of the recess which matches with the of commentator’s rotated TOL position.

As the Door coil armature is lifted it shall also lift the smaller latch lever in turn which in turn shall lift the Releasing lever. This shall remove the obstruction from the Stud pin of longer latch lever allowing the lever to swing back to its normal position to support the Door coil armature underneath.

In case, for any reason, which may be a false feed to Door coil, saturation due to over energisation of the Door coil core or any mechanical jam, the armature gets picked up and engages itself with the upper notch opposite the notch in which it was resting, it shall not be possible to operate commutator handle. As shall be seen in following paragraphs that the power supply to the Door coil is extended momentarily to enable the armature to pickup and then drop to rest on the longer latch lever, such a situation may not arise.

Check lock notch: It shall be observed that, to energise ASR circuit for taking last stop signal of despatching station Off, that it is necessary to make TOL contact. It is also necessary that once the Line clear has been granted by turning commutator to Line clear and the train has left the adjoining station it must be ensured that the next train is not be allowed to enter the block section till the previous train has reached inside station section and line has been closed by turning the commutator handle from TOL to line closed by releasing Door Lock. There is a possibility that while turning the commutator from Line clear to TOL, the operator turns the commutator to the extent of just making TOL contact and returns to line closed position. He may easily turn the commutator to line clear positing again enabling the line clear receiving station to push another train into the block.

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section without ensuring arrival of the train which was already in the block section. To avoid such a situation to arise, a check notch is provided adjacent to the locking notch in the door lock assembly fixed on the circular metal disk fixed on the commutator shaft which shall not allow the commutator to be put back to line close or line clear position when the armature of the door lock is resting on the door lock assembly. While installing the block instrument it shall be ensured that that the TOL contact is made only when the Door coil armature has dropped into the check notch.

![Diagram of yard for block release](image)

**Figure 3.2.2(B)(v).**
Portion of yard for block release

iv) **Block release circuit- energisation of door coil:** [Figure 3.2.2.(B)(v) & 3.2.2.(B)(vi)]

With the train crossing the last stop signal of the adjoining station to which the line clear was granted and the receiving station having turned the block instrument commutator handle to TOL and as the train crosses the Home signal of the receiving station occupying first track circuit 3TPR, the power supply is extended to UP BSR1 through TOL contact of block instrument and drop contact of first track circuit 3TPR energising BSR1.

![Diagram of Block release circuit](image)

**Figure 3.2.2(B)(vi) Block release circuit**

The UP BSR1 is kept held by its own contact bypassing 3TPR contact. As the train moves ahead and occupies the second track circuit A3TPR, both the track circuits are de-energised and nothing happens to the system.

As the train clears the previous track circuit 3TPR as well as A3 TPR and occupies next track circuit 101a TPR the UP BSR2 gets energised taking BSR1 in series to prove that 3TPR, the first track had dropped.
This arrangement is to prove that i) the incoming train traversed the track in a direction from block section towards station and ii) the Block overlap beyond Home signal has been cleared. It must be noticed that the BSR circuit for release of Door Lock works only when TOL contact of the block instrument is made.

By the time UP BSR2 is energised the Home signal has already been put back to On due to occupation of first track 3TPR by the train, thereby de-energising of 3HR. Power for release of door lock i.e. to energise door coil is extended through pickup contact of UP BSR2, drop contact of 101aTPR, drop contact of 3HR and drop contact of Calling-on signal C3HR to illuminate UP line block clearance indication UP BKE to negative.

UB BKE illumination indicates that the door coil energisation circuit is completed but power to the Door coil UP DC shall not be extended till the BP button is pressed to release the commutator [Figure 3.2.2(B)(vii)].

![Figure 3.2.2(B)(vii) Energisation of Door coil 'DC'

Here it is pertinent to note that the power to the door coil has to be momentary as otherwise it shall not be possible to release the commutator due to the Door coil armature sticking and engaging with the upper notch of the Door lock assembly fitted with the circular metal disk fixed to the commutator shaft. The arrangement to extend power momentarily to Door lock coil may be manual through a push button when the indication UP BKE glows, intimating that the circuit for Door coil energisation is ready or in case of mechanically operated system, through levers. A passing contact is provided on the Circuit Breaker attached to Lock Bar lever, which makes and breaks the Door coil circuit momentarily when being put back to normal to comply with provisions of GR for all normal condition after receipt of train in.

C) Block telephone: A dedicated telephone circuit with independent power not shared by any other telephone or circuit to avoid any cross connection or cross talk leading to confusion or wrong information to the Station Master is provided between the Station Masters, attached to the Block Instrument. This telephone does not have any arrangement for calling attention through ringing, except the block bell.

D) Block Bell: A single stroke block bell consists of a cast iron case to house the bell relay, and a gong mounted on it. For sending bell, as the block instrument plunger is pressed, the circuit for the bell relay at the adjoining station gets completed to energise it. With the energisation of the Bell relay a bell plunger rises and hits the gong to make sound once
and drops down due to gravity as the bell circuit is cut off with Block plunger coming to its normal position. Each time the Block plunger is pressed it hits the gong once.

**Block bell equipment:** In area electrified with 25 KV AC traction, bell circuit is provided on two conductors derived out of half quad of the quad cable terminated at the line matching transformers at both ends of the circuit at each station. The system can not work on direct current as isolation transformers are required, as such a Block bell equipment is used for transmitting 150 Hz sinusoidal waveform AC at 45 V (on load) generated by an oscillator circuit through SO relay pickup contact.

a) **On sending end**, when the plunger is pressed on sending end station, 12V DC power is extended to the oscillator, and also to energise SO relay provided in the Block bell equipment simultaneously. With the energisation of the SO relay the 150 Hz sinusoidal waveform is also extended through energised contacts SO1 & SO2 of SO relay on line communicated through isolation transformer to be received on the other end station through quad cable [Figure 3.2.2(D)(i)].

Oscillator comprises of transistor, resistance and induction coil.

b) **On receiving end** station the incoming power transformed to the secondary winding of the line matching transformer is rectified by a bridged diode rectifier through back contacts SO-1 & SO-2 of the SO relay which is normally de-energised. The rectified DC power is connected to the Block bell relay which when energised makes the plunger to hit the gong once and the block bell plunger drops with the release of the block instrument plunger disconnecting the power supply [Figure 3.2.2(D)(i)].

Different manufacturers may use different design with the basics being the same.
E) **Power supply:** Three sets of power supply are required associated with block instruments, i) Line circuit, ii) Block telephone and iii) Block bell.

i) **Line circuit power supply:** keeping in view that the three position polarised relay is immune to 10V AC only, no ripples are allowed to pass on the line. Accordingly for line circuit one of the following options is used:

   a) Primary cells: Caustic Soda cells with carbon & zinc elements or Rail Road 6t cells.

   b) Secondary cells with dual bank battery chargers: Since a battery charger with simple diode rectifiers is likely to pass on ripples on the circuit, two sets of battery bank of secondary cells is provided with a battery charger arranged in such a way that when one set of battery bank is feeding the line circuit the other is being charged by the battery charger. A switch is provided to interchange the battery sets periodically.

   c) DC – DC converters provided in IPS.

As the length of the block section varies the potential of power has to be worked out to suit line working. DC-DC converters used in IPS for block line are 12V DC to 40V DC adjustable to the required voltage.

ii) **Block telephone power supply:** The power supply for Block telephone has to be ripple free to avoid noise (humming sound) and ensure clear voice. Accordingly either primary cells are used which may be Rail Road 6t cells or Zink –soda caustic cells. On installations where IPS has been provided the power supply is taken from IPS.

iii) **Block bell circuit power supply:** Power supply for block bell is kept independent in area not provided with AC traction as the supply extends up to adjoining station.

However in area energised with AC traction, the power supply is used to energise an oscillator which in turn transmits the 150 Hz AC through a transformer inbuilt in the Block Bell equipment, while at the same time the block bell circuit is local as such one of the two practices are adopted viz. i) Internal relay room power supply is used for plunger and block bell circuit and ii) Additional 12 V power supply set of secondary cells is provided with a battery charger. Where ever IPS is provided power supply for block bell is derived from an independent DC-DC converter.

F) **System of working and circuits:**

i) **Line Circuit:** SGE double line block instrument works on single conductor with earth return for each track. In effect the circuits for up and down lines are independent and identical to each other meaning thereby that two single wires are used one for up line and the other for down line. With turning of commutator to Line clear side, Negative polarity is extended from battery through spring contacts making connection with the Commutator segments to the lower needle coil onto the line. The line wire is connected to the needle circuit at the other station and then to the coil of polarised relay and then to earth. As the current passes through the needle coil the lower needle turns to Line Clear side at line clear granting station and through upper needle of the adjoining station to which the line clear is granted. The circuit gets completed through earth at the line clear receiving station.
As the train passes the last stop signal and the sending Station Master gives coded bell signal for Train on Line, the station in advance who had granted line clear has to turn the commutator to Train On Line, thereby changing the polarity on line to positive.

**Line circuit for block instrument provided in 25 KV AC traction area** is shown in figure 3.2.2(F)(i). The circuit for non-RE area section shall be without filter unit and without transformers, through underground cable or overhead conductors.

The circuit shall be read in two parts viz. circuit for lower needle at the end of line granting block instrument and for upper needle at the end of line clear receiving station. Power is extended on line through LC contact of the block instrument, lower needle filter unit to the centre tapping of line matching transformer. At the receiving end the centre tapping of the line matching transformer is connected to the BCR through filter unit and upper needle coil connected to earth.

![Figure 3.2.2(F)(i)](image)

*Figure 3.2.2(F)(i)*

*Block instrument line circuit through filter unit in 25 KV AC traction area.*

As the Station Master granting line clear turns his commutator to Train On Line and the polarity on line circuit is changed to positive, the armature of the three position polarised
relay BCR, at train despatching station, shall make TOL contact. As the 2TR is cleared by the train, 2ASR shall get energised through 2TPR pickup contact, TOL contact of the BCR and back contact of 2GR, ensuring that the signal has gone back to On.

It may be noted that if the Station Master granting line clear does not turn his commutator to TOL, the ASR at the station sending station shall not get energised and signal shall not come Off for next train.

It is pertinent to note that i) Double line Block instrument works on non-cooperative basis as no active role is played on the block instrument by the Station Master receiving line clear, ii) negative polarity is sent on line for granting line clear for the reason of safety as when the line gets earthed at any stage it shall not make any effect on the circuit while if positive polarity used on line getting earthed for granting line clear the earth fault shall result in granting of un warranted line clear thereby creating unsafe conditions.

Filter Unit: [Figure 3.2.2 (F)(ii)] As the line circuit is on single conductor with earth return the induced e.m.f. shall be proportional to the length of the block section while entire line circuit involving needle circuit and polarised relay BCR are sensitive to AC. Therefore for the sake of safety of equipment and persons working on the circuit, a filter unit is used.

Each of the two lines is terminated on a cable terminal ‘T’ which is connected through a disconnecting link DL to a Choke L-1 for up line and L-2 for down line. These chokes offer resistance of 50 Ohms to DC and an impedance of 40 Kilo ohms to AC at 50 Hz. The out put limb of these chokes is connected to Gaseous Dischargers (GD) at striking voltage of 150 V. The other terminal of these GDs is connected to a general earth to discharge to earth a potential more than 150 V.

These chokes are also connected to another choke L-3 and a capacitor C-1, for up line and to L-4 and capacitor C-2 for down line. The other plates of these two capacitors are connected to Block earth. L-3 and L-4 chokes are connected to the block instrument up line needle circuit terminal and down line needle terminals respectively through another disconnecting link DL. Whenever a person has to work on line circuit he is required to disconnect the disconnecting link for his safety as line voltage is expected to be high enough to be fatal.

![Filter unit for double line block instrument in RE area](image)
iii) **Last stop signal control circuit (ASR):** Last stop signal ASR is the relay to ensure ‘one train one line clear principle’ [Figure 3.2.2(F)(iii)]. As discussed in preceding paragraphs the ASR is energised with the positive feed transmitted on to the line circuit by turning commutator of line clear granting block instrument to TOL, through 2TPR pickup contact, TOL contact of BCR and back contact of 2GR, to prove that previous train which has entered the block section, has cleared the last stop signal track, signal has been put back to normal and block instrument commutator has been turned to TOL thereby locking it in the same position, to be freed after arrival of the train at the receiving station. The BCR is by passed as 2ASR is energised, to keep it held energised through 2TPR pickup contact and ASRs own contact.

After arrival of the train at the receiving station line is closed by turning of the commutator to line closed position. While granting fresh line clear the commutator is turned to line clear position thereby making line clear contact of the BCR and keeping the ASR held energised.

iv) **Last stop signal GR circuit:** GR, the signal relay, is energised as soon as line clear is granted by the station in advance through back contacts of signal and route buttons. 24 V DC power is extended through pick up contact of the track circuit 2TPR, LC contact of the BCR, pick up contact of 2 ASR, signal button relay i.e. 2GNR and LR for route ZE i.e. ZELR back contacts to negative terminal energising the signal relay GR. The back contacts of Button relay GNR and ZELR are bypassed by the GR pick up contact to hold the GR through its own contact when the GNR and ZELR is de-energised.

v) **Premature TOL:** There are situations when the despatching station may give premature TOL bell code while the train has still not crossed the Advanced starter signal, which if accepted by the line clear granting station thereby turning his commutator to TOL position, shall in turn result in braking of the line clear contact of the BCR disconnecting circuit to keep GR energised thereby raising the Advanced starter signal. To avoid such a situation, the LC & TOL contacts of BCR are bypassed by GR pickup contact while at the same time the GR is made slow to release. As the BCR contact is changed from LC to TOL, the GR while trying to drop is held picked up being slow to release, during this
time the TOL contact is made and the power supply to GR is restored through bypass limb. In this case as the train occupies 2TPR, the power supply to GR as well as ASR is disconnected.

vi) **Energisation of DR:** [Figure 3.2.2(F)(vi)] With the energisation of 2 GR, 24 V DC power is extended through pick up contact of 2GR & 2 TPR to prove the track ahead clear, pickup contact of 2 ASR, pickup contact of 2ZELR route setting LR for ZE route (into block section), to negative terminal energising 2DR. With the energisation of 2 DR UP Advanced starter signal number 2 shall assume Off aspect. 2DR, R1 & R2 is by passed by the back contact of ZELR as cross protection to ensure that 2DR does not energise when the 2ZELR is dropped.

vii) **Replacement of up Advanced starter signal to On:** As the train occupies the track circuit number 2T relay 2 ASR as well as 2 GR get de-energised due to disconnection of the limb at the very beginning. This shall put the up Advanced starter signal number 2 to On position.

*It is pertinent to note that this system of block working checks arrival of the train but does not check complete arrival of the train which is left to manual surveillance.*

3.3 **Single line Token Block Instrument:** Unlike double line section where the direction of both the lines is predefined as up and down, the trains move on both directions on the same line, on a single line section. Out of various types of single line token instruments, Neales Ball Token Instrument is most widely used on Indian Railways. The instrument was originally developed for issue of ‘Card permit’ under the line clear traffic system subsequently it was modified as token instrument. It was developed by M/s Westinghouse Brake & Saxby Signal Company, having gone through many modifications there after. Neales Tablet token instruments are also used on Indian Railways.

The instrument is cooperative type as such line clear can not be granted by the station without active cooperation of the station receiving the line clear unlike SGE double line block instrument in which the line clear can be granted without cooperation from the other station. Besides interlocking of last stop signal, token is the tangible authority for the Loco pilot to enter into the block section.

3.3.1 **Token delivery and receipt arrangement:** The ball token is made of steel, embossed with a distinct number and a hole along its diameter. A recess along its other diameter is provided in the shape matching the spigot provided on the token receiving drum of the block instrument. This ensures that a token with the specified spigot only can be put into either of the paired block instruments. Same spigot arrangement is never used in the adjoining block sections. Spigot configurations are i) triangular, ii) rectangular, iii) Round, iv) Pentagonal and v) Square.
Hoop is made with two wire rings of unequal circles bound together at one end of the diameter of the circle and covered with lather or any other protective means to protect the Loco pilot from getting hurt while picking up the hoop during the train moving at full speed. The gap created at the other end of diameter between the two rings is provided with a leather pouch with a pin to hold the ball token firmly into the pouch. A stand with a spring loaded arm with the arrangement to hold the token hoop lightly is fixed by the side of the track such that it is possible for the Loco pilot to pick the hoop on running train. As the train reaches the next station the Loco pilot shall throw the hoop with the token onto a wire net basket. The token hoop shall be carried to the station by the station porter.

3.3.2 **Block Instrument design features**: The block instrument is designed such that:

i) Only one token can be extracted at one time from either of the block instruments placed at adjoining stations. It shall not be possible to extract a token by any means other than the normal procedure for taking the token out of the block instrument.

ii) The token can be extracted by cooperation of both the stations.

iii) It shall not be possible to extract a token from either of the paired block instrument after one token has been extracted making the pair out of phase, unless the token has been inserted into any of the two instruments thereby restoring the phase to original.

iv) On section where signals are worked with levers, it shall not be possible to pull the last stop signal lever until token has been extracted from the block instrument at departure station.

v) The instrument shall be capable of containing adequate number of tokens to cater for to & fro movement of the trains in the section for 15 days at least. Accordingly instruments are designed to accommodate 36 tokens at a time.

vi) A superimposed telephone dedicated to the block instrument is provided in conjunction of the block instrument.

3.3.3 **Architecture of the block instrument**: One of the block instruments out of the pair at either end of the block section is Normal parity block instrument and other is Reverse polarity block instrument. The normal polarity instrument connects positive polarity of the power source onto line and reverse polarity connects negative polarity onto the line [Figure 3.3.3(i)]. The token instrument constitutes of:

i) **Operating handle with drum and commutator assemblies**: As seen from the front side, the handle which can be turned to sides Train Going To (TGT), Line Closed (LC) and Train Coming from (TCF), is spring loaded and has to be pulled out of the notch where it rests in either of the three positions right angle to normal. The handle is attached with a circular cast iron drum large enough to accommodate only one token at a time. A circular pinion is also attached to the handle of the block instrument under which a rack shaft with grooves matching to the teeth of the pinion is placed such that as and when the handle is turned to any side the rack also moves right or left in a direction opposite to the movement of the commutator handle. Electro magnetic locks TGT and TCF are provided on either end of the rack. The locking pawl of the lock is pulled up when the magnet is energised to allow the movement of the rack to either side. It may be observed that the commutator can be rotated only when the rack is allowed to be moved by one of the locks.
The normal position of the operating handle is vertical, when the line is closed. It is turned to right hand side for TCF when line clear has been granted and to left hand side for TGT position to indicate that the line clear has been obtained and a token has been extracted from the instrument.

One end of the lever rod is attached with circular commutator pinion and to the Contact assembly on its other end. As the Operating handle is moved right or left, the commutator is also rotated, the contact assembly also rotates with the movement of the rod. This shall be called as contact assembly ‘A’ for the purpose of discussion.

