



**INSTITUTION OF RAILWAY SIGNAL ENGINEERS
MINOR RAILWAYS SECTION
GUIDELINE ON**

**TRAIN DETECTION
DC TRACK CIRCUITS**

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Anyone who wishes to contribute additional items or correct / amend any of the entries or wants further information may contact the IRSE Minor Railways Section Guideline co-ordinator at mrsdc@irse.org or via the IRSE Headquarters.

Any railway seeking to follow the guidelines in this document should ensure that it is suitable for their particular railway concern. Duty holders are reminded that they must be satisfied that they are doing all that is needed under health and safety duties to control risks. Compliance with this guideline issued by the IRSE is not mandatory as it provides advice on how an issue may be addressed.

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1 INTRODUCTION

This document provides information on DC track circuits.

This document does not include other forms of train detection such as AC track circuits, frequency track circuits, axle counters, treadles or position detectors. It also does not include associated items such as bonding, cable terminations and track circuit interrupters which are shown in a separate document.

This document does not include detailed maintenance procedures for primary or secondary cell(s).

It is not intended to be a definitive document on how to design, install, test and maintain DC track circuits, but to disseminate information on best practice.

The IRSE Minor Railways Section has used its best endeavours to ensure that the contents of this document are factually and technically correct and is suitable for its stated purpose but the IRSE Minor Railways Section cannot be liable for any subsequent use to which the document may be put.

2 DEFINITIONS

The following is a list of the more common definitions, a fuller description may be found in subsequent sections.

In this document terms relating to gender equally apply to the opposite.

Any reference made to “Signal Engineer” is a generic term and can relate to;

- Maintenance – person in charge of Signal Engineering for the Railway
- Design – Responsible Design Engineer for the design authority
- Installation – Person in charge of Installation
- New Works Testing – Tester in Charge

Any reference made to “Signalman” is a generic term and applies to the person in charge of regulating trains on the section of line where work is required.

Any reference made to “Railway” is a generic term and applies to the owner and/or operator of the relevant infrastructure.

Ballast Resistance	Each rail has a leakage to other rails and to earth through the sleepers and the ballast. The leakage resistance, effectively connected across the rails (and hence across the track circuit) is termed ballast resistance. It may be given as a value of ohms for the whole of a track circuit or as ohms/unit length for a given length of track.
Bonds	Where sections of rail are bolted together with fishplates, the electrical continuity between them may not be adequate. To ensure there is a good electrical connection, lengths of wire or cable known as bonds are connected from one rail to the other.
Common Rail	On a single rail track circuit, the rail without the IRJs, or the rail wired in parallel through points and crossings.
Cut Section	A method of reducing the continuous length of a track circuit by the use of shorter individual track circuits, each one controlling the same final TPR. They are normally indicated as a single track circuit on the signalman's indication.
Disconnection box	A box close to the insulated joint where tail cables are terminated. Typically a 2c cable would be run from the equipment case to the disconnection box and the single core cables to the rails. Can also be known as dis box (DB), or track disconnection box (TDB).
Double Rail	A track circuit where both rails are insulated by IRJs from the adjacent track circuits.

Drop Shunt	The highest value of resistance which, when connected across the track circuit as a test, will cause the track relay to fully drop away from its energised position. The exact position of the resistance and how far the relay has to drop will be defined in the test conditions for the track circuit.
Feed End	The end of the track circuit where power is fed into the rails. On diagrams, the feed end rail connections may be designated "TN" or "TB" according to the polarity.
Fouling Point	The position on a converging, diverging or crossing line beyond which the encroachment of any part of a vehicle would infringe the required passing clearance for a vehicle on the other line.
Insulated Rail Joint (IRJ)	<p>A joint between two lengths of rail, designed to isolate electrically one length of rail from another. The shape and construction of the IRJ varies according to the type of rail each side of it. The traditional joint is bolted to the rails by using an insulated fishplate.</p> <p>This joint is also known as an Insulated Block Joint (IBJ).</p> <p>They are used to:</p> <ol style="list-style-type: none">1. limit how far a track circuit extends.2. allow a changeover in rail polarity within a track circuit.3. divide up lengths of rail so that they can be connected together in a manner to make train detection more effective.
Jumpers	Lengths of cable connecting together rails which are separate or deliberately insulated from each other. Usually, this is so that the rails are connected in series within the same track circuit through points and crossings.
Pick-Up Shunt	The lowest value of resistance which, when connected across the track circuit as a test, will cause the track relay to pick up from its de-energised position. The exact position of the resistance and how far the relay has to pick will be defined in the test conditions for the track circuit. In reality, the Prevent Shunt and the Pick-Up Shunt values will be very nearly the same.
Polarity	<p>"B" is the positive side.</p> <p>"N" is the negative side.</p> <p>Note: The polarity of the voltage on the rails can be made to change within the length of the track circuit by using insulated rail joints and jumper cables.</p>
Prevent Shunt	The highest value of resistance which, when connected across the track circuit as a test, will prevent the track relay from picking up from its fully de-energised position. The exact position of the resistance will be defined in the test conditions for the track circuit.
Relay End	The end of the track circuit where the relay is connected to the rails (even if the relay is connected to the rails through an intermediate device). On diagrams, the relay end rail connections may be designated "RN" or "RB" according to the polarity.
Residual Voltage	A voltage present on the track relay when the feed set is disconnected from the rails
Shunt Box	A device that is placed across the track to simulate the presence of a train. It is used to provide readings for the drop shunt, prevent shunt and pick-up shunt testing. It consists of a variable resistor and two wires which are clipped to the rail connections.
Single Rail	A track circuit where only one of its rails is insulated by IRJs from the adjacent track circuits.
Staggered IRJs	Two IRJs in a pair of rails that are not exactly opposite each other. The length of maximum stagger must not exceed the requirements of the Railway.
Staggered Polarities	Track circuits are designed so that the polarity of the voltage on the rail on one side of an IRJ is the opposite of that on the other side. This is done so that if an insulated joint fails, the two polarities will oppose each other and cancel each other out. The resulting reduced voltage will cause the track relay to drop. This is safer than allowing the track relay to become energised from a supply from which it should be insulated.
Tail cable	A cable that runs from the equipment case to the track side disconnection box or rails direct
TFS	Track Feed set. A track circuit feed unit that just supplies the track circuit
TPR	Track Repeating Relay. The relay used within the signal box or interlocking that is controlled by the operation of the TR(s).

TR	Track Relay. The relay that is connected across the rails.
Track Circuit	A means of proving the absence of a train on a section of track. The two rails are used to connect a power source to a detector (usually a relay). The normal state with no train present is that the detector is energised. When a train occupies the section of track, the wheels short-circuit the two rails together, which will cause the current to by-pass the detector, which therefore de-energises (i.e. drops away).
Transposition IRJs	IRJs within a track circuit specially put to permit a changeover of polarities. This may be necessary to create staggered polarities at the IRJs between two neighbouring track circuits, or they may be used to extend the track circuit through point and crossing rails.
TSS	Track Service Set. A track circuit feed unit that also charges a standby battery, which is used when there is a failure of the main power supply.

3 SAFETY CONSIDERATIONS

3.1 Before Starting Work

Before working on any track circuit, inform the signaller and come to an understanding as to the work to be done. Any work which involves disconnecting a track circuit may lock signals and points and prevent train movements.

3.2 Risk Assessments

When proposing to install a new track circuit, consideration should be given to what type should be used in relation to limits of operation (track circuit length, type of rolling stock etc.), track layout (points, level crossings etc.), restrictions on available power supply and other local conditions (more than normal wet ballast).

4 BASIC REQUIREMENTS

4.1 General

A track circuit is an electrical circuit that uses the rails as a conductor. It consists of an electrical source and a regulating resistance at one end and a low resistance safety relay at the other end.

Its purpose is to prove the absence of a train from a section of line so that points may be operated and signals cleared to show a proceed aspect.

It also provides an indication to the signaller as to the position of a train or vehicles on each section of line where track circuits are fitted.