The contact assembly ‘A’ is interconnected to another contact assembly, called as contact assembly ‘B’(for the sake of discussion) through a spring loaded clutch by jigsaw teeth in such a manner that both the contact assemblies move together coupled to each other, under normal conditions. The contact assembly ‘B’ also moves independently without affecting contact assembly ‘A’ when pressed by a lever forced by the token when the token placed inside cavity below token receiving drum at the top end of the block instrument, is forced-in by pressing the bell plunger. This reverses the line polarity making both instruments ready for being normalised. A safety catch is provided near the spring clutch to ensure that the commutator ‘B’ does not move of its own thereby changing polarity on line creating situation for extraction of unwarranted token.

The bell plunger which is spring loaded moves to and fro threaded along the handle and the drum, when pressed and released makes contacts for the single stroke block bell for making sound once at the adjoining station with each pressing of the plunger. It is also attached to a lever which when pressed, pushes the ball token placed in side the cavity of token receiver drum. This forces the token to move making its way to the token receiving recess forcing the lever obstructing its passage. As discussed in preceding paragraph, the lever in turn rotates the contact assembly ‘B’.

Spring contact assembly makes circuit through brass segments fitted on the commutator ‘A’. The spring contact assembly ‘B’ makes circuit when the plunger is pressed. Polarity transmitted onto line is decided by the position of contact assembly ‘B’. In case of negative polarity Block Instrument’s negative limb of the battery bank is connected onto the line and in case of positive polarity instrument it is the positive polarity of the block battery which is connected onto the line.
The polarity of line is changed with the turning of commutator assembly ‘B’ because of turning of commutator handle or because of insertion of the token.

A hole is also provided in the operating handle drum such that it is aligned with the recess containing the token when the handle is turned to TGT side.

ii) **Token receiver drum:** As the token is received at the station, thrown by the passing Loco pilot, the same is brought and inserted into the Token selector drum. A spigot is fixed inside the receiver drum matching the configuration assigned for the section. Only one token is accepted by the drum if the ball token configuration is in exact conformity to the spigot inside drum. Station Master shall rotate the token receiver drum to release the token into another cavity, where the token shall rest on a lever and shall be able to move to the token recess of the block instrument. As discussed in preceding paragraph, the token shall be pushed into the recess of the block instrument by pressing of the bell plunger while at the same time rotating commutator ‘B’ and thereby changing line polarity.

The drum has a locking arrangement to avoid unauthorised operation.

iii) **TGT & TCF locks:** Four operations of the operating handle are possible i) Line closed to TCF, ii) TCF to line closed, iii) line closed to TGT and iv) TGT to line closed. Out of these four operations the TCF lock coil has to energise for line closed to TCF, TCF to line closed and TGT to normal. The TGT lock coil shall be energised once only for line closed to TGT operation.

The TGT and TCF lock pawls rest in the corresponding notches of the rack which is connected with the operating handle pinion, as such it shall be possible to move the operating handle to any of the three positions only when the corresponding lock coil is energised.

Safety depends much on efficient functioning of these TGT and TCF locks as sticking up of the lock pawl due to any reason which could be over energisation of the lock core or for any other mechanical reason may result in unwarranted extraction of token. To avoid such a situation conical projections are attached to the operating handle drum such that the lock pawl is forced down with each movement of the operating handle before engagement of the notch as if the lock is energised under conditions conducive for operation, the lock pawl shall reenergise.

iv) **Line Circuit and block working:** [Figure 3.3.3(i)]. As the line clear is asked by the station ‘X’, the Station Master shall transmit line clear seeking bell code by pressing plunger as many times as required as per code and shall keep the plunger pressed with the last bit of the bell code thereby sending to the adjoining station ‘Y’ the power on line with polarity depending upon that instrument being a Normal polarity or Reverse polarity. If the line clear asking instrument at station ‘X’ is of Normal polarity, the instrument shall send positive polarity on line through galvanoscope, commutator ‘B’ contacts to ‘A’ and then onto line, while negative limb of the battery shall get connected to earth through commutator ‘B’ contacts.
At the station ‘Y’, the station granting line clear, the battery supply of station ‘X’ shall pass through contacts of commutator ‘A’ to the galvanoscope to the polarised relay and then to earth thereby completing the line circuit. With the completion of line circuit, the galvanoscope needle of both the block instruments shall turn to one side depending upon battery polarity on line while at the same time the polarised relay BCR shall also get energised that of block instrument of station ‘Y’, the station granting line clear. With the energisation of polarised relay the local battery power supply shall energise TCF lock coil by extending power through armature of BCR making TCF contact, TCF coil and back to battery terminal. Observing the galvanoscope needle turning, the Station Master of station ‘Y’ granting line clear shall turn operating handle to TCF. While doing so his block instrument commutator shall turn i) causing temporary break in the contacts and ii) changing commutator ‘B’ segments readying it to send polarity other than its normal polarity for the next step. The galvanoscope needle shall get a momentary jerk due to break in contact caused by the commutator ‘A’ split contact strips, conveying to the station ‘X’ that the operating handle at the other station is being turned. The Station Master at station ‘X’ shall release the bell plunger thereby disconnecting the power link on line.

With the TCF coil getting energised the Station Master of station ‘Y’ shall be able to and shall turn his operating handle to TCF position and keep the plunger pressed to send current on line. By doing so the current shall be transmitted on line with the polarity reversed to what was being received to enable energisation of TCF coil. The current, starting from battery to contacts of commutator ‘B’ to galvanoscope to contacts of commutator ‘A’ shall pass onto line. This, at station ‘X’, seeking line clear, shall pass through galvanoscope, polarised relay and to earth consequently resulting in turning of needle of galvanoscope to the side opposite to its earlier position because of changed polarity. With the energisation of polarised relay the feed shall be extended to the TGT lock coil through BCR contact thereby lifting the TGT lock pawl. The Station Master observing jerk on galvanoscope needle and then the same becoming steady shall turn his operating handle to TGT.

The TGT lock pawl once lifted to allow the operating handle to move to TGT position is forced down into the check lock notch of the rack moving with the operating handle, by an extended projection especially designed to ensure force dropping of the lock pawl, even when the operating handle is pulled out with plunger pressed. This action coincides with the commutator position when the spring contacts which connect the line to the circuit are not in contact with the brass segments momentarily. As the commutator further moves on thereby making line contact thereby re-energising the TGT lock coil the TGT lock pal gets lifted and allows the operating handle to move to TGT position. This is the Line Clear granted by station ‘Y’ and received by station ‘X’ condition. With this the token is released through the token selector to the operating handle drum and to the outlet, put into the token delivery hoop pouch ready to be delivered to the loco pilot.

The last stop signal is also electrically interlocked in the same way as in case of double line block instruments.
v) **Token Selector**: [Figure 3.3.3(v)] There are four recesses in parallel above the operating handle drum, to accommodate all the tokens. Looking from back these recesses are numbered as 1, 2, 3 and 4.

![Figure 3.3.3(v) Token recesses and token selector](image)

When the token is dropped from the top, it can go to any of the recesses. A toothed drum, the token selector, does the job of selecting token from one of the token recesses. The Token selector is connected with the operating drum such that it rotates when the operating drum is rotated to TCF, TGT or Line closed position. It, having two cavities, is designed such that it receives a token from recesses 1 and 3 or two and four. During the rotation, the token selector does two functions i) it lifts the tokens in each recess during its movement to either position to disturb all the tokens thereby releasing any of the jammed token and ii) transfer one token to the operating handle drum.

vi) **Line clear cancellation**: If the need arises at station ‘X’ to cancel the line clear after extraction of the token, the token so extracted shall be inserted back into the token receiving drum of its own block instrument and plunger be pressed which shall press the lever, turning commutator ‘B’ thereby changing polarity onto the line. Station Master of station ‘X’ shall keep the commutator pressed to energise the other end station ‘Y’ block instrument’s polarised relay and in turn energise the TCF coil there. The Station Master on the other end station ‘Y’ shall then turn his block instrument’s operating handle to line closed position. The Station Master of station ‘Y’, who has turned his operating handle to line closed position shall then press the plunger and keep it so to energise the adjoining station ‘X’’s block instrument’s polarised relay thereby energising the TCF lock coil. The Station Master of station ‘X’ shall also turn his block instrument’s operating handle to line closed position.

3.3.4 **Single line Tablet Token block Instrument**: The basic principle of operation of Neales Tablet Token block Instrument is the same as token ball instrument while the tablet token is the circular metal disk with hole in its centre configured to match different spigots provided into the tablet receiving drum.

3.3.5 **Use of single line token block instrument in RE area**: As the polarised relay is used with single line token instrument too, when used in area provided with 25 K AC traction, the overhead alignment shall be converted to underground Poly Ethylene insulated quad cable and a
filter unit shall essentially be required to be put in line circuit in the manner similar to as described in case of SGE double line block instrument in preceding paragraphs.

In addition, block bell equipment shall also be used connecting pair of block instrument on PET quad cable through isolation transformers at both the ends, for block bell as well as for line circuit derived through central tapping of the transformers. The telephone shall also be worked on double conductors of PET quad cable.

3.3.6 Power supply: Power supply for the instrument has to be ripple free DC. For line circuit its voltage shall be suitable to operate the system and polarised relay depending upon length of the block section, while power supply for block bell and the attached block telephone shall be separate for each, similar to as described for SGE double line block instrument.

3.3.7 Token Balancing: It is not always possible that number of trains going in each direction shall be the same in opposite direction thereby resulting in creation of a token imbalance situation causing reduction in token strength in one block instrument and accumulation of more numbers in the paired block instrument. The situation calls for removing excess tokens from one block instrument and filling them back into the paired block instrument where the deficit has occurred. This token balancing is to be done by a technical authorised person only.

3.4 Single line token-less block instrument with handle: Single line token-less block instruments are designed in conformity to specification number IRS S 98-2001. Major features which affected section capacity adversely while using the tokens are i) reduction in speed by the driver while collecting the token hoop to avoid injury while running at high speed, missing the token hoop thereby stopping the train and collecting it by sending co-pilot back and iii) in case of big yards where the cabins are distantly placed too much time taken to deliver the token to the loco pilot to be acceptable and iv) on sections where traffic is not even on both the directions token balancing becomes another important but non-technical job to be undertaken by technical authorised persons. Accordingly token less block instruments came into existence for single line block working. Daido type token less block instrument is by and large in use. Here Daido handle type single line token-less block instrument is taken-up for study.

3.4.1 Daido single line Token less block instrument design and working: [Figure 3.4.1a] Front panel of the block instrument is provided with block lever handle, push buttons PB1 and PB2, switches S1 and S2 with corresponding counters, TOL and TER indicators, key holes for Station Master’s key and Occupation key, a Galvano-meter and bell gong with a hammer at the top of the instrument body (Block Working Manual 2008, paragraph number 3.49). Buzzer1 (BZ1) and Buzzer2 (BZ2) audio indications are also provided with the block instrument.

Frequency allocation: The instrument works on audio frequency system i) F1 being 2000 cycles per second assigned to one of the block instruments of the pair and ii) F2 being 2500 cycles per second assigned to the other block instrument of the same pair.

Each of these frequencies is modulated at the rate of 65 and 85 cycles per second i.e. F1 modulated with 65 cycles per second and also at 85 cycles per second as well as F2 modulated with 65 Cycles per second and also at 85 cycles per second.
Frequency F1 is used for i) Line clear request, ii) Train Clearing block section, iii) Cancellation after obtaining line clear.

Frequency F2 is used for i) Granting permission to approach and for ii) Train on Line while the train is entering into the block section.

i) **Galvano-meter:** Detects incoming and outgoing current during transmission and reception of code signals

ii) **Block Lever Handle:** This handle can be turned from i) Line Closed to Train Going To (TGT) and ii) Line Closed to Train Coming From (TCF). A Lock magnet controls the movement of the Block lever handle to either side [Figure 3.4.1b]. Notches on outer periphery of the locking arrangement attached to the Block Lever Handle are controlled by lock magnet, the lever allows movement of the handle only when the magnet is energised otherwise the projected notches obstruct the movement. On the inner periphery of the same locking arrangement, work as safety device against sticking of the magnet lever due to over energisation or any other reason by force pulling the magnet lever inside each notch by the projections provided underneath each such notch. Selection of the frequency to modulate the frequency assigned to the block instrument i.e. F1 or F2 is done through the position of the Block lever handle. If the Block lever handle is in Line Closed position the modulating frequency shall be 65 cycles per second and when it is turned to TCF, the modulating frequency shall be 85 cycles per second. It shall be possible on the paired block instrument to turn the Block lever handle to TGT only when modulated frequency received there is 85 cycles per second only. To be able to turn the Block Handle lever to Line closed, the other station frequency modulated at 65 cycles per second shall be required.

iii) **Push buttons PB1 & PB2:** PB1 button when pressed actuates NR relay to energise single stroke bell at the adjoining station block instrument. PB2 button when pressed transmits the designated frequency say F1 meant for train despatching station (2000cps or 2500cps). The given audio frequency is modulated depending upon status of the Block Lever Handle. Code Relays CR1 provided in the adjoining station block instrument responds to the F1 modulated at 65 cycles per second and another code relay CR2 to the same frequency modulated at 85 cycles per second. Energisation of relay CR1 releases lock enabling movement of Block lever handle from line closed to TCF, TCF to Line closed and TGT to Line closed positions, while energisation of relay CR2 releases lock enabling movement of the Block lever handle from Line closed to TGT.

iv) **Switch S1:** This switch is operated for cancellation of the line clear by the sending station obtained when the train has not left the station which sought the line clear.

v) **Switch S2:** This switch is operated to receive the train back on proper reception signal when it had to be sent back from the destination station without having been received there.

vi) **TOL:** This indicator changes from its normal position white to red when the train has entered into the block section. The indicator is of magnetic stick type consisting of two coils. Normal coil is energised via front contact of TOLR while reverse coil is energised through Block lever handle contacts.
vii) **TER**: This is Time Element Relay energisation indicator appearing after pre-determined time of two minutes when the cancellation of the Line Clear is possible. It works on single coil which energises after 2 minutes of pressing S1 button.

![Diagram of Daido Single line token-less block instrument](image)

**Figure 3.4.1a**

*Daido Single line token-less block instrument*

viii) **Buzzer 1**: The buzzer BZ1 operates through front contact of TOLR to call attention of the Station Master that the train had entered into the block section. Accordingly TOL indication also appears along with this buzzer ringing.
ix) **Buzzer 2**: The buzzer BZ2 operates through front contact of 2R. This buzzer operates when the train clears the block section for calling attention of the Station Master that the train had arrived and process for closing of the section had to be initiated.

x) **Station Master’s key**: The arrangement to lock the block instrument when the key is extracted by the Station Master out of the block instrument is to ensure that no unauthorised operation takes place when the Station Master is away. During this period the block instrument becomes non-functional except the block bell and appearance of ‘TOL’ indication. Telephone can be used for communication.

xi) **Occupation key**: This key can be removed only when the block instrument is in line closed position. This key is carried by the Loco pilot while shunting. The removal of this key also makes the block handle inoperative.

3.4.2 **Operation for train movement**: At station ‘X’ block instrument, the Station Master presses button PB1 which makes single contact for transmitting bell codes to the adjoining station to request for line clear. As station ‘Y’ agrees to grant line clear, the Station Master of station ‘X’ presses button PB2 which has three contacts and transmits the allotted frequency of 2000 cycles per second modulated at the rate of 65 cycles per second superimposed on DC, to station ‘Y’, the line clear granting station.

Station Master at station ‘Y’ shall turn Block Lever Handle to TCF and press PB2 button to transmit 2500 cycles per second frequency allotted to this block instrument modulated at the rate of 85 cycles per second. This enables Station Master at station ‘X’ to turn the Block Lever Handle to TGT. With this the relay TRSR energises and the Advanced starter signal is then taken off.

As the train passes over first track circuit ahead of the Advanced starter signal, i) the Advanced starter signal is restored to On, ii) the 2000 cycles per second modulated on 85 cycles per second frequency is transmitted automatically from the block instrument at sending station, iii) TOL indication appears on the block instruments of both the stations and iv) buzzer starts ringing at both the stations.

Station ‘Y’ shall acknowledge the train on line by transmitting bell code using PB1 button and prolong the last beat by keeping it pressed, which shall stop transmission of 2000 cycles per second frequency from station ‘X’, stop ringing of buzzer while TOL indication shall continue to be displayed on both the instruments.
As the train enters within Home signal of the receiving station ‘Y’, the Home signal shall automatically be replaced to On and the buzzer shall start ringing at receiving station. The Station Master at receiving station then shall press PB2 button which shall transmit the frequency 2500 cycles per second modulated by 65 cycles per second to enable Block Lever Handle to be turned to Line closed position at sending station ‘X’ thereby normalising TOL indication on this block instrument.

After normalising his block instrument handle to line closed, the Station Master of station ‘X’ shall press PB2 button to send 2000 cycles per second modulated by 65 cycles per second thereby enabling station ‘Y’ also to turn his block lever handle to line closed position.

3.4.3 Cancellation of line clear before despatch of the train: In case it becomes imperative to cancel the line clear before the train is despatched and the block lever handle has been turned to TOL by the station in advance, the Station Master of the despatching station say ‘X’ for example here, shall intimate the station in advance that the line clear already granted by him is to be cancelled and shall operate switch S1. TER indication shall appear on his block instrument after a lapse of given time of 2minutes. The Station Master shall put the S1 button to normal along with which the TER indication shall also turn back to red indication. The despatching station ‘X’ shall then press PB2 button to send 2000 cycle per second frequency modulated by 65 cycles per second and prolong it pressed to enable the adjoining station ‘Y’ to turn his block lever handle to line closed position.

The station ‘Y’ then shall press his block instrument button PB2 and prolong the same pressed to facilitate the station ‘X’ to turn his block instrument block lever handle to line closed position.

3.5 Block working by track circuits: Under absolute system of block working, the operation of block instruments needs time restricting the total minimum distance between the two block stations. The time taken in granting line clear, giving train on line message and closing of the block instrument has to be at least less than the time taken by a train running at the booked speed. If this is allowed to happen each train shall have to stop waiting for line clear. To overcome this situation, the block sections smaller than required are provided with track circuits.

As mentioned in preceding paragraph under the same chapter, the block instruments provided to maintain the integrity of the block section under Absolute Block working system are not capable of ensuring complete arrival of the train which is left to the Station Master who ensures this by observing Last Vehicle (LV) board. Under the present scenario of over utilisation of section capacity surveillance by Station Master may not be error free, as such block working is established by using DC or AC track circuits for smaller block sections where the system fulfils both the requirements and in longer block sections Axle counters are used where only the block section clearance is required to be proved. DC & AC track circuits have already been discussed in Chapter VII, for monitoring devices as its use for block working shall be taken up here.

3.5.1 Block working by track circuits under Absolute Block system of working: Under Absolute Block system of working, as per Indian Government Railways General Rules clause 8.01:

a) No train shall be allowed to leave a Block station unless Line clear has been received from the block station in advance;
b) On double lines, such Line Clear shall not be given unless the line is clear, not only up to first stop signal at the Block Station at which such Line Clear is given, but also for an adequate distance beyond it;

c) On **single line section** such Line clear shall not be given unless the line is clear of trains running in the same direction, not only up to first stop signal at the Block Station at which such Line Clear is given, but also for an adequate distance beyond it, and is clear of trains running in the direction towards the block station to which such Line Clear is given;

The adequate distance so mentioned above shall under normal circumstances be not less than:

i) 400 metres in case of two-aspect lower quadrant signalling or two-aspect colour light signalling, and

ii) 180 metres in case of multiple aspect signalling or modified lower quadrant signalling.

**Essentials for block working by track circuits on double line and single line sections** are:

**On single line section:** A train may be given line clear by a Block station to the Block station in rear manually by operations of the direction switch, provided that the block section is track circuited throughout its length or axle counters are provided at either end of the block section [BWM 2008 (NCR) paragraph 7.01].

**On double line section:** A train may be given line clear by a Block station to the Block station in rear automatically, by means of track circuits or axle counters provided that [BWM 2008 (NCR) paragraph 7.02]:

i) The section between last stop signal of despatching station and the first stop (reception) signal along with the block overlap thereon, at the receiving station shall be provided with the continuous track circuits or axle counters.

ii) Last stop signal of the station in rear is so controlled that it is not possible to display Off aspect unless block section in advance is shown to be clear by track circuits or axle counters and,

iii) Visual Indicators are provided at each Block station on the block panel showing the conditions of the block sections both in rear and in advance of the station.

Accordingly clear and occupied indications of all the track circuits in between last stop signal of despatching station and first stop signal of the receiving station including overlap thereon shall be provided at stations at both the ends of the block section.

One independent track circuit each shall be provided ahead of last stop signal of departure station and one ahead of first reception signal of the receiving station for the purpose of replacement of these signals.

A) **Absolute Block System of working by track circuits on double line section:** [Block working manual 2008, North Central Railway paragraph 7.07].
a) **Sequence of operation:**

i) The Station Master of the receiving station shall grant line clear on telephone.

ii) The Station Master of despatching station shall take the departure signals Off after observing Block section track indicator clear indication on his panel. As the train enters into the block section and occupies first track circuit beyond last Stop Signal (LSS) of the station despatching the train, white light of the block section clear indicator shall change into red and buzzer shall start ringing at the station receiving the train which shall stop on acknowledging by pressing acknowledgement button on the panel.

b) **Circuit for controlling last stop signal on double line section:** [Figure 3.5.1A(i) & Figure 3.5.1A(ii)] Considering ‘X’ & ‘Y’ stations operated by control cum indication panel, at both ends of the block section, i) complete section is provided with track circuits, ii) all track circuits between up Advanced starter of station ‘X’ and up Home signal of station ‘Y’ including overlap beyond, are proved clear for taking Off up Advanced starter signal of station ‘X’, iii) all track circuit clear indication is provided at station ‘X’ as well as station ‘Y’, iv) track stick relay 18 TSR is energised at station ‘Y’ through 18 TPR pick up contact, 18 RECR pick up contact to prove that signal had gone back to On after passage of previous train and 18 GNR back contact, to ensure that no move has been initiated, bypassing 18 GNR back and 18 RECR pickup contacts by its own contact of the 18 TSR to hold 18 TSR in picked up condition to prove that the signal was replaced to normal and overlap track 18 TR has been cleared after passage of previous train received, as well as to implement one train one signal principle; v) UP BCR is energised at station ‘X’ when station ‘Y’ grants line clear, energising relay LCR at station ‘Y’ and transmitted to station ‘X’ through pickup contacts of LCR, proving 18 TPR pickup contacts, vi) 2 TSR is energised at station ‘X’, through pickup contact of 2 TPR & 2 RECR and back contact of 2 MLR and is kept held energised bypassing 2 MLR and 2 RECR contacts by its own contact.

LCR is energised at station ‘Y’ by pressing LCPB (Line Clear Press Button) along with group button GBNR simultaneously, proving 18 TSR and 2/4/6/18 TPR pickup contacts and is held picked up through its own contact and back contact of group relay GBRNR. Line clear may be cancelled by station ‘Y’ by pressing GBRN along with PBLC button thereby disconnecting limb of LCR causing its de-energisation, as and when it is required to cancel the line clear. The cancellation of line clear shall be affective only till the train has not crossed Advanced starter signal [Figure 3.5.1A (iii)].

2 TPR and 18 TPR relays are energised locally at station ‘X’ & ‘Y’ respectively through pickup contacts of respective TRs and proved in desired circuit. 18 TSR pickup contact is proved in line clear circuit at station ‘Y’ to ensure that the previous train which had left station ‘X’ crossed the up Home signal number 18 and occupied and cleared track circuit 18 TR thereby putting Home signal 18 to On.

For taking Off the up Advanced starter signal-2 for despatch of train from station ‘X’ the signal relay 2 GR is energised by pressing signal button 2 GN and route button MUN on panel which shall energise 2 MLR (route initiating relay) after proving interlocking i.e. no route conflicting to the one in question has been initiated etcetera. Energisation of 2 MLR in turn energises 2 GR proving UPBCR pickup contact i.e. line clear received from station ‘Y’ which includes 18 TSPR
pickup contact proving previous train has cleared the overlap beyond up home signal of station ‘Y’ and no movement is taking place on overlap track circuit, 2 TSPR pickup contact, 2TPR and 4/6/8/18 TPR pickup contacts to prove section ahead clear and 2MLR pickup contact for taking Off signal number-2 having been initiated at the Control cum Indication Panel and relevant interlocking requirements have been fulfilled [Figure 3.5.1A(ii)].

As the train passes up Advanced starter S-2, 2MLR and consequently 2GR shall get de-energised putting the signal back to On due to occupation of track circuit 2TR. The signal is retained at On and maintained so till next line clear is received for the want of i) energisation of 2TSR, ii) clearance of the block section which shall be re-energised only after all the track circuits in the section are cleared of the train and iii) re-energisation of 18 TSR ensuring taking Off of up home signal at station ‘Y’ having normalised the up Home signals after arrival of previous train.

Energisation of 4/6/8/18 TPR combined with 2TPR is also meant for providing ‘Block Section Clear’ indication to the Station Master. Another relay proving all track circuit clear is energised at the Station ‘Y’ to provide the Station Master with block section clear indication.

Figure 3.5.1A(i).
Circuit for block working by track circuits on double line section
Circuits are designed to comply with the provisions of GR and SEM in a manner different by different railways.

**Figure 3.5.1A(ii).**

*Circuit for block working by track circuits on double line section*

**B) Absolute Block System of working by track circuits on single line section:** While on a double line section the direction of traffic is predefined, on single line section it must be ensured before taking Off a departure signal in addition to other conditions provided for block working with continuous track circuits as under double line section, that the block section is clear of trains before line clear is granted by the station on either end of the block section. Two systems are prescribed for line clear working i) by means of direction switch and ii) by means of push buttons [Block working manual 2008, North Central railway paragraph 7.05]. Single line working also can be operated using levers where electro mechanical signalling system is in vogue.

**I**  
**By means of direction switch:** A direction switch is provided on the panel having two positions ‘N’ and ‘R’ along with indications TGT and TCF.

**Granting line clear:**

i) The Station Master of receiving station ‘X’, for granting line clear shall turn his direction switch to position ‘R’ after ensuring block section clear indication, with this white light shall appear on TCF indicator on the panel, thereby white light shall appear on TGT indication at the sending station ‘Y’. Sending station shall take LSS of his station Off to despatch the train.

ii) Station Master of sending station ‘Y’ shall seek line clear from the adjoining station ‘X’ on telephone keeping his direction setting switch on his panel is in position ‘N’. The receiving station ‘X’ shall turn his direction switch to ‘R’ position which shall result in

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display of white light on TGT indication on despatching station ‘Y’. Station Master of station ‘Y’ shall take Off his LSS to despatch the train.

Train entering block section: as the train enters block section occupying first track circuit ahead of LSS, the TGT and TCF indications at despatching and receiving stations respectively shall turn to red indication and buzzer shall start ringing at the receiving station. Station Master at the receiving station shall press acknowledgement button to stop buzzer ringing.

Train out of block section: As the train clears block section white reed indication of TCF shall turn to white while maintaining TGT indication of the sending station to be red. Station Master of the receiving station shall turn his direction setting switch to ‘N’ position thereby illuminating his TGT indicator with red light and disappearance of white light of the TCF indicator.

The line is closed and both station YGT indicators display red indication.

Cancellation of line clear: For cancellation of line clear by station sending the train the Station Master at the sending station shall restore the LSS to On and shall not alter the points until the Loco Pilot is issued with written memo that the train is being detained. The Station Master at the receiving station shall turn his direction switch to ‘N’ position and press button ZN and keep it pressed till the line clear cancellation counter steps up by one number. With this red indication lights shall appear on TCF and TGT indication on both the stations.

In case line clear has to be cancelled by receiving station which has granted line clear, he shall turn direction switch to ‘N’ position and press button ZN on his panel. With this the LSS at the sending station shall be restored back to On if the train had not already passed the LSS, thereby making the buzzer to ring and turning TGT indication on the panel red. TGT and TCF indications on sending and receiving stations shall extinguish after 120 seconds of after pressing of the cancellation button. With this line clear shall stand cancelled.

(II) By means of Push buttons: Push buttons and indicators used are i) TGT button, ii) TCF button, iii) group button(GN/GEN), iv) Cancellation button, v) App. ACK. Button, vi) TGT direction indicator, vii) TCF direction indicator, viii) Block track indicator (BTKE) and ix) Slot indicator ‘YKE’.

Granting line clear:

i) The Station Master of receiving station ‘X’ for granting line clear shall press his TCF button along with group button, after ensuring block section clear indication, with this white light shall appear on TCF direction indicator on the panel, while at the same time YKE white light indication shall be displayed on the line clear receiving panel.

ii) Station Master of sending station ‘Y’ shall, having observed YKE indication shall press his TGT button with the group button on which the TGT indicator shall be illuminated with white light. With this line clear is granted by the receiving station.

Station Master of station ‘Y’ shall take Off his LSS to despatch the train.
(III) **Operation by levers:**

i) When operated by levers, a direction lever is provided in addition to all other levers in the cabins of stations on each end of the block section. The direction lever is provided with a lever lock and can be pulled only when i) the section between the two stations is clear of trains not only up to the first stop signal at receiving station but also up to overlap beyond it and ii) all signals have been put to normal at the back of previous train.

ii) When the lever in cabin of station ‘Y’ is pulled the direction lever at station ‘X’ is released to be pulled to set direction. Once the direction is set and line clear is received from station ‘Y’, station ‘X’ can despatch the trains. For change in the direction same action shall be repeated as discussed in preceding paragraph.

**Circuit for operation through Control cum Indication panel with push buttons:** Part of the yard sufficient to understand block working has been taken for example [Figure 3.5.1B (i)].

Station ‘X’ is provided with down Advanced starter signal 2 and Home signal 19. Track circuits 4T & 6T have been provided in the block section while track circuit number 18/3T covers the overlap beyond down home signal number 18 at station ‘Y’. Station ‘Y’ is similarly equipped with up Advanced starter signal 3, Track circuit number 2/19T works as overlap beyond up Home signal number 19 of station ‘X’.

![Figure 3.5.1B(i)](image)

*System of working & circuits for single line block working with track circuits*

Pick up contacts of all track circuits in the block section between up and down home signals of station ‘X’ and ‘Y’ are taken to energise BZTR at station ‘X’, to prove block section track clear. The BZTR is repeated at station ‘Y’ as BZTPR. The BZTR shall be added with pickup contact of
2/19 TR, the overlap beyond up Home signal for the train to be despatched from station ‘Y’. Similarly when the train is to be despatched by station ‘X’ the 18/3 TPR shall be added to BZTPR, to prove clearance of block section including overlap.

**Granting line clear:** As the station ‘X’ initiates to grant line clear by pressing button TCF with group button GBS, relay TCFNR is energised through Station Master’s key-in contact, BZTR pickup contact to prove block section clear and TGTR back contact, being for opposite to the direction movement [Figure 3.5.1B(ii)].

With the energisation of TCFNR, interlocked relay TCF(R)R is energised, power extending through pickup contact of 2/19 TPR, pickup contact of BZTR, back contact of 2YR, pickup contacts of 2ZR3, XTCFN & 19NPR i.e. up Home signal on which train is to be received had been put back to normal after reception of preceding train and then back contacts of XUYR1 & XUYR2 to prove these relays had been put to normal after reception of preceding train, 2NPR and XTGT(N)R pickup contacts to prove that the down Advanced starter signal is On and no down direction movement which is opposite to the one under process is contemplated and then through back contact of XTCF(N)R to prove that opposite direction movement is not initiated [Figure 3.5.1B (iii)].

With the energisation of TCF(R)R, TCFPR (not a latch relay) is energised to create repeater relays[Figure 3.5.1B (iv)].

[Figure 3.5.1B(v)] As the TCF(R)R is energised, power is extended to the station ‘Y’ to energise 3YR to enable the despatching station ‘Y’ take Off up Advanced starter signal number 3 through XCNR and XATR back contacts to prove that line clear cancellation has not been initiated by pressing CN button [Figure 3.5.1B(ii)], 2YR back contact i.e. opposite direction departure signal’s 2YR is not energised (this contact is also instrumental in cutting off power extending to 3YR when energised), pickup contacts of XTGT(N)R, XTGF(R)R, XTGFPR, BZTR and 2/19TPR so far at station ‘X’ and then at station ‘Y’, through pickup contacts of 18/3TPR which is the up Advanced starter signal number 3 track circuit being an integral part of the block section, energising 3YR. With the energisation of 3YR a white indication shall illuminate on the control cum indication panel of station ‘Y’ (not shown in the diagram).

Relay 3YPR is energised at station ‘Y’ extending power through pickup contacts of YTGT®R, 3YR, 3ZR3 and YTSR to negative limb.
Energisation of 3YR enables energisation of 3ZR2 through pickup contact of 3ZR1 and back contact of 3ZR3 to be discussed in ensuing paragraphs.

**Part of the set of circuits for station ‘X’ shall be read for station ‘Y’ also assuming changed numbers and prefixes.**

**Arrival of train at station ‘X’ energising UYRs:** [Figure 3.5.1B(iv)] As the train arrives at station ‘X’, it occupies track circuits 2/19TR first and then 19TR. The XUYR1 energises through pickup contact of XTCF(R)R, back contacts of BZTR and 2/19TPR and pickup contact of 19TPR. UYR1 is kept held through its own contact bypassing contacts of BZTR, 2/19TPR & 19TPR. UYR2 is energised through pickup contacts of XTCF(R)R, UYR1, 2/19TPR and back contact of 19TPR. UYR2 is also kept held by its own contact bypassing the 2/19TPR and 19TPR contacts.

![Figure 3.5.1B(iii) Circuits for initiation of TCF & TGT latch relays & X TSR](image)

**Repeater relays for TCF(R)R & TGT(R)R and UYRs**
Normalisation of system at receiving end station ‘X’: To normalise the system, line clear granted by station ‘X’ by energisation of XTCF(R)R is cancelled by energisation of XTCF(N)R which is automatically done by passage of the train. XTCF(R)R in turn energises XTCFRPR. Energisation of UYR1 and UYR2 prepares circuit for energisation of TCF(N)R to cancel line clear, through pickup contacts of 2/19TPR and BZTR, back contact of 2YR, pickup contact of 2ZR3, back contact of XTCFR which is laying de-energised, back contact of XTGNTR, pickup contacts of UYR1, UYR2, 19 TPR & 19NPR and back contact of XTCF(N)R. However it may be seen that pickup contact of 19TPR shall be available after energisation of UYR1 & UYR2 and clearance of 19T by the train. 2ZR3 shall not be de-energised by the passage of the train over track circuit 2/19T, the contact of the 1/19TPR having been bypassed by XTCFPR in ZR circuit.

In case UYR1 or UYR2 do not energise due to any reason, the route can be released by pressing CN button energising 120JR after 120 seconds of initiation of cancellation. CNR is energised through pickup contact of BZR to ensure that no cancellation takes place with the train in the block section.

Despatch of the train from station ‘X’: On getting white small illuminated indication of energisation of 2YR on control cum indication panel, the Station Master of station ‘X’ shall press TGT button energising TGTNR [Figure 3.5.1B(ii)], energising in turn TGT(R)R through pickup contacts of 2/19TPR to prove LSS track circuit energised, BZTR to prove block section clear, 2YR to prove TCF button has been pressed at station ‘Y’ and line clear has been received by station ‘X’, XTGTNR i.e. the TGT button relay energised, XTCF(N)R to ensure that opposite direction grant of line clear had not been initiated at the station and back contact of XTGT(N)R the TGT normal relay [Figure 3.5.1B(iii)]. Energisation of TGT(R)R in turn shall create repeater TGTRPR [Figure 3.5.1B(iv)].

For taking the departure signal S2 Off, besides proving energisation of 2YR, pickup contacts of XTSR, 2ZR3 and XTGT(R)R are proved in 2YPR circuit which in turn is proved in 2HR circuit [Figure 3.5.1B(v)].

2YPR is not only a repeater to 3YR but plays a vital role in sequence of operation by proving 2ZR3 & XTSR energised before taking the down Advanced starter signal 2, Off. As the train enters the block section having started from station ‘X’, 2YR, XTSR as well as 2ZR3 shall get de-energised. However as the train clears track circuit number 18/3T at station ‘Y’ the 2YR shall get energised again but 2YPR shall not get energised preventing the station ‘X’ from taking the last stop signal taking Off again with fresh line clear.

It is pertinent to note that energisation of 2YR is indicator of block clearance while signal can not be taken Off again due to de-energisation of 2YPR (see 2YPR circuit).

Function of XTSR: XTSR as all normal proving relay to ensure one signal one train principle. It is energised through pickup contacts of 2/19TPR, BZTR, TCF(N)R and TGT(N)R and is held picked up through its own contact bypassing XTGT(N)R and XTCF(N)R contacts to ensure that once the TSR is de-energised due to passage of train with either TGT(R)R or TCF(R)R energised. The XTSR is held picked up through its own contact bypassing contacts of XTGT(N)R &
TCF(N)R. it shall be re-energised only after clearance of block section, energisation of 2/19TPR, TCF(N)R and TGT(N)R [Figure 3.5.1B(iii)].

**Figure 3.5.1B(v) - YR circuit**

*Function of 2NPR:* 2NPR is signal number 2 normal proving relay which energises through back contact of 2DR, pick up contact of 2RECR and back contacts of 2ZR1 and 2ZR2 and is kept held picked up through its own contact bypassing contacts of 2ZR1 & 2ZR2 [Figure 3.5.1B(vii)].
Normalisation of system at despatch end station & function of ZR1, ZR2 and ZR3: 2ZR1, 2ZR2 and 2ZR3 function during despatch of train from its station [Figure 3.5.1(vii)]. The relay is also used to transmit indication onto the panel [Figure 3.5.1(vi)]. For the sake of study station ‘X’ is taken as despatching station energising XTGT(R)R. For the sake of study station ‘X’ is taken as despatching station energising XTGT(R)R.