4.2 Operation of a Basic DC Track Circuit

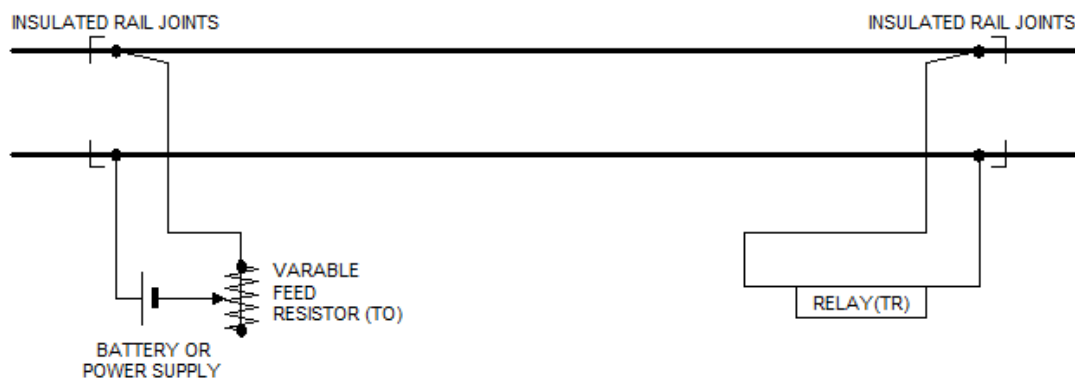


Figure 1 - Basic DC Track Circuit

A feed is applied to the rails at one end, with each rail being of opposite polarity. At the other end a relay is connected across the rails. The current passes down one rail to energise the relay and returns through the other rail. When clear of all vehicles, the track relay (TR) is energised. When a vehicle wheelset is placed across the rails, it causes a short circuit across the feed which drops the TR.

To ensure correct operation, the feed end voltage is regulated, usually by a variable resistor that is wired in series with the feed. This resistor also acts as a load to the feed when the track has a short circuit from the wheelset.

To test the track circuit, a variable train shunt resistance (shunt box) is used to represent the train wheels. The use of the train shunt resistance is given in section 8.4.

It is safer to use a circuit that is normally energised as, under a fault condition such as a loss of power, the relay will drop and indicate “occupied” to the signalman. If a track circuit relied on a relay to pick, a power failure would not operate the circuit and a train would not be detected.

The basic track circuit uses DC voltage; however, other types of track circuit using AC voltages at various frequencies have been developed. This document only considers DC track circuits.

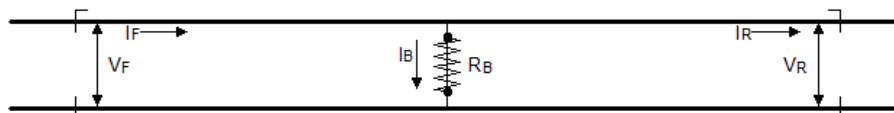
The type of track circuit used will be decided at the design stage.

4.3 Ballast Resistance

The rails are held secure in metal rail-chairs or base plates that are attached to sleepers. The sleepers act as an insulation between the two rails and are prevented from moving by stone ballast packed around them.

This insulation is not perfect, it has a resistance value that may affect the correct operation of the track circuit. When the sleepers and the ballast become wet, the resistance value will drop. If the track circuit is set with a high drop shunt value, the wet ballast may act as a resistance across the rails and drop the track relay.

While it is assumed that the rails have zero resistance, over a long distance they will have a finite value. This, combined with the ballast resistance, will limit the length of the track circuit. The maximum for basic DC track circuit is about 800 metres on good dry ballast. In practice, this is reduced in areas of poor ballast conditions where the maximum may be as short as 400 metres.



V_F - FEED VOLTAGE I_F - FEED CURRENT
 V_R - RELAY VOLTAGE I_R - RELAY CURRENT
 R_B - BALLAST RESISTANCE I_B - BALLAST CURRENT

E_B - MEAN RAIL VOLTAGE $1/2 (V_F + V_R)$

$$R_B = \frac{E_B}{I_B} = \frac{1/2 (V_F + V_R)}{I_F - I_R}$$

$$I_F = \frac{V_{VR}}{R_{VR}} \text{ AND } I_R = \frac{V_{CR}}{R_{CR}}$$

WHERE

V_{VR} IS THE VOLT DROP ACROSS THE FEED RESISTOR
 R_{VR} IS THE RESISTANCE SETTING OF THE FEED RESISTOR
 V_{CR} IS THE VOLT DROP ACROSS THE RELAY COIL
 R_{CR} IS THE RESISTANCE OF THE RELAY COIL

IN THIS WAY, FOUR ACCURATE VOLTAGE READINGS ON A WORKING TRACK CIRCUIT WILL YIELD THE ACTUAL BALLAST RESISTANCE AT THE TIME OF MEASUREMENT

Figure 2 - Calculation of Ballast Resistance

If there are problems with the correct operation of a track circuit due to the condition of the ballast resistance, there are two possible solutions.