All the three ZRs are normally energised. As the signal is taken Off with 2YPR energised proving pickup contact of 2ZR3, the 2 NPR is de-energised due to energisation of 2DR and de-energisation of 2RECR consequently de-energising 2ZR1 which in turn de-energises 2ZR2 due to break in its circuit too. 2NPR gets re-energised with the de-energisation of ZR1 and ZR2, de-energising of 2DR and energising of 2RECR with the occupation of 2/19TR and is kept held picked up through its own contact bypassing contacts of 2ZR1 & 2ZR2. 2YR also gets de-energised with the occupation of 2/19TR and continues to be so till block section is occupied and BZR is de-energised. Accordingly 2ZR1 gets energised through pickup contacts of 2NPR and XTGT(R)R & back contact of 2YR and is kept held picked up through its own contact bypassing XTGT(R)R and 2YR contacts.

2ZR3 also de-energises with the occupation of 2/19 TPR due to movement of the train from station ‘X’ to station ‘Y’. The relay contact bypassed by XTCFRPR is to avoid de-energisation of 2ZR3 when the train movement is in opposite direction.

As the train clears 18/3Track at station ‘Y’, 2YR gets re-energised energising 2ZR2 through pickup contact of 2ZR1, 2YR and back contact of 2ZR3 and is kept held through its own contact bypassing 2YR and 2ZR3 contacts.
As the train clears track circuit 18T at station ‘Y’ the YTCF(N)R is energised de-energising YTCF(R)R at station ‘Y’ thereby disconnecting the 2YR circuit [Figure 3.5.1B(v) for station ‘Y’].

As the 2YR is de-energised, 2ZR3 is energised through pickup contact of 2/19TPR, 2ZR2, and back contacts of XTSR, 2YR, and pickup contact of 2NPR and is kept held picked up through its own contact bypassing 2ZR2, XTSR, 2YR and 2NPR contacts.

XTGT(N)R is energised normalising the system with the energisation of 2ZR3, power extending through pickup contact of 2/19TPR, BZTR, back contact of 2YR and pickup contact of 2ZR3 simultaneously de-energising XTGT(R)R. XTSR is energised with the energisation of XTGT(N)R as well as it extinguishes indication TGT on control cum indication panel.

*Panel Indications and counter:* [Figure 3.5.1(vi)] Indications on the panel are TGT, TCF, Block section clear and occupied, while there is one counter.

When TGT button is pressed, TGT indication gets illuminated with white light through energised contacts of TGTRPR, 2ZR3 and 2YR, which turns red i) with the de-energisation 2ZR3 or ii) with the de-energisation of 2YR and picked up contact of 2ZR3.

TCF indication is illuminated with white light through the pickup contacts of TCF(R)R and BZTR which turns red with the de-energisation of BZTR.

The cancellation counter steps one above by pressing of cancellation button

Two red and two white indications are provided through BZTR pickup and drop contacts respectively to show clearance and occupation of block section.

3.6 **Block proving and block working by Axle counters:** Block working by block instruments do not prove complete arrival of train at the receiving station which is solely dependent on verification of last vehicle by the Station Master or the Cabin Master whosoever is operating the block instrument. With increase in traffic and verification of last vehicle becoming a routine, cases have been there when the parted portion of the train leftover in the block section remained undetected, necessitating methods to prove clearance of block section to be developed not leaving on the human element.

To ensure that the block section gets cleared of the train full or a part thereof, entire block section is required to be monitored by providing track circuit or axle counters in the entire stretch of the track. DC, AC, AFTC or other type of track circuit superimposed on the rails are provided in smaller sections as has been discussed in preceding chapter monitoring devises Chapter –vii, which are also provided in automatic block sections where, in any case, shorter length track circuits have to be provided for smaller automatic block sections. However, monitoring longer block section clearance by axle counters has been found to be more convenient which is ensured by, i) proving block section clearance using axle counters and interlocking this information with
the block instrument, ii) proving block section clearance using axle counters and using Block Panel instead of block instruments.

For both the arrangements analogue or digital axle counters may be used. However besides use of trolley suppression track circuits, owing to reliability better than analogue, digital axle counters are being used for all such future requirements.

A) Proving block clearance by axle counters: Single section analogue axle counter transducers are provided between the replacement track circuits of the concerned Advanced starter signal and the overlap track circuit of Home signal at the receiving station on double line section and on either station on single line section. These track circuits serve purpose of trolley suppression also. Output of the receiver amplifier of electronic junction box is transmitted on ½ quad of a quad cable from the receiving station to the station despatching the train where the evaluator is kept in the relay room (chapter- vii, monitoring devices). Pickup contact of the block clearance relay provided on the evaluator, is proved in the GR circuit of the last stop signal of the despatching station. As the train arrives at the receiving station having cleared the overlap track circuit, the block clearance relay pickup contact is proved in block instrument closing circuit. The block clearance relay is repeated at the receiving station, for this purpose as well as for giving physical indication to the Station Master for ensuring block clearance before attempting to close the block instrument.

Block clear indication is also used for closing block instrument at receiving station without interlocking the block clear proving relay with the block instrument, system in vogue. However it is not considered of any vital significance as the procedure is left on human judgement.

Single section digital axle counter, axle detector is provided ahead of the last stop signal of the despatching end station and ahead of Home signal of receiving station. A signal replacement tack circuit, in any case is required to be provided ahead of the last stop signal at despatching station and ahead of first reception signal at the receiving station. Accordingly the axle detectors may have to be provided in between these signal replacement track circuits to maintain contiguity of both the track vacancy monitoring devices. The axle detectors are connected with each other through ½ quad of star quad cable or optical fibre. Since both the axle detectors are self equipped with track indication relays, block section clear indication is also available at both end stations. Proving block clearance in the last stop signal at the despatching station and closing of block instrument at the receiving station is done in the manner same as discussed in case of analogue axle counter system. Arrangement shall be same in case of single and double line sections.

In case it is proposed to replace the conventional DC or AC track circuits for signal replacement, multi-section digital axle counters may be used for last stop signal and home signal replacement track circuit in addition to the block proving zone. This way on double line section four track circuits each direction shall be required to be used.

Resetting: In case even after complete arrival of the train at the receiving station, the block section is not shown clear, the axle counter shall be required to be reset. The resetting is done by the station receiving the train since he has to verify complete arrival of the train, while despatching end station shall cooperate.
A reset box, provided at both end stations, with a key, a button, and track clear and occupied indications.

The system is designed such as that even after resetting process, first train shall be passed on paper authority to enter the block section. The following train shall be allowed to pass on proper signals provided block section shows clear indication after passage of the first train.

B) **Block working with axle counters with Block Panel:** Block instrument and axle counter system are interlocked with each other to maintain integrity of the block section for ensuring complete arrival of the train by verifying clearance of the block section by axle counters. This makes a mix of block working system replacing block instrument by a block panel and providing block proving by axle counter, into a unified system.

Accordingly block working with a panel is designed in conformity to specification number RDSO SPN 188-2004 with UFSBI/MUX-Combiner. The system has a set of two operating panels and proves block clearance by analogue axle counters. Block Panel working with axle counters can be provided on double as well as single line sections.

a) **Block working panel system is equipped with:**
i) SM’s Panel provided in Station Master’s room at stations on both ends of the block section, for operation of block.

ii) Axle counter with two detection points one set each for up and down lines on double line section and one set for single line section.

iii) Multiplexer and combiner converter at stations on both ends of the block section.

iv) Set of relays mounted on relay rack at stations on both ends of the block section.

b) **SM’s panel:** The panels for single line as well as double line section are provided with i) SM’s key, ii) Axle counter resetting key, iii) shunt key, iii) Press Buttons, iv) indications, v) counters and vi) buzzers, to carry out functions for train operation and vi) dedicated telephone attached with the panel, besides, one key each for Station Master and the S&T staff is provided at the cover making the interior of the panel accessible jointly only by the SM and the S&T staff.

Functions and specific provisions in the panel to conform the requirements of single and double line sections are detailed in ensuing paragraphs.

c) **4/2 wire converter:** The Evaluator is kept at station at receiving or sending end station as the case may be, as such, in order to reduce the transmission channels a 4/2 wire converter at the other end station converts the operating frequency of transducer receiver ‘B’ to 3.5 KHz and allows transducer ‘A’ operating frequency to be continued as 5 KHz and four conductors output of transducers ‘A’ & ‘B’ into two wires for transmission to the evaluator at the station where evaluator is placed.

d) **Multiplexer, combiner and converter:** Block control panel and axle counter status information is shared by both stations communicated to and fro through quad cable using coded messages so as to be limited to 1½ quads. Two sets of twelve channel multiplexers using time division multiplexing technique, provided at each station are i) Transmitter multiplexer called as
Tx-Mux and ii) Receiver Multiplexer called as Rx-Mux. Each multiplexer consists of two groups each being of six channels. One transmitter and one receiver form one set placed at both the stations at the end of the block section. Each set of the two works on a frequency different then other. The frequencies used are 1100/1300 Hz and 1500/1700 Hz.

Tx-Mux and Rx-Mux are equipped with a combiner and converter.

c) **Combiner and converter:** The coded Frequency Shift Keying (FSK) signal output of MUX transmitter containing on/off status of block information relays and output of 4wire/2wire junction box from transducers installed near the Advanced starter signal containing channel information is unified by the combiner and sent to adjoining station as single channel massage, which is converted into relevant input signals for MUX receiver for operating repeater relays and the ‘A’ and ‘B’ channel input signals by the converter.

i) **Combiner:** Transmission of pick up and drop status of block information relays along with transducer channel status is unified by combiner by means of coded Frequency Shift Keying (FSK) signal and transmitted to the adjoining station. Information so transmitted is received at the adjoining station.

ii) **Converter:** The unified signal sent by the combiner received at the adjoining station is de-coded and converted into relevant input signals for Rx-Mux for energising relays repeater to main relays along with status inputs of the transducers ‘A’ & ‘B’ of the station adjoining from where the signals were despatched. The transducer ‘A’ & ‘B’ outputs are connected to the evaluator concerned.

As a typical example number of relays used at the station where the evaluator is kept, is twenty and at the other station it is eighteen for single line section, in case of the system designed by M/s Central Electronics Limited Sahibabad, Delhi.

f) **Automatic checking of conditions for granting line clear and automatic display of status of the block section on the panel:** The system checks i) clearance of block section not only up to Home signal but also up to block overlap at station receiving the train and ii) restoring all signals to normal after clearance of the block section by the train at the receiving station, generating conditions for granting Line Clear, automatically.

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The status of block section is displayed on both end SM’s panel by the system automatically by the movement of the train.

I) **Block working by panel on Single line section:** The section being single line, one set of axle counters is used for both directions track section being one. The evaluator for may be kept at either end station. Electronic junction box shall be used for transducers. 4/2 wire converter shall be used near Advanced starter signal at the station where evaluator is not kept. 1½ quads out of Jelly filled six quad 0.9mm diameter copper conductor cable is used for the system.

*An Schematic layout showing arrangement of axle counters, combiner converters and distribution of cable cores for single line block working with axle counters is placed as figure 3.6.(B)(I)(ii).*

A panel for Block Working is designed in conformity to Drawing number RDSO /S-32010/ 003/ 001. Refer figure 3.6.B(I)(i) for profile of the panel designed by M/s CEL for block working on single line section. This operating panel is used at the station where evaluator is provided.

Similar panel is provided at the other end station where evaluator is not provided with the difference that reset bush button is provided in place of axle counter reset key and the axle counter reset counter.

Function of keys, buttons, indicators, counters and buzzers provided on and associated with the single line section SM’s panel are:

i) **Keys and their functions:**

*Station (SM’s) Master’s key:* the key when out of the panel shall prevent transmission of bell communication, ii) transmission of line clear enquiry code, iii) resetting of axle counter and iv) release of shunt key.

*Axle counter reset key:* The key is required to be turned and pressed for resetting of the axle counter with the cooperation by adjoining station by pressing axle counter Cooperation button. The key works as safety device as well as button for resetting. When the key is extracted out of the panel it shall not be possible to reset the axle counter.

*Shunt key:* Shunting can be performed in block section only when key has been extracted from the panel, to be used by Loco Pilot as authority for entering block section for shunting.

ii) **Buttons and their functions:** Push buttons on the panel are non locking type.

*Bell push button:* used for transmitting bell codes to the adjoining station. This button is also pressed along with Train Going To button to obtain line clear, with Cancel button to cancel line clear.

*Train Going To button:* used by despatching station for setting Train Going To status at the sending station when pressed with bell push button and Train Coming From status at the station to receive the train. Green TGT indication appears on the sending station panel.
**Cancel button:** Used by the Station Master of the receiving station for cancellation of the line clear till the train has not left the despatching station or the train is required to be pulled back to the despatching station.

**Cancel cooperation button:** used to cooperate by the despatching station with the line clear cancellation by the receiving station.

**Acknowledge button:** It is used to acknowledge the train on line and train out of section conditions, by pressing this button the buzzer for the corresponding condition is also silenced.

**Axle counter resetting cooperation button:** The button is required to be pressed to cooperate simultaneously by the Station Master of the station where evaluator of the axle counter has not been provided, while resetting is being done, by the Station Master of the station where evaluator has been provided, by turning and pressing the resetting key.

**Shunt button:** used to extract the shunt key.

**Catch/slip siding key:** provided on the panel when there is a catch or slip siding to perform catch/slip operations.

### iii) Indicators and their meaning:

**Line closed:** Provided with white or yellow coloured LEDs, encased in the rectangular shaped box, when illuminated indicates that there is no train in the block section and line clear has not been granted.

**Train coming From (TCF):**
Green/red LEDs are arranged to make a shape of arrowhead one pointing towards ‘station to’ and another towards ‘station from’.

The steady green lights of the *arrow pointing towards 'station from'* indicate ‘train coming from’ status. The lights flash when the line clear is withdrawn before entry of the train into the block section or the section has been cleared after arrival of the train but signals at the back of the train have not been put back to On. This indication changes to red when the train enters into the block section, to indicate train on line condition.  

*Train Going To (TGT):* The steady green lights of the *arrowhead pointing towards 'station to'* indicates ‘train going to’ status. The lights flash when the line clear is withdrawn before entry of the train into the block section or the section has been cleared after reaching of the train but signals at the back of the train have not been put back to On. This indication changes to red when the train enters into the block section to indicate train on line condition.  

*Last stop signal:* Profile of the signal is depicted on the panel face. Green light on the signal profile indicates signal Off and red light as signal On status.  

*Line free:* indication has two circular indications above Train entry acknowledge button. The green light indicates block section is free of trains and red light indicates its occupied or blocked back status.  

*SNKE (local):* Yellow illuminated light in circular shape indicates last stop signal, first stop signal and control over the signal has been put to normal.  

*SNKE (Other end):* Yellow circular illuminated light indicates that the last stop signal, first stop signal and their controls have been put to normal and TCF indication is not available at the station on the other end of the block section.  

*SNK-IN/OUT:* The indication is for status of the shunting key. When illuminated green it indicates shunting key is in, it turns red when shunting key is taken out.  

*Acknowledgement of train in and out:* The indication is associated with the buzzers. It is illuminated along with ringing of the buzzer when the train enters into block section and when train clears the block section at the next station. The indication is extinguished with the pressing of acknowledgement button.  

*Cooperation timer:* timer starts flashing with the start of resetting process for 120 seconds.

iv) **Counters:** Counters are provided for keeping the record such as if the axle counters are reset it must be recorded for the purpose of monitoring axle counter health as well as, to analyse operational irregularities if any. Counters are for:

*Cancel:* Line clear cancellation or train having been pulled back to the station wherefrom it started.

*Reset:* Each axle counter resetting is counted.

v) **Buzzers:** Buzzers are audible aid to draw attention of the operator for happening of certain activity where the Station Master is supposed to take any action such as train entering block section and train out of section. The buzzer stops ringing with pressing of acknowledgement button.

vi) **Sequence of operation for despatch of the train from one station to the other on single line section:** (Block Working Manual 2008 North Central Railway, paragraph
number 7.39, to suit the requirements specific to single line section). When a train has to be despatched from one station say station ‘X’ to station ‘Y’, the Station Master shall request the station ‘Y’ for grant of line clear. The Station Master ‘Y’ shall ensure line between the two block stations to be clear, through illuminated local SNKE indication and grant line clear telephonically. On receipt of the acceptance, the Station Master ‘X’ shall press bell & TGT buttons simultaneously which shall cause in i) disappearance of line closed indication, ii) appearance of Train Going To indications at his panel, iii) Disappearance of line closed indication and iv) appearance of Train Coming from indication on the panel of station ‘Y’. Station Master at station ‘X’ shall take his departure signals Off. Train shall leave the station.

As the train shall pass the last stop signal entering into the block section the i) line free indication turns red, ii) Train Going to indication turns red and iii) buzzer starts ringing at the station ‘X’ while iv) train Coming from indication turns red, v) line clear indication turns red and buzzer starts ringing at station ‘Y’. Both stations acknowledge buzzers by pressing Ackn. button.

As the train passes the first stop signal and clears the overlap at station ‘Y’ i) Train Coming From indication turns flashing green, ii) buzzer starts ringing and the Station Master presses the Ackn. button at station ‘Y’ while at the same time at station ‘X’ iii) Line clear indication turns green, iv) Train Going to indication turns flashing green, v) buzzer starts ringing and vi) The Station Master acknowledges by pressing Ack. button.

As the Station Master of station ‘Y’ replaces all controls of reception to normal i) SNKE (local) indication appears, ii) Train Coming From indication disappears and iii) line closed indication appears at station ‘Y’ while at the same time at station ‘X’ iv) Line Free indication turns green, v) Train Going To indication turns flashing green, vi) Buzzer starts ringing and vii) the Station Master acknowledges by pressing Ackw. button, consequently viii) Train Going To flashing green indication disappears and ix) Line closed indication appears.

II) **Block working by panel on double line section:** The section being double line, two sets of axle counters are used one for each line. The evaluator for each line shall be kept at the station on the receiving end accordingly an electronic junction box shall be used for transducers near Home signal of receiving station while a 4/2 wire converter shall be used near Advanced starter signal at the despatch end station. 1 ½ quads out of Jelly filled six quad 0.9mm diameter copper conductor cable is used for the system.

An Schematic layout showing arrangement of axle counters, combiner converters and distribution of cable cores for single line block working with axle counters is placed as figure 3.6.(B)(II). SM’s panel for operation on double line section is designed different from the SM’s panel for single line section [Figure 3.6.B(II)(i)]. Similar panel is used at the station on the other end of the block section. Function of keys, buttons, indicators, counters and buzzers provided on and associated with the single line section SM’s panel are:
Figure 3.6.(B)(II). Schematic layout showing arrangement of axle counters, combiner converters and distribution of cable cores for double line block working with axle counters

i) **Keys and their functions:**

- **Station (SM’s) Master’s control key:** The two position key when out of the panel only i) transmission of bell communication and ii) train entering/clearing/axle counter failure/ restored buzzer acknowledgements by Train Going To acknowledge or Train Coming From acknowledge shall be possible.

- **Axle counter resetting key:** The key is required to be turned and pressed for resetting of the axle counter with the cooperation by adjoining Station Master, by pressing axle counter Cooperation button on his panel. The key works as safety device as well as button for resetting. When the key is extracted out of the panel it shall not be possible to reset the axle counters.

- **Line Clear Blocking (LCB) key:** When taken out by the Station Master at the receiving end i) the facility to obtaining line clear by the despatching station stands withdrawn and ii) by pressing of the Bell button also while the LCB key is taken out, shall cancel the already granted line clear to the despatching station.
Buttons and their functions: Push buttons on the panel are non-locking type.

Bell push button: used for transmitting bell codes to the adjoining station when pressed. This button is also pressed along with Train Going To button to obtain line clear.

Train Going To (TGT) button: used by despatching station for setting Train Going To status at the sending station and Train Coming From status at the station to receive the train, when pressed with bell push button. TGT indication appears as Illuminated green strip on the sending station panel.

Cancel button: Used by the Station Master of the receiving station along with taking out the LCB key, for cancellation of the line clear till the train has not left the despatching station or the train is required to be pulled back to the despatching station.

Acknowledge button: It is used to acknowledge the train on line and train out of section conditions, by pressing this button the buzzer for the corresponding condition is also silenced.

Axle counter resetting cooperation button: The button is required to be pressed to cooperate by the station adjoining to who is resetting by turning and pressing the resetting key.

Catch/slip siding key: provided on the panel when there is a catch or slip siding to perform catch/slip operations.

Indicators and their meaning:

Line closed: Indication appears as an illuminated white strip on the panel when there is no train in the block section.

Train coming From (TCF): Indication appears as illuminated green strip light on the panel at receiving station when TGT push button is pressed with Bell push button on the panel at despatching station and the conditions for granting line clear are fulfilled. A small circular green light provided by the side of TCF as Line Free indication is illuminated when the block section is clear and a red light to indicate when the block section occupied or block forwarded/block backed.

Train Going To (TGT): Indication appears as illuminated green strip light on the panel at dispatching station when TGT push button is pressed with Bell push button provided conditions for granting line clear are fulfilled. A small circular green light provided by the side of TGT as Line free indication is illuminated when the block section is clear and a red light to indicate when the block section occupied or block forwarded/block backed.

Figure 3.6.B(II)(ii).
Station Master’s operating panel for double line block working with axle counters

### Table: Station Master’s operating panel for double line block working with axle counters

**AXLE COUNTER BLOCK SYSTEM**

<table>
<thead>
<tr>
<th>Double Line</th>
<th>Name of Station</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

**Indicators**

- **LINE OCC/BLK FOR./BLK BACK**
  - LINE OCC/BLK FOR./BLK BACK
- **TRAIN COMMING FROM**
  - Line Free
- **TRAIN GOING TO**
  - TOL
  - LC
  - TCF
- **LINE OCC/BLK FOR./BLK BACK**
  - Line Free

**Keys**

- **SMS**
  - LCB Key
- **RECO-OP.**
- **TOL**
- **LC**
- **TGF**
- **ACK.**
- **TCF**
- **BELL**

**Indicates**

- **RES**
- **RES CO-OP.**
- **TOL**, **LC**, **TCF**
- **TGF**
- **ACK.**

**Line Free**

- A small circular green light provided by the side of TCF as Line Free indication is illuminated when the block section is clear.

**Block Forwarded/Block Backed**

- A red light to indicate when the block section is occupied or block forwarded/block backed.
Train On Line (TOL): Indication appears on the SM’s panel at dispatching as well as receiving stations as illuminated red strip light on the panel when the block section is occupied by a train under line clear.

Last stop signal: Profile of the signal is depicted on the panel face. Green light on the signal profile indicates signal Off and red light as signal On status.

Reset cooperation indication: An illuminated circular yellow indication by the side of the resetting key indicates that cooperation has been extended by the adjoining station for resetting of axle counter.

Acknowledgement of train in and out: The indication is associated with the buzzers. It is illuminated along with ringing of the buzzer when the train enters into block section and when train clears the block section at the next station.

iv) Counters: Counter is provided for keeping the record of axle counters resetting for the purpose of monitoring axle counter health as well as, to analyse operational irregularities if any.

v) Buzzers: Buzzers are audible aid to draw attention of the operator for happening of certain activity where the Station Master is supposed to take any action such as train entering block section and train out of section. The buzzer stops ringing with the pressing of acknowledgement button.

vi) Resetting of axle counter: As and when the block section continues to show occupied even after arrival of the train at the receiving station, the Station Master after making himself sure about arrival of the complete train at his station shall advise the despatching station so and request him for cooperation in resetting the axle counters. The Station Master of the adjoining station shall press cooperation button on his panel which shall be indicated on the panel of the Station receiving the train. He shall insert key into the key hole rotate and press which shall operate the counter by one step. On release of the key the block section axle counter indication shall show Line Free indication on the panel.

vii) Sequence of operation for despatch of the train from one station to the other on double line section: (Block working manual 2008 clause 7.19)

Obtaining line clear by station ‘X’: Station Master of station ‘X’ shall press call attention push button to which adjoining station, Station Master of station ‘Y’ shall acknowledge and shall telephonically grant line clear on which the Station Master of station ‘X’ shall achieve Line Clear by pressing TGT push button along with bell push button simultaneously and keeping them pressed. Block panel at station ‘X’ shall display TGT green indication simultaneously disappearing of white Line Closed indication on which he shall release the push button. At station ‘Y’ green TCF indication simultaneously disappear along white Line closed indication shall disappear.

Despatch of train: Station ‘X’ takes the Last Stop Signal (LSS) Off, the train proceeds and occupies track circuit ahead of last stop signal raising the signal back to On. TOL red indication appears on the panel of station ‘X’ and ‘Y’, buzzer starts ringing, Line occupied red indication also appears and Line Free indication disappears on the panels of both the stations. TGT green indication at station ‘X’ and TCF green indication on panels at station ‘Y’ disappears. LSS profile on panel of station ‘X’ shows red. SMs at station ‘X’ & ‘Y’ presses TGT & TCF Ack. Buttons respectively to stop ringing of buzzer.

Arrival of train at station ‘Y’ having cleared block overlap: As the train clears block overlap arriving inside station section, the TCF buzzer starts ringing at station ‘Y’ panel, which is stopped by pressing the TCF ACK. button by SM of station ‘Y’.

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Closing of block section: The block section is closed automatically after the clearance of block section by the train. With this, line closed and train On line indications disappear at both the panels. The Station Master sends train out of section code signals to Station Master of station ‘X’.

Digital axle counters instead of analogue for block working: With the advent of digital axle counters the block proving is being done by single section digital axle counters.

Block working with block panel may also be done using single section digital axle counters along with Tx & Rx Muxes and combiner converters in place of analogue axle counters.

Since the trolley suppression track circuit is no more required with digital axle counters, multi section digital axle counters are also being used for block working including replacement track circuit beyond last stop signal and overlap as well as replacement track circuit beyond first reception signal at the receiving end thereby axle counters replacing DC, AC or any other track circuit.

Provision Intermediate block signalling has become of great convenience by using multi-section digital axle counters in place of i) Advanced starter signal replacement track circuit, ii) providing axle counters in one stretch between Advanced starter signal and the IBS, iii) providing Axle counter in place of IBS replacement track circuit, iv) Block proving by axle counters between IBS and first stop signal at the receiving end and v) axle counter in place of overlap track circuit beyond first stop signal at the receiving end.

3.7 Splitting of the block section for increasing section capacity: Larger block sections under Absolute Block system of working cause delay due to larger time taken by trains in clearing the block section thereby impairing section capacity. Methods employed for improving the situation is, splitting the block section by introducing i) Block Hut in between the two adjoining block stations on single or double line sections, ii) Intermediate Block Post and iii) Automatic Block Signalling.

a) Block Hut: Block Hut created by splitting the original block section is a ‘C’ class station equipped with full compliments of signals and block working with adjoining block stations using any standard form or block instruments of block working. Usually no train is made to stop at such Block Huts because it is meant only for operational purpose. The purpose of creating the Block Hut is defeated if the original block section is not large enough so much so that the time taken in operation of block instrument is more than the travelling time of the train in splinted parts of the original block section. Full compliment of operational staff is to be posted at such block huts to operate the block instruments thereby causing recurring financial burden to the railway exchequer [Indian Government Railway rules 2006, clause 1.03(2)].

b) Intermediate Block Post: Intermediate Block Signalling (IBS) is an arrangement of signalling on double line section on which a long block section is split into two portions each constituting a separate block section by providing an Intermediate Block Post [Indian Government Railway rules 2006, clause 1.02(30) & 1.02(31)]. Accordingly Intermediate Block post is a ‘C’ class station where Intermediate Block Stop Signal (IBSS) is provided preceded by a
Distant signal or set of Inner Distant & Distant signals, depending upon sectional speed. Block Hut can be commissioned on a single as well as a double line section. However an Intermediate Block Post can be installed on up and down lines independently on a double line section only.

Longer block section is splinted into two, almost midway of the total block section. The portion between the station despatching train and the IBSS is required to be track circuited contiguously, between last stop signal of the station and the overlap beyond IBS, with single or more track circuits. The part of the section beyond last stop signal of the station and the IBS including overlap beyond is controlled by the despatching station. The block section between IBS and the first stop signal including the overlap beyond first stop signal of the receiving station may or may not be provided with the track circuits.

Accordingly, the section beginning from the Advanced starter signal up to IBSS is controlled by track circuits while the section between IBSS and the first stop signal of the station in advance is controlled by Block Instrument which is provided at the sending and receiving stations. In effect the Block section controlled by the block instrument is reduced to almost half, starting from the IBSS.

The arrangement in addition to increase in section capacity, has advantage over the Block Huts i) no man power is required to manage the IBS in addition to what is already deployed at the both end stations adjoining the block section, ii) no additional time is required for operation of block instruments as the block instruments working between end stations continue as per original arrangement and iii) the train, if comes to an stop at the IBSS because of non clearance of the section beyond IBSS by the train ahead, shall pass the IBS after observing the given procedure.

**Minimum requirements of Intermediate Block Signalling (IBS) are:**

i) Provision of stop signal (IBSS) preceded by a Warner or Distant signal.

ii) Section between last stop signal of the despatching station and the IBSS be provided with contiguous track circuits.

iii) A track circuit equal to the length of overlap beyond IBSS be provided this track circuit shall also be used for replacement of IBSS by passage of train over it.

iv) A means to replace the last stop signal with the passage of train and also to ensure that the last stop signal can not be taken off unless the entire section between last stop signal and the IBS including overlap thereof is clear.

v) A means to ensure that the IBSS can not be taken Off unless the line clear has been granted by the station in advance.

vi) A means to ensure that the IBSS once put back to On due to passage of train is maintained in On position until the train has cleared the block section, the block instrument has been turned to line closed and fresh line clear is granted.

vii) A means to ensure that the block instrument line polarity is reversed by crossing of the IBS by the train thereby turning block instrument needle to Train On line position automatically.

viii) An indication to the Station Master of the despatching station to show the status of track vacancy.
ix) Telephone provided at the IB Post, near the IBSS, connected directly with the despatching end Station Master.

x) The Intermediate Block Signal post shall be provided with mark ‘IB’ painted in black on white circular plate.

c) **System of Intermediate Block Signalling working (IBS):** First portion of the track between last stop signal of the despatching station and the IBSS is provided with contiguous track circuits. Overlap beyond the IBSS is also track circuited. Second part of the section which is controlled by the block instrument may or may not be provided with track circuits for the purpose of proving block clearance. Track section vacancy clearance device may be a track circuit superimposed on the rails or axle counters. In such a situation multi-section digital axle counters are used.

If stations ‘X’ and ‘Y’ are situated at both the ends of the block section under Absolute Block system of working and the train ‘A’ is to be despatched by station ‘X’ to station ‘Y’ through the IBSS, the Station Master of station ‘X’ shall seek line clear from station ‘Y’ on the block instrument. The IBS Signal numbered 2 shall be taken Off through line clear contact of the BCR followed by the Distant signal which shall assume green indication with the IBSS assuming green. The up Advanced starter signal shall be taken Off provided the track circuits 8T, 4T & 6T between up Advanced starter signal and the overlap track circuit ahead of IBSS 2 are clear. It is pertinent to note that the Advanced starter signal is controlled purely by the track circuits and grant of line clear has no implications on its taking Off [Figure 3.7c].

![Figure 3.7c Layout IBS](image)

The trains shall be allowed to move on. After the clearance of overlap track beyond up Home signal line can be closed as described in preceding paragraphs of block working by SGE double line block instrument.

In case a train ‘B’ is to follow the train ‘A’, the up Advanced starter signal number 8 may be taken Off if the previous train ‘A’ has cleared track circuits between signal number 8 and the IBSS2 including overlap track circuit 2T.
If the train ‘A’ happens to be in Block section-2 by the time the train ‘B’ occupies Block Section-1 and finds IBSS indication red it shall stop short of the IBSS and contact the Station Master on telephone provided on the signal post (the telephone is connected to Station Master of despatching station i.e. station ‘X’). The Station Master shall authorise the loco pilot on the phone under exchange of private number or any other procedure laid down for the same to proceed, if the Intermediate Block Stop Signal is defective. If the IBSS is not defective the train ‘B’ shall move into the block section after clearance of IBSS on proper line clear.

It may be observed that two trains can be inserted into by splinting the larger block section.

In case the failure of IBSS happens before the train is despatched from the station ‘X’, both the Block sections starting from up Advanced starter signal number 8 up to IBSS2 and from IBSS2 to up Home signal 18 including overlap thereon, shall be treated as one block section and Loco pilot shall not have to stop at the IBS displaying red indication.

In case the telephone provided at the IB post is defective or there is no telephone, the Loco pilot shall proceed to pass the IBS signal at On after waiting for 5 minutes observing an speed of 15 KMPH cautiously and be prepared to stop his train short of any obstruction. [Indian Government Railways General Rules book 2006 Clause 3.75 (1), (2), (3) & (4)].

In case the complete section between stations ‘X’ and station ‘Y’ is provided with track circuits or Axle counters to prove block clearance, the track circuit arrangement for Block section ‘1’ shall be same as shown in figure 3.7c, while the block section-2 shall be provided with track circuits between track circuit 2T and up Home signal number 18 and overlap thereon with track circuit number 18T. Similar arrangement has been shown on down line for the same section.

4. **Automatic Block signalling system:** Out of two systems of working on Indian railways Automatic Block System is the other system of working besides Absolute Block System of working permitted to be used on Indian Railway in normal course. Detailed features have been covered in Indian Railway Signal Engineering Volume-I.

With the track capacity on parts of golden quadrilateral route saturated to 120%, providing automatic Block signalling is the best interim solution as usually more than two trains can be pushed into an Automatic Block section at any stage of time against only one under Absolute Block system of working, without loss of speed.

As may be seen in the figure a three aspect signalling system or four aspect signalling system may be used for Automatic Block system with minimum inter-signal spacing of 1000m. The system can be provided on single as well as on double line section.

4.1 **Automatic Block Signalling on double line section:** The basic difference in system of signalling system accrues because of the section being double line or single line. On the double line section the direction of traffic is defined as ‘Up’ and ‘Down’ which dictates the train movement in the given direction only.
A) **Essentials of Automatic Block System on double line**: Essentials of Automatic Block System where trains are worked on Automatic Block System on a double line section [Indian Government Railway General Rules clause 9.01]:

i) The line shall be provided with continuous track circuiting or axle counters;

ii) The line between two adjacent Block Stations may, when required, be divided into a series of Automatic Block Signalling sections each of which is the portion of the running line between two consecutive stop signals, and the entry into each of which is governed by a stop signal, and

iii) The track circuits or axle counters shall so control the stop signal governing the entry into an automatic Block Signalling section that:

a) The signal shall not assume an ‘Off’ aspect unless the line is clear not only up to the next stop signal in advance but also for an adequate distance beyond it, which unless otherwise directed by approved special instructions, shall be not less than 120 metres, and;

b) The signal is automatically placed to ‘On’ as soon as it is passed by the train.

Accordingly signalling arrangement for Automatic Block Signalling on a double line section for three aspect signalling scheme has been shown on down line and the four aspect signalling scheme has been shown on up line section for the sake of example in the plan. The arrangement for four aspect and three aspect signalling scheme has been shown for the purpose of discussion only while two dissimilar arrangements shall not be installed on the same section at site.

B) **Three aspect signalling scheme for Automatic Block System on double line section**: As in figure 4.1.B, three aspect signalling has been provided on down line. The aspect sequence starting from home signal shall be, when home is red, automatic signal 510 shall display yellow indication and Automatic signal 508 shall display green, preceded by Automatic signal 506 which shall also display green. As home signal assumes yellow indication, the Auto signal 510 shall display yellow if starter ahead is red and the train is being received on main line, and next signal in rear, 508 shall display green preceded by signal number 506 & 504 which also shall display green indications. However the level crossing gate numbered as 415 is protect by gate signal numbered 502. The Gate signal is placed at a minimum distance of 180 meters from the gate, but in this example, this limits the distance between signal number 504 and 502 to 900 metres only.

In consideration of the fact that the inter-signal distance between two signals to display less restrictive aspect than the signal to which it is repeating, shall be not less than 1000m, the gate signal shall repeat the same aspect as that of signal number 504 when the gate signal is taken Off, after having the gate being closed and locked against road traffic. It is pertinent to note here that while an automatic Block signal displays Off aspect when there is no train ahead up to the desired distance a Gate stop signal shall display red indication under normal circumstances when open to road traffic. Signals preceding the gate signal shall assume less restrictive aspect than the signal in advance, following regular aspect sequence.

Level crossing gates in Automatic signalling scheme are governed by rules different than for gates in station section, station limits and absolute block section. Refer Indian Railway signal engineering Volume-I for details.
C) **Four aspect signalling scheme for Automatic Block System on double line section:**

Four aspect signalling scheme has been provided on up line in the same figure 4.1.B. In this case indication displayed by automatic signal number 501 preceding up Home signal number shall display yellow when the home signal 3 shall show red, preceded by signal number 503 which shall show double yellow. Signal number 505 is gate signal placed at 180 meters preceding gate number 415 shall display red when the gate is open to road traffic. Signal number 507 shall again display yellow and 509 shall display double yellow indications. Signal number 19 is the last stop signal of the station ‘Y’ ad shall be controlled by the station being semi automatic signal. When ‘A’ marker of signal number 19 is illuminated proving all the conditions for taking last stop signal Off, signal 19 shall also display green indication having been placed at a distance of 1000m from the signal 509.