- a) Change the type of track circuit used. Some types are better suited to poor ballast conditions than others.

- b) If the track circuit is long and it is not possible to use another type, divide the track into two or more shorter sections. This is not the preferred method as it requires extra equipment. However, when a DC track circuit in excess of 800 metres is required, it should be split into two or more equal length sections.

4.4 Maximum Track Circuit lengths

There are limitations to the length of DC track circuits for reliable operation which are detailed in the table below. These variables can depend greatly on the ballast resistance and the type of sleepers in use. It has been noted in some areas historically that some track circuits have been known to operate for nearly 2500 metres but generally these are not associate with performing interlocking functions, they would have been used as an annunciator track for a level crossing box. The addition of a track feed relay can also reduce the maximum effective length.

Configuration	Max Length (Timber Sleepers)	Max Length # (Concrete Sleepers)
9Ω track relay only	700 Metres	1200 Metres
9Ω Track Relay and feed end relay	500 Metres	750 Metres
9Ω Track Relay only with relay end adjustment resistor	350 Metres	500 Metres
20Ω Track Relay only	700 Metres	1200 Metres
20Ω Track Relay and feed end relay	600 Metres	900 Metres
20Ω Track Relay only with relay end adjustment resistor	350 Metres	500 Metres
60Ω Track Relay only	250 Metres	350 Metres
Diode Tracks	550 Metres	1000 Metres

- See notes in section 6.2.1, as the residual voltage could influence the length and configuration of the track circuit.

5 SYSTEMS AND EQUIPMENT

The DC track circuit consists of a length of track, which has a source of dc power connected to one end and a relay connected to the other. The track circuit can be either single or double rail type. A typical double rail DC track circuit is shown in figure 1.

An adjustable feed end resistor is provided to regulate the voltage to the track circuit and the relay. It also acts as a load to the power supply when the track is short-circuited by the wheels of a train. The resistor should be adjusted so that the track circuit will operate correctly.

IRJs separate individual track circuits from each other and are placed at the limits of the track circuit. IRJs are also used to electrically split up a track circuit within a point and crossing area.

There are various designs of standard DC track circuits, which can differ in the type of power feed and the relay used. Which types are used at a particular site can depend on the following;

- Mains power availability and reliability,
- Track conditions,
- Track circuit length,
- Types of train using the track,
- Need for immunisation from ac supply,
- Type of accommodation available for the equipment.

Some track circuits may have more than one track relay. In addition to the usual relay at the far end from the feed, there may be a relay at the feed end and occasionally elsewhere within the track circuit. These extra relays are used to overcome problems with train detection caused by residual interfering voltages on the rails.

5.1 Primary Cell Fed

This type of feed would normally only to be used when there is no mains power available. It may also be used for short-term work such as stagework or temporary alterations.

Non-rechargeable cell(s) are used as the power supply. These cells produce an output of 1.5 volts; two cells may be wired in parallel to increase the mean time between failures of the track circuit. The low voltage output makes this type of feed only suitable for short tracks. When extra voltage is required, a number of cells may be wired in a series. Typical feed arrangements are shown in figure 1 above. The exact number of the cells depends on the conditions of the track.

This arrangement is normally used with a low voltage relay such as a shelf type BS1659 2-ohm or 2.25-ohm.

5.2 Charger Fed with One Secondary Cell

This type of track circuit has been extensively used on railways, particularly at electro-mechanical signal boxes where mains power is available but cannot be guaranteed, such as the normal domestic supply.

The charger unit will have a variable output (normally about 2-2.5 volts under load) and will be able to continuously charge one standby secondary cell as well as feed the track circuit. The output is adjustable so that it provides the correct charge to the cell.

The feed end resistor must be provided to regulate the track circuit voltage.