D) **Three aspect versus four aspect signalling scheme:** In three aspect signalling scheme a red signal is preceded by a yellow signal followed by a green signal. The Loco pilot when finds a green indication in three aspect signalling section knows that he has at least two kilometres to control and stop the train at the next Automatic signal which is red. In four aspect system of signalling a red indication of the automatic signal is repeated by yellow indication followed by double yellow and further followed by green. In this case the Loco Pilot finds green indication at a distance of three kilometres from the Automatic Block signal with red indication. The Loco Pilot in this case finds double yellow at a distance of two kilometres from the Automatic Block signal with red indication. It may be appreciated that while Loco Pilot is better warned in case of four aspect signalling system he is tempted to reduce speed finding double yellow as compared to green as in case of three aspect signalling system. It can therefore be seen that in case of four aspect signalling system lesser number of trains can be pushed into the entire section between two stations because of poor speed as compared to three aspect signalling system where more number of trains can be pushed in the same section with faster speed. It may be further seen that by achieving faster speed in case of three aspect signalling system the section capacity apparently is enhanced at the cost of margin for controlling the train by the Loco pilot while in case of four aspect system of signalling Loco pilot may feel relaxed. While by and large four aspect signalling system is used, the system of signalling is chosen based upon better factor of safety. Another criterion for choosing between three aspect and four aspect signalling schemes is optimising balance between section capacity and train speed.

E) **Circuit for working automatic signals on double line section:** A relay hut or location large enough to accommodate power supply and controlling relays is provided near each automatic signal. If signals for up and down lines happen to fall in near vicinity of each other, size of the hut shall be increased suitably to accommodate both.

If the section where automatic signalling is being installed in the area electrified with 25 KV AC traction the distance between controlling relay and the signal has to be restricted because of unscreened signalling cable being used and depending upon source of illumination being incandescent lamp or LED. Although it is not a constraint but usually automatic signalling is provided in sections electrified with AC traction where the traffic density is already high.
Figure 4.1.B

Three & four aspect Automatic Block System signalling scheme
A power cable of suitable capacity (depending upon length of the section) is run through all such relay huts to cater for power to i) illuminate signal lamps /LEDs, ii) track circuit batteries and iii) energise relays. (Refer to the chapter of this book on power supply).

Circuit is taken for study with four aspect signalling system (Figure 4.1.E). Automatic signal number 501 is placed next behind up Home signal number 3 of station ‘X’. This is the last automatic signal in the section between stations ‘X’ & ‘Y’ as such its aspects are controlled by the signal 3 which is semiautomatic signal provided with an ‘A’ marker illuminating when the signal is switched to be semiautomatic state.

Each signal has one HR which is controlled by track circuits not only up to the next signal ahead but also the overlap beyond next signal.

Signal 501 has four aspects. 501 HR is energised at the ‘location signal 501’, through 3HR or 3RECR (connected parallel to each other) along with proving track number 3T overlap track of signal 3 ahead, followed by picked up contacts of all the contiguous track circuits in between the two signals viz. C3T, 501AT, and 501T, thereby proving interlocking requirements. 3HR in turn controls yellow indication of the signal. Other aspects of the signal number 501 are controlled directly by the indications displayed by the signal number 3 but through HR energised. Till the HR is not energised, the signal 501 shall display red indication.
Aspect control of signal 501 shall be 501 to display yellow when signal 3 is red, double yellow when signal 3 is yellow and green when signal 3 displays double yellow last two situations when the route is set for mainline. In case the route is set for loop line signal number 3 shall display indication yellow with route.

In case signal 3 displays yellow indication with route set for main line, power is extended through pick contact of 3HR, pick up contacts of 3HECR & back contact of 3HHECR to energise 501HHR when signal number 3 is showing yellow. As 3HHECR is energised power is extended to 501DR through pickup contacts of 3HECR and 3HHECR when signal number 3 is showing double yellow. When signal number 3 is showing green indication 501DR shall be energised through 3HR and 3 DECR pick up contacts.

Relay DR is made slow to release to avoid bobbing of the signal indication when the aspect of the signal in advance i.e. signal number 3 is changed from double yellow to green, 3HECR and 3HHECR shall be dropped and 3DECR shall be energised thereby bobbing 501 DR momentarily, which is sustained by 501 DR being slow to release.

This sequence of signal control continues through signals following signal number 501.

All track circuits in series in the block section are repeated cumulatively through one relay energising in the end stations, for the purpose of i) Indication of the status of the block section, ii) approach locking of the home signal and iii) approach warning & approach locking of the level crossing gates in the automatic block section or station section.

4.2 Signalling scheme for Automatic Block System on single line section:

A) Essentials of Automatic Block System on single line: Essentials required to be observed for train working in single line automatic block section are provided as under Indian Government Railways General Rules clause 9.03 as follows:

i) The line shall be provided with continuous track circuiting or axle counters,

ii) The direction of traffic shall be established only after Line Clear has been obtained from the block station in advance.

iii) A train shall be started from one Block Station to another only after the direction of traffic has been established.

iv) It shall not be possible to obtain line clear unless the line is clear at the Block Station from which Line Clear is obtained, not only up to the first Stop Signal but also for an adequate distance beyond it, which unless otherwise directed by approved instructions, shall be not less than 180 metres.

iii) The line between two adjacent Block Stations may, where required, be divided into two or more of Automatic Block Signalling sections by provision of Stop signals.

iv) After the direction of traffic has been established movement of train into, through and out of each Automatic Block Signalling section shall be controlled by the concerned Automatic Stop signal and the said Automatic Stop signal shall not assume ’Off’ position unless the line is clear up to the next Automatic Stop signal, provided further that where the next Stop Signal is a manual Stop signal, the line shall be clear for an adequate
distance beyond it, which unless otherwise directed by approved instructions, shall be not
less than 180 metres and;

vii) All stop signals against the established direction of traffic shall be at ‘On’.

It is pertinent to note that unlike Automatic Block System on double line, where an overlap of
120m is required beyond next Automatic block signal, to be kept clear for assumption of Off
aspect by previous Automatic Block signal, in single line section only the section between
Automatic Block signal and the next Automatic Block signal is required to be clear for previous
signal to assume Off aspect (except in case of next signal being manual stop signal were an over
lap shall also be taken). However certain railways are providing 120 meters extra ahead of next
stop signal, as an abundant precaution as the case is with North Central railway.

B) Circuit for working automatic signals on single line section: A relay hut or location
large enough to accommodate the power supply and the controlling relays is provided near each
automatic signal. Normally the automatic block signals for up and down direction fall in near
vicinity to each other accordingly the size of the hut is designed suitably to accommodate relays
and power supply for both signals. If the section where automatic signalling is being installed in
the area electrified with 25 KV AC traction, the distance between controlling relay and the signal
has to be restricted because of unscreened signalling cable being used and depending upon source
of illumination being incandescent lamp or LED.

a) A power cable of suitable capacity is run through all such relay huts, as discussed in
preceding paragraph for double line section.

b) In case of automatic signalling in single line section major deviations with double line
section are i) the direction of traffic has to be established before allowing entry into the automatic
block section in case of single line section as against double line section where the direction of
traffic is predefined, ii) line clear is required to be granted by station receiving the train which is
not applicable in double line section iii) Direction shall be established only after grant of line
clear which is not required in double line section.

Circuit for four aspect single line automatic signalling system: SIP placed at figure 4.2B is taken
for study of the circuits of which Circuit for control of down automatic signal number 508 is
taken for example:

The signal is placed between automatic signals 506 and 510 in the section between station ‘X’
and station ‘Y’ on down direction. In order to comply the requirement that, i) for a train to start
from one station to another, direction of traffic shall be established first and ii) the direction of
traffic shall be established only after receipt of line clear from the station in advance and the iii)
line clear shall be granted only after entire section is clear of trains including block overlap ahead
of first stop signal at the receiving station.

Condition number iii) i.e. ensuring section clear, has to be complied first which is done, for down
direction movement, by proving all track circuits clear energising a relay DN TKR. The relay is
energised selected through 48bTR pickup contact with point number 48 normal and if point
number 48 is reversed, proving track circuit number 48aTPR In addition to 48bTPR along with
proving all track circuits clear including overlap beyond down home signal 18 of station 'Y' with track circuit numbers: 10TR, 2TPR, 3TPR, 505ATR, 506ATR, 508ATR, 510ATR and 18TPR.

Figure 4.2 B
Automatic Block Signalling scheme on single line section
Figure 4.2B(a)  Up & down TKR circuits
Similarly for up direction UPTKR is energised proving track circuits energised starting from up starter signals up to up home signal and overlap thereupon [Figure 4.2 B(a)].

18TSR is energised at station ‘Y’ proving pickup contacts of 18TPR, 18RECR and 18UYR2 and is kept held picked up by its own contact bypassing 18RECR and 18UYR2, when the signal 18 is taken Off and 18UYR2 is also not energised, to prove that down home signal 18 of station ‘Y’ had been replaced to On after passage of the last train.

As the rain occupies 18TPR the 18TSR shall get de-energised and shall pickup again only when 18TPR has been cleared, 18 RECR picked up i.e. the signal was replaced to On, and 18UYR2 is energised with the occupation of first track 19T after clearance of the overlap track 18T by the train to prove that he train traversed the route and allow the 18TSR to be picked up as soon as the 18TPR gets free.

To fulfil second condition i.e. granting of line clear, line clear is granted by station ‘Y’ by pressing line clear button LCPBN on his panel along with group Signal button GBN. ‘X’ LCR is energised through 18TSR and DN TKR picked up contacts along with picked up contact of relay GBNR and Line Clear granting Press Button Relay LCPBNR. The ‘X’ LCR once energised is kept held through its own contact and back contact of GBRNR. As and when the line clear is to be cancelled, button GBRN is pressed together with line clear granting button, energising GBRNR and ‘X’LCPBR which breaks path of ‘X’LCR and causes it to de-energise. The ‘X’ LCR relay is repeated at station ‘X’ as BCR [Figure 4.2B (b)(i)]. With the energisation of DN BCR at station ‘X’, indication of receipt of line clear is displayed on the panel of the Station Master.

Similar shall be arrangement for up direction movement of the train.

c) Establishing the direction: Two systems are prevalent for establishing direction, i) the direction can be set by either of the stations out of the two placed at the either end of the automatic block section or ii) the direction can be set by any one of the designated station only.

Here second system adopted by Southern Railway, under which only one of the two stations is nominated to establish direction is taken for study. Station ‘X’ is taken as direction establishing station [Figure 4.2B (b)(ii)].

A rotary, direction setting two position switch DS is provided at the station ‘X’ which when turned to left ‘L’ sets ‘up’ direction and when turned to right ‘R’ shall set ‘down’ direction if the conditions are satisfied. An all normal relay FLR is energised at the station ‘X’ proving Station Master’s ‘Key In’ relay SMR pickup contact proving intent of the Station Master for the action, DN TKPR pick up contact to prove that down direction line is clear for granting line clear, UP TKR pickup contact to prove that up line is clear for granting line clear, 2 MLR back contact and 3ASR pickup contact to prove that down Advanced starter signal and up home signals have not been initiated to be taken Off along with DN SNR to prove all normal at the station ‘Y’ also. DN SNR is energised at station ‘X’ through back contact of 19HLR to prove that up Advanced starter signal has not been initiated to be taken Off and pickup contact of 18ASR to prove that down
Home signal has also not been initiated for being taken Off at station ‘Y’. This DN SNR is proved energised in FLR circuit [Figure 4.2B(b)(ii)].

Observing receipt of line clear indication the Station Master of station ‘X’ shall turn his direction setting switch to ‘R’ position in cooperation with Station Master of station ‘Y’. Station Master at station ‘Y’ shall press his cooperation button while the switch DS is being turned to ‘R’ position by Station Master of station ‘X’ [Figure 4.2B(b)(i)].

FZR and FKR are ‘Q’ series latch relays one coil of which is energised through the back contact of the other relay. These latch relays are read as FZR(N) and FZR(R) in context of normal and reverse coils. However these have been changed to read as FZR(UP) and FZR(DN) for the sake of convenience for study the circuits. Similar is the case with FKRs.

With the turning of the DS to ‘R’ position the power is extended to FKR(UP) second coil through ‘R’ position contact of switch DS, FLR pickup contact, FKR(UP) pickup contact, YCOOPR pickup contact and again FLR pickup contact to negative limb thereby energising second coil of FKR(UP) de-latching FKR(UP). The power is also extended simultaneously through same ‘R’ position contact of switch DS to FZR(UP) second coil through FLR contact and then FZR(UP) pickup contact and FLR pick contact to negative limb [Figure 4.2B(b)(ii)].

A similar set of FKRs only is provided at station ‘Y’ (not shown here).
With the de-latching of FZR(UP) and FKR(UP) the system at station ‘Y’ is also set preparing for setting of direction for which a relay FRPR for setting down direction and FNPR for setting up direction is energised at station ‘Y’. The corresponding FKR's at station ‘Y’ are reset corresponding to energisation of FNPR or FRPR [Figure 4.2B(b)(iii)].
To set down direction FRPR is energised at station ‘Y’ power extending from station ‘X’ through back contact of FKR(UP), FZR(UP) and pickup contact of FZR(DN), short circuited by FZR(DN) as cross protection measure and at station ‘Y’ through back contact of FNPR.

For setting, up direction FNPR is energised at station ‘Y’ through back contact of 2MLR, 2HR, pickup contact of X HZR, the relay to prove any aspect of reception signal at station ‘X’ illuminated by energising the HZR through 10RECR or 10HECR or 10DECR, pickup contact of FKR(UP), back contacts of FKR(DN) & FZR(DN), pickup contact of FZR(UP), short circuited by through back contact of FZR(UP) as cross protection measure at station ‘X’ through back contact of XFRPR at station ‘Y’ [Figure 4.2B(b)(iii)].

As the FRZR is energised at station ‘X’, FKR(DN) is energised through ‘R’ position contact of switch DS, FZR(DN) pickup contact, FRZR pickup contact, DN TKPR pickup contact, BCR pickup contact through coil of the relay and pickup contact of FLR to negative limb.

It is pertinent to note that FKR which is the final direction setting relay is energised proving line clear obtained.

Similar is the circuit for up direction setting.
As the FKR(DN) is energised, DN ZR relay is energised through pickup contact of FZR(DN), pick contact of FKR(DN) and back contact and UP ZR (opposite direction ZR) [Figure 4.2 B (b)(ii)].

DN ZR relay is repeated in each automatic signal location hut along with UP ZR relays [figure 4.2B(c)].

Figure 4.2B(c) Direction setting relay and aspect sequence for signal 508

Down automatic signal number 508 Control circuit: [Figure 4.2B(c)] Contrary to double line section where under no train conditions signals display starting from the semiautomatic or manual signal’s red aspect followed by yellow, double yellow and green further repeated by green by all following signals in four aspect signalling territory, in up & down directions alike, in single line automatic bock signalling section the signals follow this sequence only in the established
direction while each signal in direction opposite to the direction established shall display red indication only.

508HR, signal’s basic aspect relay, is energised through pick up contact of overlap track 18TPR, signal 510 RECR or 510HR pickup contacts, both put in parallel proving that either the indication of the signal 510 is red or yellow, along with proving all track circuit relays in between the two signals and the overlap beyond signal 510, 510 TR, 508A TR and 508 TR pick up contacts. In addition the pick up contact of the down direction establishing relay DN ZR, back contact of opposite direction establishing relay UP ZR is also proved in the HR circuit. Opposite direction signal On aspect shall also be proved in the HR circuit through 507RECR pick up contact in the 508HR circuit [Figure 4.2B(c)].

It is pertinent to note here that any signal shall acquire any aspect other than On only when corresponding direction ZR is energised. If UP ZR is energised all signals in up direction shall be controlled by the track circuits ahead i.e. by movement of the train in the same direction as established while all signals in direction opposite to what is established shall remain at On.

508HHR to display double yellow indication is energised through 510 HR pick up contact, 510 HECR pick up contact and 510 HHECR back contact i.e. when signal 510 is displaying yellow indication. 508 DR is energised to display green indication, through 510 HR pickup contact, 510 HECR pickup contact and 510 HHCR pick up contact or through a parallel circuit directly through 510 DECR pickup contact. The DR relay is made slow to release so that it does not bob (drop and pickup), thereby giving shock to the Loco pilot, while the signal ahead is changing its indication from double yellow to green [Figure 4.2B(c)].

C)  **Semiautomatic signals:** Signals within station section are designed to be operated manually. However for the stations which fall into the automatic block sections on its end, the signals provided on the main line may be operated as automatic signal to facilitate through running of trains till it is required to control the train manually. Such manually operated signal, when made convertible to automatic operation, becomes ‘Semiautomatic signal’. Such signal is provided with an illuminated ‘A’ marker to indicate to the Loco pilot that the signal is functioning as automatic signal and when the ‘A’ marker is not lit the signal is considered as manually operated. The Loco pilot shall follow the rules for automatic signal when the ‘A’ marker provided on the signal is illuminated and he shall follow rules of manually operated signals when the ‘A’ marker is not lit.

In terms of the SEM Part-II, September 2001 paragraph 20.1.2.5 (a), the circuit for illuminated ‘A’ marker shall be such that the ‘A’ marker lights up only when the signal is working as an automatic signal, (b) The circuit for illuminated ‘AG’ marker, provided at level crossing gate in automatic signalling section, shall be such that the ‘AG’ marker lights up only when the conditions for ‘A’ marker to light up are satisfied except for the level crossing gate which may either be open to road traffic or may have failed, (c) in terms of paragraph 20.1.2.6 of the SEM Part-II, September 2001, the illumination of ‘A’ marker shall prove correct setting and locking of points as required and shall ensure back locking of the route. Level crossing gates, if any, on the route shall be proved closed to the road traffic when ‘A’ marker is illuminated.
For the purpose of study signalling plan placed at figure 4.2 B and ‘A’ marker controlling relay circuit at figure 4.2 C, may be referred to.

Down Advanced starter signal number S2 working as semiautomatic signal placed at the beginning of automatic block single line section is taken for study. The arrangement for S2 is different than for manual as well as for an automatic signal. Accordingly signal controlling relay 2MLR is energised through 2TSR pick up contact to ensure ‘one slot one train’ principle, 3ASR pickup contact to ensure that opposite direction Home signal has not been initiated to be taken Off, DN ZR pickup contact to ensure that line clear has been received and direction has been established before the signal is initiated to be taken Off, through pickup contacts of signal button.
relay 2GNR and route button M UNR which are pressed to take the signal Off along with pickup contact of signal replacement relay EGRNZR. 2 MLR is kept held through its own pickup contact, DN ZR, 2TSR and EGRNZR pickup contacts. As and when the signal is required to be put back to normal before departure of the train, EGRNZ and 2GNR buttons are pressed simultaneously de-energising EGRNZR and energising 2GNR thereby disconnecting both the negative limbs de-energising 2MLR. Advanced starter signal is required to detect the last trailing point in either position through 48 NWKR or RWKR only when it is locked in the route. When the point is required to be changed to despatch the train from a loop line WZR is energised is energised. Under conditions when the signal-2 is working as manual 2MLR is de-energised by de-energisation of 2TSR due to occupation the first track 2T just ahead of the signal necessitating taking the signal Off after passage of each train.

The Pick up contact of 2MLR is inserted in 2HR circuit so that the signal does not assume Off aspect automatically, of its own, controlled by the aspects of signal and track circuits ahead.

As and when the down advanced starter signal S2 is required to be converted to semiautomatic signal, an ‘A’ marker is required to be illuminated at the signal post. 2AMYR is energised through 2MLR pickup contact and AMYR and GBNR pickup contacts by pressing corresponding buttons. 2MLR is kept held picked up through its own and GBRNR back contacts. To revert the signal back to manual mode 2AMYR is de-energised by pressing 2AMY and GBRN buttons disconnecting the negative limb. This way illuminated ‘A’ marker holds interlocking characteristics same as that of 2MLR when illuminated, while at the same time gives choice to Station Master to switch on between manual and automatic modes.

As the train occupies the first track beyond down signal 2, the Advanced starter, de-energisation of 2TSR shall de-energise 2MLR necessitating taking the signal Off after passage of the train and re-energisation of 2TSR, making the signal manual as such 2TSR pickup contact in 2MLR circuit is bypassed by 2AMYR pickup contact. Till the 2TSR is bypassed by 2AMYR and down direction is established, the trains can continue running in down direction uninterrupted. 2AMYR can be put back by pressing 2AMYN and GBRN buttons disconnecting the negative limb thereby converting the signal to manual mode again.

‘A’ marker is illuminated at the concerned signal post through pickup contacts of 2AMYR.

*It is pertinent to note that the illumination of ‘A’ marker at the signal post allows the train to move ahead even when the signal displays On aspect due to train ahead.*

**Emergent change of direction:** As and when any track circuit in the section fails, direction setting shall not be possible due to non availability any of the TKR. Under such conditions Emergent setting of direction shall be resorted to after verification of clearance of trains in the block section through exchange of private numbers between existing sending end and receiving Station Masters. One press button with a counter is provided on the panel of the Station Masters on each end of the Automatic block signalling section, which is pressed simultaneously by both of them to bypass the track circuits in the block section and then set the direction.
‘A’ Marker on double line section: In case of double line section obtaining line clear from the station in advance, as well as establishing of direction shall not be required except the movement of trains shall be through telephone, as such AMYR shall be energised through pick up contact of MLR and TSR shall be bypassed by AMYR to convert the signal to Automatic mode, keeping remaining circuit almost the same as that for single line section.

5. Moving block: Out of different systems of train working under Indian Railways Absolute Block system and Automatic Block system have been authorised for regular use. Under Absolute Block system of working the space defined as block section between two block stations is fixed. Similar is the case with Automatic Block system where the section between two block stations is divided into number of automatic block sections each such section being controlled by an Automatic Block signal. Here again the distance between two automatic block signals is fixed varying between minimum 1000 metres to 1500 metres. It is pertinent to note here that the block is identified by signals wherefrom the block starts and where it ends.

The lengths of block sections are dependent on the populace of the area which decide inter-station distances. The stations may be situated at longer distance between each other in lightly dense population or closely situated in densely populated area. The inter satiation distances therefore may vary from many kilometres to few hundred meters.

A train is not permitted to enter a block section until signalled on double line section, single line section with token less working or on delivery of token on single line section provided with token working. In each case, a train cannot enter the block section until not only the block section itself is clear of trains, but also an overlap beyond first stop signal at the receiving station is also clear. In Automatic Block Signalling section where signals are closely spaced, this overlap could be as far as the signal following the one at the end of the section, effectively enforcing a space between trains of two blocks.

When calculating the size of the block sections, and therefore the space between the signals defining boundary of the block section, the following have to be taken into account:
   i) Section speed (the maximum permitted speed for each train in the given section),
   ii) Gradient (to compensate for longer or shorter braking distances),
   iii) The braking characteristics of trains on that line,
   iv) Sighting (how far ahead a driver can see a signal),
   v) Reaction time (of the Loco pilot).

Some tracks operate so that certain large or high speed trains are given overriding priority above some other trains for which two block sections in front of the train are kept clear such is the case with Rajdhani Express and erstwhile long haul goods trains. Under such circumstances one disadvantage of having fixed blocks is that faster trains are allowed to run side tracking comparatively slower trains as if the faster train has to stop, the longer the stopping distance, and therefore the longer the blocks need to be, thus decreasing the line's capacity.

Under a moving block system, computers calculate a 'safe zone' around each moving train into which no other train is allowed to enter. The system depends on knowledge of the precise
location and speed and direction of each train, which is determined by a combination of several sensors viz. active and passive markers along the track and train borne tachometers and speedometers as the GPS system cannot be used because they do not work in tunnels. With a moving block, line side signals are rendered superfluous, and instructions are passed directly to the cab of the loco of the trains. This has the advantage of increasing track capacity by allowing trains to run closer together while maintaining the required safety margins.

Moving block is in use on London's Docklands Light Railway, New York's Canarsie "L" Line. It forms part of the European Rail Traffic Management System's level-3 specification for future installation in the European Train Control System, which at level 3 specifications, is scheduled to feature moving blocks that allow trains to follow each other at exact braking distances allowing optimum utilization of available track length.

Moving block is not in vogue in India at present.

6. **Block interface**: Two block instruments on either end of the block section are interconnected through copper conductors of PET quad cable. This connectivity is through hard wire. Block working with axle counters through Block Panel use time division multiplexing technique using MUX and combiner converter, requiring communication between two ends of the block system for transmission of around 25 relays is managed through 1½ quads of PET quad cable. However when inter block instrument communication is required to be exchanged through Optical Fibre, Radio or Microwave, it can be done only after converting the data compatible to the medium of communication.

Although hardwire drawn copper conductor may be used as media of transmission, Universal Fail Safe Block Interface (UFSBI) shall essentially be required for use when media of transmission is OFC or radio.

Block instruments on either end of the block section have to communicate with each other to establish integrity of the block section. The information to be shared may be through relays or may be analogue. When the media of communication between the two block instruments is either OFC or radio, an interface is essentially required to be used at both the stations to transfer the block instrument status to the media of communication and also receive the information transferred from the other end block instrument. The working is as such full-duplex.

Since the communication through OFC is digitised, the Fail Safe Block Interface has to convert the information received from the block instrument to digital form. The Fail Safe Block Interface shall also be able to interface when the media of transmission is hard drawn copper conductor.

Universal Fail-Safe Block Interface is manufactured and procured under specification number-RDSO SPN 147-1997.

One of the system design to conform the specifications, contains i) Central Processing Unit having three processors with inter processing links, ii) Interface relay set, iii) Input-Output
module, iv) Resetting Box with a counter, v) Panel with audio alarms and visual Indications, vi) Full duplex Modem and vii) Power supply arrangement through DC-DC converters [Figure 6].

6.1 Central Processing Unit: The unit has three central processors which run concurrently with EPROM and RAM. In case a fault is detected in any of the processors it shall shut down while remaining two shall continue to function on two out of three, principle. It transmits data onto the communication channel at the rate of 2400 bauds.

As and when communication failure takes place the local UFSBI goes to safe Standby mode and restarts on receipt of at least three valid frames. However when the output of local UFSBI fails due to any reason, the system shuts down and can be restarted by after resetting.

6.2 Interface relay set: It is a set of ‘Q’ series relays for transferring output data out and receiving data in. The status of the relay energised locally is accordingly transferred to the Central Processing Unit for onwards transmission and the information received from the other end block instrument is transferred to the local block instrument.

The outgoing information is transferred to the central processing unit in the form of make and break contacts of these relays. Similarly the data received from the other end block instrument is used to energise the concerned relays, out of Interface Relay set, to be fed to the Local Block Instrument.

There is provision of 16 inputs in the block of 8 to read changeover relay contacts, one input reads one relay contact in the form of make or break contact. 16 output ports in the block of 8 are there for driving ‘Q’ series relays.

6.3 Input output Module: This electronic module transfers Incoming/ outgoing information specific to the type of block instrument.

6.4 Resetting Box with a counter: The resetting shall be done when the local system fails. Each resetting shall be counted on the counter.

6.5 Panel for Audio and video alarm: For diagnostic purposes the panel displays system fault in coded form with audio alarm to draw attention. The audio alarm may be shunned by pressing acknowledgement button while the video alarm shall continue to display.
6.6 **Full duplex Modem:** The data is transferred and received across the media of communication, through full duplex modem.

6.7 **Power supply:** System works on 24V DC fed through a DC-DC converter which provides all the supply requirements.

7. **Cab signalling:** is a system that communicates track status information to the loco cab of the train, where the Loco pilot can see the information. The simplest system displays the trackside fixed signal aspects viz. green, yellow or red, guiding the Loco pilot for safe running of his train, while more sophisticated system also displays allowable speed, location of nearby trains, and dynamic information about the track ahead. In modern systems, a speed enforcement system usually overlays on top of the cab signalling system to warn the loco pilot of conditions ahead, and to automatically apply the brakes and bring the train to a stop if the driver ignores the dangerous condition. The system ranges from simple coded track circuits to transponders that communicate with the cab, to communication-based train control systems.

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Chapter - IX  Self assessment

1. **Multiple answer question:**

1. There are six systems of train working out of which only:
   (a) Two are permitted for regular use*
   (b) Four are permitted for regular use.
   (c) Only Absolute Block system is allowed to be used.
   (d) Only Automatic Block system is allowed to be used.

2. Signal line Token-less Diado block instrument works on frequency:
   (a) 2000 CPS
   (b) 2500 CPS
   (c) 2000 CPS & 2500CPS*
   (d) None of the above.

3. 4/2 Wire converter used with analogue axle counter is placed at the station where:
   (a) Evaluator is placed
   (b) Where evaluator is not placed*
   (c) No where.
   (d) Any where.

4. 4/2 Wire converter contuse in formation to be sent on 4 wires in to 2 wires using:
   (a) Transformer.
   (b) Two different frequencies 5KH3/2 3.5KH.
   (c) Using two different frequencies 1.1 KHz & 1.3 KHz.
   (d) With the same frequency as used by transducer on time division principle.

5. Intermediate Block signalling system constitutes:
   (a) Intermediate Bloc.
   (b) Intermediate Block post signal.
   (c) A telephone at the IBSS.
   (d) All of them*.

2. **Select the right answer (True/False):**

1. Multiplexer used with Block working by Axle Counters transmits information on Time division principle –True*/False.

2. Checking condition for granting line clear is done automatically by the system of block working with axle counter –True*/False

3. Single line Diado token-less of block instrument operating handle locking arrangement has projection inside to pull the lock lever to ensure locking of handle – True*/False

4. The plunger pushes token placed inside token selector of single line token block instrument to turn commutator and change line circuit polarity –True*/False

5. Universal fail safe Block interface communicates information using MUX-True*/False

6. A level crossing gate falling in Automatic block singling section may not be interlocked –True/False*.
7. In case of Automatic Block Single line section Line clear by the station in advance is not required – True/False*
8. Track circuits are essentially required to be provided in Automatic Block signalling section – True*/False
9. Trains move faster in four aspect Automatic Block signalling system than in case of three aspect Automatic signalling system – True/False*
10. Level crossing gate may be approach locked in Automatic block section as well as in Absolute Block section by using a track circuit placed at 1.4 Km for the level crossing gate – True/False*

3. **Answer the following question:**

1. Write short notes on any two of following:
   (a) Signal line Token block interment.
   (b) Single line Token-less block interment.
   (c) Double line block interment.
2. Describe absolute block system of working trains when the section between two stations is provided with DC track circuits on single line section, supported by explanatory circuits.
3. Describe Automatic Block systems of working of train on single line section with requirement of direction setting, supported by explanatory circuits.
4. Describe digital axle converter and compare them with analogue axle counters.
5. Write short notes on:
   (a) Sequence of operation for dispatch of a train on single line section when block working is with Axle counter Block panel.
   (b) Establishing discretion on single line Automatic Block working section.
   (c) Moving block.
   (d) Space system of Block working.

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CIRCUIT NOMENCLATURE & SYMBOLS FOR SIGNAL DRAWINGS

This section covers the various circuit symbols used in the signal drawings, and the nomenclature used to describe them. The majority of information for this page came from a book labeled *Graphical Signal Symbols and Written Circuit Nomenclature*, published by The Railway Educational Bureau in 1950, and written D. C. Buell.

This first section deals with the standard AAR abbreviations and nomenclature used in the labeling of relay drawings. If you have ever tried to read a signal drawing, and can't make sense out of it, these "TLA's" should help you.

1. **General Abbreviations:**
   A Approach
   B Block, button, positive energy (hereafter referred to as power).
   C Common, changer, counter, correspondence, circuit, controller, code, checking contacts.
   D Proceed indication of a signal, detector, decoding.
   E East, eastward, electric light, element.
   F Traffic.
   G Green, signal (operating mechanism), ground.
   H Home, Approach indication of a signal.
   J Skate, dual control.
   K Indicator.
   L Left, lock preventing initial movement of a lever from normal or reverse position, locking, lever, light, split battery, lock valve.
   M Lock preventing final or indicating movement of a lever, magnetic, marker.
   N Normal, north, northward, negative.
   O Order, operating, off, overload, out.
   P Pole, power, purple, push, repeating, primary.
   Q Local or secondary coil (as in double-element relay or mechanism).
   R Right, red, reverse, relay, power operated controller or contactor, route, stop indication of a signal.
   S South, stick, storage, southward.
   T Track, time, train, telephone, transformer, transmitter.
   U Retarder, route, unit.
   V Train stop (track element), electro-pneumatic stop valve.
   W Switch (point) (operating mechanism), west, westward, white.
   X Crossing, interlocking, bell, buzzer, AC.
   Y Slot, yellow, hold clear.
   Z Use for any special terms (to be noted on plan).

2. **Energy Wires (power supply):**
   C Common DC.
   EC Common East, meaning DC from system east (likewise for north, south, and west).
   FC Common traffic locking.
   CX Common AC.
ENX  Negative voltage AC from POR for lighting, or east negative AC power (likewise for north, south, and west).
NX   Negative AC power.
BL   Positive side of split battery.
NL   Negative side of split battery.
CL   Common of split battery.
N    Negative of DC power.
B    Positive of DC power.
EB   Positive power east (likewise for north, south, and west).
BB   Battery - second battery.
BBB  Battery - third battery.
BX   Positive AC power.
EBX  Positive AC power from POR for lighting or east positive AC power (likewise for north, south, and west).

3.  Operated Units Relating To Track Circuits:
   T    Track section.
   TR   Track relay.
   TPR  Relay repeating track relay.
   TPPR Relay repeating track repeating relay.
   TSR  Track stick relay.
   TSPR Relay repeating track stick relay.
   BPR  Block repeater relay, relay repeating the track circuits in a block.
   BK   Block indicator.

4.  Wires Relating To Track Circuits:
   TB   Track positive - positive power to rail.
   TN   Track negative - negative energy from rail.
   RB   Relay positive - wire from positive rail to relay.
   RN   Relay negative - wire from negative rail to relay.
   TO   Positive control of local coil, double element AC track relay.
   TP   Positive control of TPR
   TPP  Positive control of TPPR.
   TPS  Positive control of TPSR.
   TK   Positive control of TK.
   BP   Positive control of BPR.
   WB   Positive rail to switch circuit controller.
   WN   Negative rail to switch circuit controller.
5. **Operated Units Relating To Switches:**

- **W**: Switch operating mechanism or lock valve.
- **WR**: Relay, controller, or contactor controlling both normal and reverse operations of a switch or an electric switch lock.
- **WNR**: Relay, controller, or contactor controlling the normal operation of a switch or an electric switch lock.
- **WRR**: Relay, controller, or contactor controlling the reverse operation of a switch or an electric switch lock.
- **WRPR**: Relay repeating WR.
- **WNRPR**: Relay repeating WNR or normal position of WR.
- **WRRPR**: Relay repeating WRR or normal position of WR.
- **WPR**: Relay repeating position of a switch.
- **NWPR**: Relay repeating normal position of a switch or normal position of WPR.
- **RWPR**: Relay repeating reverse position of a switch or reverse position of WPR.
- **WK**: Indicator indicating the position of a switch.
- **WL**: Switch lock operating mechanism of a switch.
- **NWLPR**: Relay repeating normal position of a switch lock.
- **NJPR**: Relay repeating normal position of a dual-control lever.
- **RJPR**: Relay repeating reverse position of a dual-control lever.
- **NWK**: Indicator indicating the normal position of a switch.
- **RWK**: Indicator indicating the reverse position of a switch.
- **WAK**: Indicator indicating the condition approaching a switch.
- **RWLPR**: Relay repeating reverse position of a switch lock.
- **WCR**: Switch correspondence relay.

6. **Wires Relating To Switches:**

- **NW**: Normal control of switch operating mechanism.
- **RW**: Reverse control of switch operating mechanism.
- **N10W**: Individual return wire to 10 switch operating mechanism.
- **WR**: Positive control of WR.
- **N10WR**: Negative control of 10WR.
- **WNR**: Positive control of WNR.
- **WRR**: Positive control of WRR.
- **WPR**: Positive control of WRPR.
- **WNRP**: Positive control of WNRPR.
- **WRRP**: Positive control of WRRPR.
- **WP**: Positive control of WPR.
- **N10WP**: Negative control of 10WPR.
- **NWP**: Positive control of NWPR.
- **RWP**: Positive control of RWPR.
- **NWLP**: Positive control of NWLPR.
- **WK**: Positive control of WK.
- **N10WK**: Negative control of 10WK.
- **NWK**: Positive control of NWK.
- **RWK**: Positive control of RWK.
WA  Positive control of WAK.
WL  Positive control of WL.
RWLP Positive control of RWLPR.
WC  Positive control of WCR.
NJP  Positive control of NJPR.
RJP  Positive control of RJPR.

7. **Operating Units Relating To Signals:**

   HR  Relay controlling approach indication of a three position signal, or the proceed indication of a two signal in one arm signaling.
   DR  Relay controlling proceed indication of a signal.
   HDR Relay controlling approach and proceed indication of a signal.
   HPR Relay repeating HR or approach and proceed indication of HDR.
   HSR Home stick relay controlling the approach indication of a signal.
   DPR Relay repeating DR or proceed indication position of HDR.
   RGPR Relay repeating signal mechanism at stop.
   HGPR Relay repeating signal mechanism at approach.
   RHGPR Relay repeating signal mechanism at approach and stop.
   DGP Relay repeating signal mechanism at proceed.
   RGK Indicator indicating signal mechanism at stop.
   HGK Indicator indicating signal mechanism at approach.
   DGK Indicator indicating signal mechanism at proceed.
   ETOHR East train order HR (likewise for north, south, and west).
   ETOHDR East train order HDR (likewise for north, south, and west).
   ETOPHR East train order repeater HR (likewise for north, south, and west).
   ETOPDR East train order repeater DR (likewise for north, south, and west).
   HDGPR Relay repeating signal mechanism in the approach and proceed position.
   HDGK Indicator indicating signal mechanism in the approach and proceed position.
   HY  Hold clear or retaining mechanism of the approach indication of a signal.
   DY  Hold clear or retaining mechanism of the proceed indication of a signal.
   HG  Approach indication operating mechanism of a signal.
   DG  Proceed indication operating mechanism of a signal.
   RG  Stop indication operating mechanism of a signal.