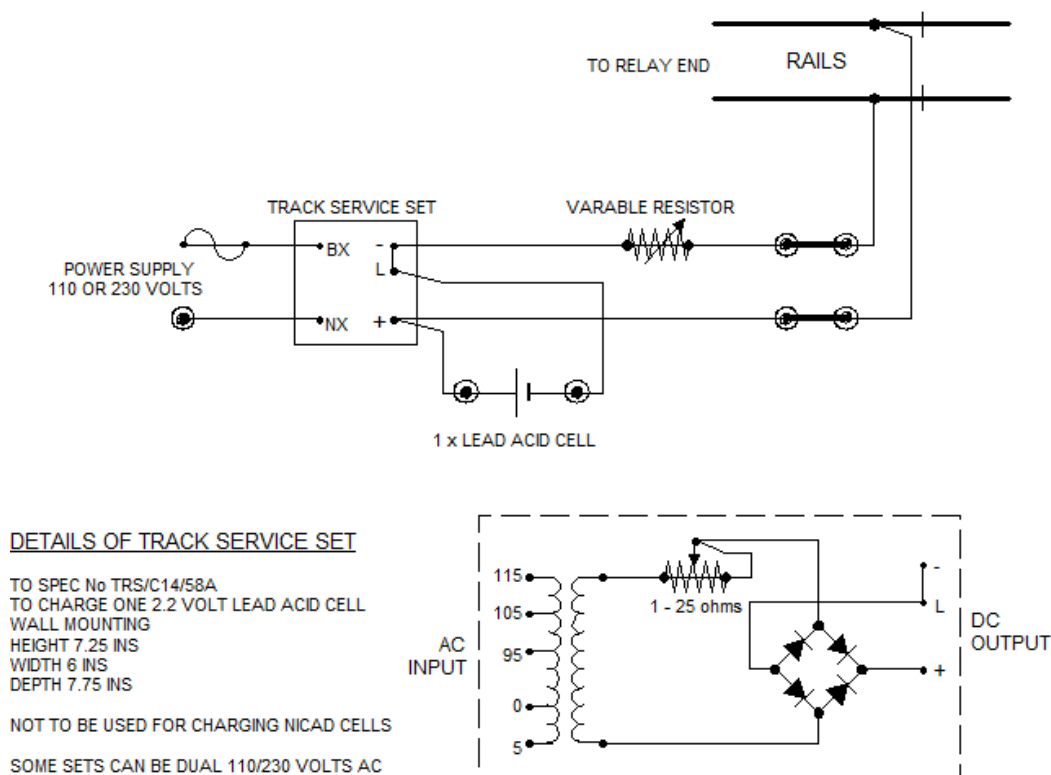


Figure 3 - Typical Low Voltage Track Circuit using a Track Service Set

This arrangement is normally used with a low voltage (max 0.5 volts) relay such as a shelf type BS1659 2-ohm or 2.25-ohm or plug-in type BR938 4-ohm.

Note: Some railways have found that certain types of modern lightweight rolling stock (class 14X, 15X and 16X DMUs) cannot be reliably detected by 2-ohm and 2.25-ohm shelf relays.