8. **Wires Relating To Signals:**

   H   Positive control of HR.
   D   Positive control of DR.
   HD  Positive control of HDR.
   N10HD Negative control of 10HDR.
   HP  Positive control of HPR.
   HS  Positive control of HSR.
   DP  Positive control of DPR.
   RGP Positive control of RGPR.
   HGP Positive control of HGPR.
   DGP Positive control of DGPR.
ETOH  Positive control of ETOHR.
ETOHD Positive control of ETOHDR.
ETOPH Positive control of ETOPHR.
ETOPD Positive control of ETODR.
HDGP  Positive control of HDGPR.
HDGK  Positive control of HDGK.
RGK   Positive control of RGK.
HGK   Positive control of HGK.
DGK   Positive control of DGK.
HG    Positive control of HG.
DG    Positive control of DG.
RG    Positive control of RG.
N10HG Negative control of 10HG.
HY    Positive control of HY.
DY    Positive control of DY.
RHGP  Positive control of RHGPR.

9. **Stick, Traffic, and Directional Operated Units:**
SR   Stick relay.
ESR  East stick relay, likewise north, south, and west.
LSR  Locking stick relay.
EASR East approach sticking relay, likewise north, south, and west.
ASR  Approach stick relay.
FL   Traffic lock preventing initial movement of a traffic lever from normal or reverse.
FLM  Traffic lock preventing initial movement of a traffic lever from normal or reverse and also preventing final or indicating movement of same lever.
FR   Traffic relay.
FLR  Traffic lock relay controlling FL.
FLMR Traffic lock relay controlling FLM.
FLK  Traffic lock indicator.
FSR  Traffic stick relay.
EFSR East traffic stick relay, likewise north, south, and west.

10. **Wires Relating To Stick, Traffic, and Directional Operated Units:**
S    Positive control of SR.
ES   Positive control of ESR.
LS   Positive control of LSR.
EAS  Positive control of EASR.
AS   Positive control of ASR.
FL   Positive control of FL.
FLM  Positive control of FLM.
F    Positive control of FR.
FLR  Positive control of FLR.
FLMR Positive control of FLMR.
FLK  Positive control of FLK.
FS         Positive control of FSR.
EFS        Positive control of EFSR.

11.  **Operated Units Relating To Indicators, Locks, Indication Magnets, and Relays Used For Locking Purposes:**
M         Lock preventing the final movement of a lever.
L         Lock preventing the initial movement of a controlled function or lever.
NK        Normal indicator indicating normal position of a unit.
RK        Reverse indicator indicating reverse position of a unit.
TER       Time element relay.
NM        Lock preventing the final movement of a lever to the normal position.
RM        Lock preventing the final movement of a lever to the reverse position.
NL        Lock preventing the final movement of a lever or a controlled function from its normal position.
RL        Lock preventing the final movement of a lever or a controlled function from its reverse position.
LR        Relay controlling L lock.
LPR       Repeater of L lock relay.
MR        Relay controlling M lock.
MPR       Repeater of M lock relay.
TE        Time element.
TESR      Time element stick relay.
LK        Lock indicator repeating electric locking.
TEPR      Relay repeating energized position of TE.
TECP      Relay repeating checking contact of TE.

12.  **Wires Relating To Indicators, Locks, Indication Magnets, and Relays Used For Locking Purposes:**
M         Positive control of M.
L         Positive control of L.
NK        Positive control of NK.
RK        Positive control of RK.
TE        Positive control of TER.
NM        Positive control of NM.
RM        Positive control of RM.
NL        Positive control of NL.
RL        Positive control of RL.
LR        Positive control of LR.
LP        Positive control of LPR.
MR        Positive control of MR.
MPR       Positive control of MPR.
TES       Positive control of TESR.
LK        Positive control of LK.
TEP       Positive control of TEPR.
TECP      Positive control of TECPR.
13. **Operated Units Relating To Highway Crossing Signals:**
   - **XX**: Crossing bell.
   - **EXR**: Eastward interlocking or crossing relay, likewise north, south, west.
   - **XG**: Wig-wag mechanism - crossing gate mechanism.
   - **XY**: Slot for wig-wag mechanism - crossing gate mechanism.
   - **EOR**: Electric light operating relay (flasher relay).
   - **XSR**: Directional relay to hold crossing signal clear as train recedes from crossing.

14. **Wires Relating To Highway Crossing Signals:**
   - **XG**: Positive control of XG.
   - **RXG**: Reverse control to XG (drive down mechanism).
   - **E1**: Positive wire to No. 1 unit of flashing light signal (to be designated by letter N, E, S, W).
   - **E2**: Positive wire to No. 2 unit of flashing light signal (to be designated by letter N, E, S, W).
   - **XS**: Positive control of XSR.
   - **EX**: Positive control of EXR.
   - **EO**: Positive control of EOR.

15. **Operated Units Relating To Approach And Annunciating Of Trains:**
   - **AX**: Annunciator indicating approach traffic.
   - **EAX**: Eastward Annunciator indicating approach of eastward traffic, likewise north, south, and west.
   - **AER**: Relay used for approach lighting.

16. **Wires Relating To Approach and Annunciating Of Trains:**
   - **AX**: Positive control of AX.
   - **EA**: Positive control of EA.
   - **E**: Positive control of ER.

17. **Miscellaneous Operated Units:**
   - **AK**: Approach indicator.
   - **AR**: Approach relay.
   - **PCR**: Pole changing relay.
   - **NLPR**: Relay repeating the normal position of a lever.
   - **RLPR**: Relay repeating the reverse position of a lever.
   - **E**: Electric light.
   - **TO**: Train order.
   - **WTO**: West train order signal governing westward traffic, likewise north, south, and east.
   - **RR**: Route relay.
   - **VR**: Train stop relay.
   - **VSR**: Train stop stick relay.
   - **VPR**: Train stop retaining relay.
   - **VY**: Train stop retaining mechanism.
   - **XR**: Interlocking relay.

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TOR     Train order relay.
POR     Power off relay.
LOR     Light out relay.
ME      Marker light.
OR      Overload relay.
GDR     Ground detector relay.
CT      Code transmitter.
DU      Decoding unit.

18. **Wires Relating To Miscellaneous Operated Units:**
AK      Positive control of AK.
A       Positive control of AR.
PC      Positive control of PCR.
NLP     Positive control of NLPR.
LP      Positive control of RLPR.
R       Positive control of RR.
V       Positive control of VR.
VS      Positive control of VSR.
VP      Positive control of VPR.
VY      Positive control of VY.
X       Positive control of XR.
TO      Positive control of TOR.
PO      Positive control of POR.
LO      Positive control of LOR.
ME      Positive control of ME.
O       Positive control of OR.
GD      Positive control of GDR.
CT      Positive control of CT.
DU      Positive control of DU.
### SYMBOLS FOR READING ELECTRICAL SIGNALLING CIRCUITS AND THE SIP

<table>
<thead>
<tr>
<th>Wiring Symbol</th>
<th>Written Circuits</th>
<th>Wiring Symbol</th>
<th>Written Circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Symbol A]</td>
<td>The dotted line shows that reference to the other circuit is required.</td>
<td>![Symbol B]</td>
<td>The dotted line shows that reference to the other circuit is required.</td>
</tr>
</tbody>
</table>

**A.C. relay, double element with three position armature fitted with one N and one R dependent contact.**

**D.C. neutral polar relay with neutral armature fitted with one front and one back dependent contact.**

| ![Symbol C]  | The dotted line shows that reference to the other circuit is required. | ![Symbol D]  | The dotted line shows that reference to the other circuit is required. |

**D.C. interlocked relay, Mechanical inter-locking prevents both armatures assuming fully de-energized position at the same time.**

**D.C. interlocked relay, Mechanical inter-locking prevents both armatures assuming fully energized position at the same time.**

<table>
<thead>
<tr>
<th>![Symbol E]</th>
<th>Electric lamp double pole</th>
<th>![Symbol F]</th>
<th>Electric lamp triple pole</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Symbol G]</td>
<td>Electric lamp used as indicator</td>
<td>![Symbol H]</td>
<td>Bell Single stroke</td>
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<tr>
<td>![Symbol I]</td>
<td>Magneto bell</td>
<td>![Symbol J]</td>
<td>Electrically operated horn</td>
</tr>
</tbody>
</table>

| ![Symbol K]  | a. Lock out contact | ![Symbol L]  | b. Lock in contact |

**Lock proving contact**

---

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<table>
<thead>
<tr>
<th>Normal</th>
<th>Reverse Position 3</th>
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<tbody>
<tr>
<td>Thumb Switches: 2 - Position</td>
<td></td>
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<table>
<thead>
<tr>
<th>Left</th>
<th>Centre</th>
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<td>Thumb Switches: 2 - Position</td>
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<tr>
<th>Right</th>
<th>Floor push or foot plunger control</th>
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<td>Thumb Switches: 2 - Position</td>
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<tr>
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<td>Thumb Switches: Multi - Position</td>
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<table>
<thead>
<tr>
<th>Reverse Position 2</th>
<th>Reverse Position 3</th>
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<tbody>
<tr>
<td>Thumb Switches: Multi - Position</td>
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<table>
<thead>
<tr>
<th>Contact closed points in normal position</th>
<th>Contact closed points in reverse position</th>
</tr>
</thead>
<tbody>
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<td>Detector contact, for point only</td>
<td></td>
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<table>
<thead>
<tr>
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<th>Contact closed points in reverse position, bolt in</th>
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</thead>
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<tr>
<td>Detector contact, for both point and bolts</td>
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<tr>
<th>Time controlled front contact</th>
<th>Time controlled back contact</th>
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</thead>
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<td>Time releases relays</td>
<td></td>
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<tr>
<td>Special contact (Requires reference to notes)</td>
<td>Resistor, variable (irrespective of the means of variation)</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Resistor (General symbol) (Inductive or non-inductive)</td>
<td>Resistor, practically non-inductive for the purpose of which it is used</td>
</tr>
<tr>
<td>Inductor (General symbol)</td>
<td>Inductor, variable (Irrespective of the means of variation)</td>
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<td>Inductor with iron core</td>
<td>Capacitor, fixed</td>
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<tr>
<td>Capacitor, variable (Irrespective of the means of variation)</td>
<td>Capacitor (Electrolytic) (Open plate is positive)</td>
</tr>
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<td>Transformer</td>
<td>Motor (General symbol)</td>
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<td>Connection to earth</td>
<td>Terminal block</td>
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<td>Fuse</td>
<td>Lightning arrestor</td>
</tr>
<tr>
<td>Written Circuits</td>
<td></td>
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<tr>
<td>------------------</td>
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<tr>
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<td><img src="image2.png" alt="Circuit Diagram" /></td>
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<th>Slow pick up</th>
<th>Front or Top contact</th>
<th>Back or Bottom contact</th>
<th>Contact on flasher relay.</th>
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<th>Three position relay polarized armature de-energized contact</th>
<th>Three position relay polarized armature reverse contact</th>
<th>Two position latch relay normal contact</th>
<th>Two position latch relay reverse contact</th>
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</thead>
<tbody>
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<td><img src="image10.png" alt="Circuit Diagram" /></td>
<td><img src="image11.png" alt="Circuit Diagram" /></td>
<td><img src="image12.png" alt="Circuit Diagram" /></td>
<td><img src="image13.png" alt="Circuit Diagram" /></td>
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<td><img src="image17.png" alt="Circuit Diagram" /></td>
<td><img src="image18.png" alt="Circuit Diagram" /></td>
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<td><img src="image23.png" alt="Circuit Diagram" /></td>
<td><img src="image24.png" alt="Circuit Diagram" /></td>
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<tr>
<th>Signal, the lever locked electrically.</th>
<th>Signal, released by block at ‘line clear’.</th>
<th>Signal lever released by token.</th>
<th>Signal, the lever of interlocked with key.</th>
<th>Automatic signal.</th>
</tr>
</thead>
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<tr>
<td><img src="image25.png" alt="Circuit Diagram" /></td>
<td><img src="image26.png" alt="Circuit Diagram" /></td>
<td><img src="image27.png" alt="Circuit Diagram" /></td>
<td><img src="image28.png" alt="Circuit Diagram" /></td>
<td><img src="image29.png" alt="Circuit Diagram" /></td>
</tr>
<tr>
<td>Semi-automatic signal.</td>
<td>Ground telephone.</td>
<td>Relation of the signal to the track and the direction of traffic.</td>
<td>Block section limit board.</td>
<td>Stop board, calling-on sigg board, absolute block sigg begin etc.</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------</td>
<td>---------------------------------------------------------------</td>
<td>---------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Point without lock with bar (2-levers).</td>
<td>Point with lock and bar (1-lever).</td>
<td>Point with lock and bar (2-levers).</td>
<td>Point with lock without bar (1-lever).</td>
<td>Point with lock without bar (2-levers).</td>
</tr>
<tr>
<td>Single slip.</td>
<td>Double slip.</td>
<td>Released by token.</td>
<td>Released by key on token.</td>
<td>Released by key from signal box.</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------------------------</td>
<td>----------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
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<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
<td><img src="image5.png" alt="Diagram" /></td>
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<table>
<thead>
<tr>
<th>Insulating rail joint, track circuit in both direction.</th>
<th>Insulating rail joint, track circuit on left, none on right.</th>
<th>Insulating rail joint, track circuit on right, none on left.</th>
<th>Track Circuit portion (single line plans).</th>
<th>Digital axle counter.</th>
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<tbody>
<tr>
<td><img src="image6.png" alt="Diagram" /></td>
<td><img src="image7.png" alt="Diagram" /></td>
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<td><img src="image9.png" alt="Diagram" /></td>
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<tbody>
<tr>
<td><img src="image11.png" alt="Diagram" /></td>
<td><img src="image12.png" alt="Diagram" /></td>
<td><img src="image13.png" alt="Diagram" /></td>
<td><img src="image14.png" alt="Diagram" /></td>
<td><img src="image15.png" alt="Diagram" /></td>
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</table>

Gradient posts. (Upper figures show lengths for unit rise or fall.)
<table>
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<tr>
<th></th>
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<tbody>
<tr>
<td>Gong or siren.</td>
<td>Bell (Trembler).</td>
<td>Point machine (power).</td>
<td>Point machine (dual control).</td>
<td>Clearance bar operated from signal box.</td>
</tr>
<tr>
<td>Ground frame (Uncovered).</td>
<td>Ground frame (Covered).</td>
<td>Block instrument (permissive).</td>
<td>Block instrument (absolute non-controlled).</td>
<td>Block instrument (absolute controlled).</td>
</tr>
<tr>
<td>Symbol</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>![Symbol]</td>
<td>Lever frame/panel (Operator facing track).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>![Symbol]</td>
<td>Lever frame/panel (Operator with back to track).</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>![Symbol]</td>
<td>Lifting barriers interlocked and worked from signal box. Add note if power-operated.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>![Symbol]</td>
<td>Lifting barriers interlocked and worked from ground.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>![Symbol]</td>
<td>Lifting barriers non-interlocked and worked from ground.</td>
<td></td>
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**Figure 4.2.1d**

*Symbols used for reading Signal and Interlocking Plan & wiring diagram*
## REAR VIEW PROFILE OF ‘Q’ SERIES RELAYS

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<thead>
<tr>
<th></th>
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<th>B</th>
<th>C</th>
<th>D</th>
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<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>3/4</td>
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<td>F</td>
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<td>F</td>
</tr>
<tr>
<td>5/6</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>7/8</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>1/2</td>
<td>F</td>
<td>F</td>
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<td>3/4</td>
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<td>B</td>
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<td>7/8</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
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</tbody>
</table>

### QBKA1

* Supply + HF + Load & ** Load - HF - Supply.

### QBKA1 & QNHXC1

### QSRA1

### QECX

### QL1

### QS2 & QS3
<p>| | | | |</p>
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<td>QSA3</td>
<td>8F - 4B</td>
<td>QSPA1 &amp; QNHX1</td>
</tr>
<tr>
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<td>8F - 4B</td>
<td>2F - 2B</td>
<td>QUCX1 &amp;2</td>
</tr>
<tr>
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</tbody>
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Lamp Proving Relays
QBA1, QN1
&QNA1
QBA1, QN1 & QNA1

LED Lamp Proving Relays

QBBA1 & 2, QNN1 & QNNA1

Fig. 4.2.1e
Contact layout (Rear view) of Q series relays

*****

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Figure 2
Typical Panel diagram to suit Signal & Interlocking Plan in Figure 4.7.2A
About this book

‘Indian Railway Signal Engineering’ has been covered in four volumes. The first volume was published in June 2008. The fourth volume of the book in your hands is in 347 pages covered under nine chapters with 204 illustrative diagrams, is designed to provide electrical system of operating devices, operated equipment, transmission media, electrical system of interlocking, Electronic Interlocking, monitoring devices, power supply for signalling system and block working systems and developments in signalling system for improved safety, prevalent on Indian Railways. Electrical and electronic interlocking has been compacted to form this book.

The book shall be useful as ready reference in day-to-day practice of Signal engineering as well as it shall be equally helpful in preparation for departmental examinations, for which the book covers – electrical version for implementation of essentials of systems of block working of trains on Indian railways, explained and supported by circuit diagrams along with description of associated cables, power supply arrangements, control cum operating panel, computer based operation for EI, its requirements, architecture, and development of programme, DC, AC, AFTC track circuits and axle counters. All the information in this book shall form fundamentals for planning and designing of Signal engineering works covered in Volume-II.

Opinion about the book

I, find that EI, the black box, which is the future system of interlocking coming fast, as covered under an independent chapter, gives a fairly good idea of the system and the subject has been covered in considerable length which shall be very use full for consumption of Railway Signal Engineers ……

OFC has been in use of electrical and electronic system of interlocking as a transmission media and has been usually considered basically under the domain of telecommunication. Addition of knowledge of OFC manufacture, working, joining, transmission and measurement shall serve purpose big way for signalling system to adopt this media of transmission by signal engineers as well…….

……… I consider this volume of the book to be use full for ready reference for signal engineers.

P.K. Srivastav,
CSTE
North Central Railway

I took three readings of the Volume-I, of the book and cleared written examination for LGS.

R.K. Mishra
CTI/HQ NCR

First volume was organised and well written. By what time ivth volume of the book shall be available?

Many LGS and LDCE aspirants.

About the author

Pramod P. Goel, the author of this book is BSc, MBA and Member IETE. He retired as Deputy Chief Signal & Telecom Engineer having served Indian Railways for about 40 years. During this period he worked in construction organisation for about nine years and for about thirteen years in Central Organisation for Railway Electrification. After retirement he worked with RITES for about one year and than got associated with the prestigious work of modernisation of signalling system in Ghaziabad - Kanpur section as Consultant. Over the period he has gathered an excellent multi dimensional blend of experience in Signal & Telecom Engineering.

Other volumes of the book, by the same author under publication:

i) Indian Railway Signal Engineering – Volume-II: The book covers planning and designing of signal engineering works starting from site survey, preparation of Signal Engineering Plan and other associated diagrams such as Station Working Rule Diagrams, Panel diagram etcetera.

ii) Indian Railway Signal Engineering – Volume-III: The book covers two aspect semaphore signalling system, wire run, rod run, rod compensation, lever frames and their details; Double wire Upper Quadrant multiple aspect signalling system, signal machines, wire compensators, Interlocking Table for single wire and double wire signalling, Dog charts etcetera.