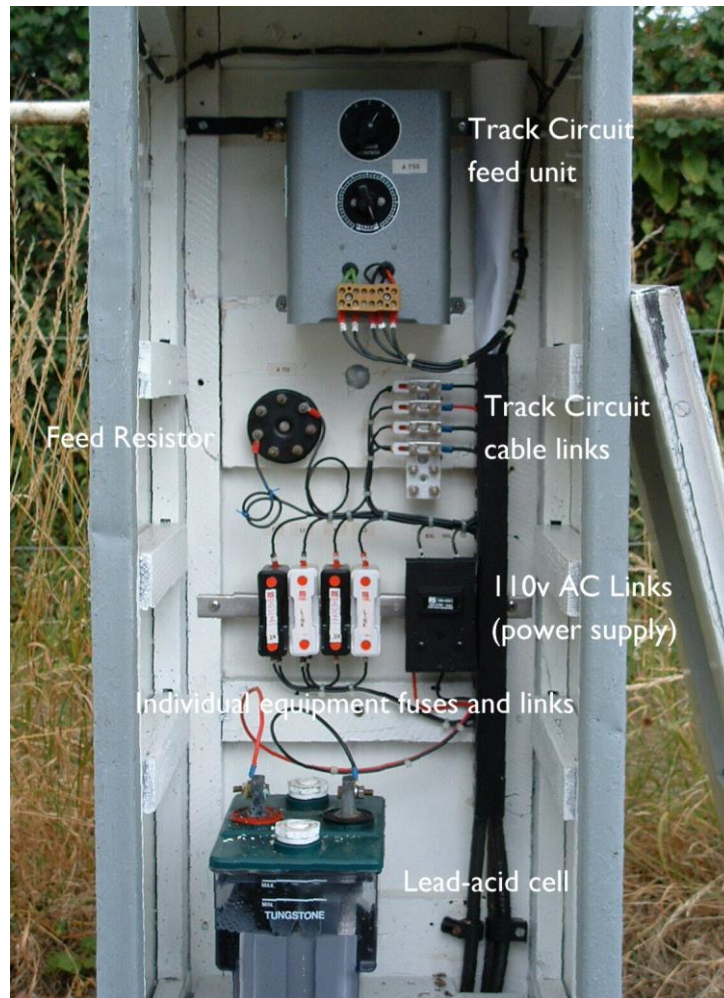


Figure 4 - Typical Low Voltage Track Feed Location

5.3 Charger Fed with Medium Voltage Secondary Battery

This is used where mains power is available but cannot be guaranteed such as the normal domestic supply. The charger unit will have a variable output of a nominal 6 volts or 12 volts under load and will be able to continuously charge a standby battery as well as feed the track circuit. The output is self-adjustable so that it provides the correct charge to the cell.

The feed end resistor must still be provided to regulate the track circuit voltage.

This arrangement should only be used with a plug-in BR939 20-ohm relay.

5.4 Transformer/Rectifier Feed Unit without Secondary Battery

This type of track circuit should only be used where the main power is backed-up either by a generator or battery fed inverter.

The basic configuration is a single track relay without any additional relay end resistance. The feed unit to BR867 has two flying lead selectors which will be set up on commissioning. Generally no further adjustment is required in service.

Relay Type Selector shall be selected according to relay type:

- Terminal 9R for a BR 966 F2 9-ohm relay.
- Terminal 20R for a BR 939 20-ohm relay.

Feed Lead Resistance Selector shall be selected according to the feed cable resistance:

- Terminal S for short leads (up to 60 metres of 2 core 2.5mm² or equivalent). A short circuit at the rails should give a feedset output voltage of 1.2V or less.
- Terminal L for longer leads. A short circuit at the rails gives a feedset output voltage greater than 1.2V.

The drop shunt will generally be in excess of 0.6-ohm

Note: The minimum acceptable drop shunt for this arrangement is 0.5-ohm.

This track circuit can also be used with a BR966 F9 60-ohm relay. The feed unit will be set up for the 20-ohm relay (terminal 20R) and set for long feed leads (terminal L) regardless of the actual cable length.

Note: The minimum acceptable drop shunt for this arrangement is 1.2-ohm.

5.5 Relay End

The relay used will depend on the design of each track circuit. There are two types of relay which have been established as standard for track circuits, the shelf type and the plug-in type.

5.5.1 Shelf Relays

The shelf type will have a coil resistance of either 2-ohm, 2.25-ohm or 9-ohms. The relay has four sets of contacts, two of which are “changeover”, while the other two are front contacts only.

Specification	Coil Resistance	Typical Pick-up Volts	Rated Current
BS1659	2 ohms	0.3	
	2.25 ohms	0.3	78mA (min) 82mA (max)
	9 ohms	0.5	39mA (min) 41mA (max)



Figure 5 - BS1659 4-arm Shelf Relays

The shelf type relay consists of two coils wired in parallel. The 2-ohm relay has 2 x 4-ohm coils and the 2.25-ohm relay has 2 x 4.5-ohm coils. The 9-ohm relay has 2 x 4.5-ohm coils wired in series. Although each relay is pre-wired, it is possible to inter-change the coil connections of relays with 2 x 4.5-ohm coils to produce a 2.25-ohm or a 9-ohm relay.

5.5.2 Plug-in Relays

The plug-in type is designed to fit into a relay base that would normally be mounted in some form of relay rack. There are four types available. The plug-in relay will normally have only two front contacts.

Specification	Pin code	Coil Resistance	Minimum Pick-up Volts	Rated Current
BR938	101	4-ohms	0.5	117mA (min) 146mA (max)
BR966 F2	110	9-ohms	1.2	140mA (min) 175mA (max)
BR939	105	20-ohms	2.0	92mA (min) 115mA (max)
BR966 F9	104	60-ohms	10.0	



Figure 6 - BR930 Series Track Relay

5.6 General Installation (New work)

Follow the arrangements shown on the installation drawings; these should not be amended without authority from the Signal Engineer. The drawings will show the type of equipment to be used and the wire and cable size.

6 TRACK CIRCUIT DESIGN

6.1 Design Considerations

The following should be considered for a new track circuit;

- The track relay must be sufficiently immune to interference voltage so as to prevent the relay being falsely energised. Track circuit length may need to be reduced to achieve this.
- Track circuits should be configured, wherever practicable, such that IRJ failure does not cause a false clearance. This is generally achieved by having opposing polarities across each IRJ.
- Where practical, the relay end of the track circuit should be where a train first occupies the track section. It is accepted that on lines where trains run in either direction, this may not always be possible.
- Where practical, track circuits through points should have the relay at the toe of the points.

6.2 Alternative Designs

Various alternative arrangements of DC track circuits can be used where the basic configurations are not possible.

6.2.1 Feed End Relay

Within reasonable limits, DC interference on a DC track circuit does not cause a problem, provided that all the bonding remains intact. However, it may cause a wrong side failure when a disconnection within the track circuit occurs and the stray DC can then falsely energise the relay.

Typical sources of DC interferences can be:

- Common bonding with adjacent track circuits
- Certain types of concrete sleepers, typically bullhead concrete sleepers that were used widely on the Southern Region of British Railways
- Areas where the track is on an ash foundation

With a second track relay connected across the rails at the feed end, the possibility of an unsafe failure is reduced. Whilst a feed end relay can be applied to any DC track circuit, the additional load imposes a reduction in maximum permitted length and if primary cells are used, it will reduce the operational life of those cells.

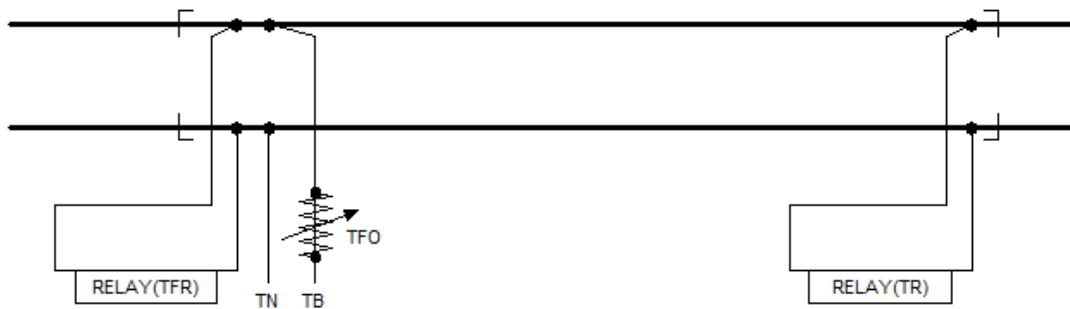


Figure 7 - Feed End Track Relay

Where such a relay is fitted, the following shall apply:

- The feed end relay shall be to the same specification as the track relay (TR).
- The feed end relay shall be connected across the rails at the same position as the feed, although its connections to rail shall be independent of those used for the feed.
- Both relays shall independently control the track repeat relay (TPR).
- There shall never be more than two track relays on one track circuit.

6.2.2 Relay End Adjustment Resistance

Designs of track circuit using the BS1659 (9-ohm) shelf type or BR938 (4-ohm) plug-in relay operate at a drop-away rail voltage below 0.3V and are therefore susceptible to loss of train shunt under adverse conditions. The track feed set should be capable in providing at least 3V DC to the rails. This type of track circuit is ideal for use where a railway operates infrequently.

The sensitivity of these relays can be improved by inserting additional resistance in series with a track relay. To achieve the correct voltage at the relay the track circuit feed supply will have to be increased. This will raise the rail voltage at which it operates and therefore reduce the significance of any interference voltages present across the rails.

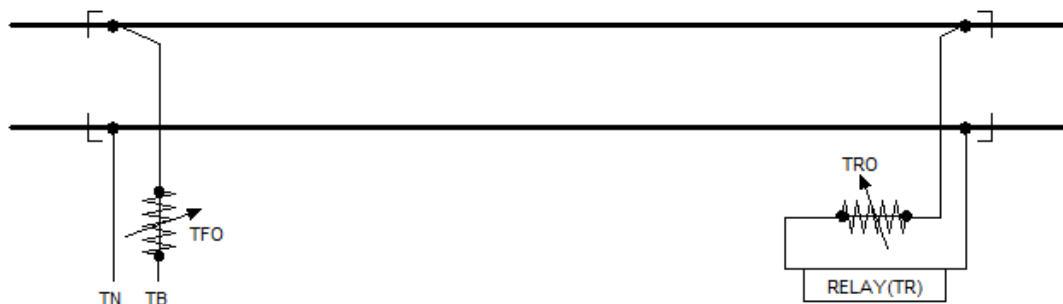


Figure 8 - Track Circuit with a Relay End Adjustment Resistor

This arrangement will reduce the maximum length of the track circuit.

Note: The AC immune track relays to BR939 (20-ohm), BR966 F2 (9-ohm) and BR966 F9 (60-ohm) have drop-away values in excess of 0.7V, and will operate satisfactorily without the need of a relay end resistor.

Note: Track circuits using the BS1659 (2-ohm or 2.25-ohm) relays cannot be improved with this method and should not be used where the problems may occur.

6.2.3 Diode Track Circuit.

A diode track circuit has both the track relay and the feed at one end of the track circuit, with a diode across the rails at the opposite end. It requires an AC power supply, making it more difficult to provide a standby. It is particularly useful at level crossings in rural areas, and terminal lines where providing lineside power distribution cable may not be practical.

Power is supplied to the rails via a transformer and series adjustable feed resistance with a BR966 F2 (9-ohm) track relay connected across the feed leads. This is an AC track circuit using a DC relay.

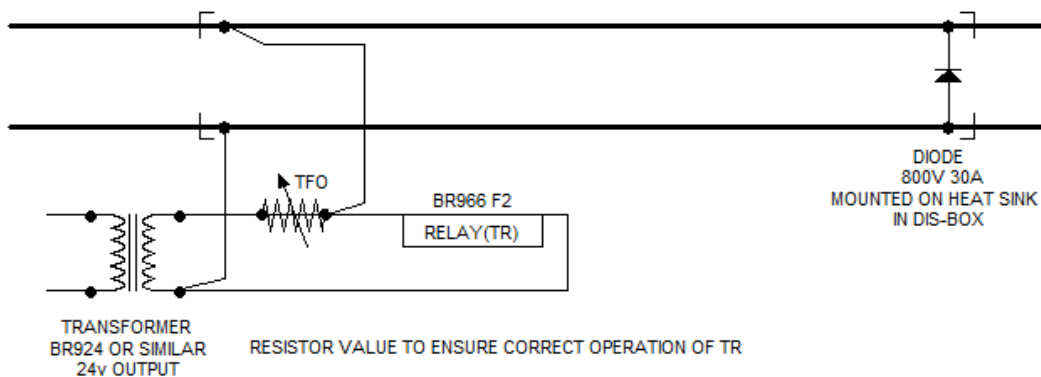


Figure 9 - Basic Diode Track Circuit

The diode presents a near short circuit to alternate half cycles of the AC supply, therefore the rails and relay are presented with a half wave rectified waveform to which will allow the relay to pick.

With an open circuit through the diode or any other disconnection, only AC is present on both rails or across the relay and therefore the relay remains de-energised.

The presence of a train or a short circuit failure of the diode, the AC supply is not rectified and therefore the relay will not pick. The feed resistance will act as a load to the supply.

Although the design uses an AC immune relay, the track circuit itself is not AC immune.

A treadle is sometimes provided at the diode end (normally when used at a level crossing), and this normally configured so that it disconnects the diode and applies a short circuit across the rails.

6.3 Insulation and Isolation

The power supplies feeding a DC track circuit are generally earth free in order to give a degree of first earth fault tolerance. The equipment shall therefore be suitably isolated from any conductive material that may become earthed (e.g. signal wires, point rodding etc.).

7 TESTING (NEW TRACK CIRCUIT)

7.1 The Basic DC Track Circuit

The details below relate to a basic DC track circuit, and not those that are fitted with a track relay resistor (see section 7.2). The following procedure should be used to set up a new track circuit. When the set up procedure has been done, the fuses and links should be disconnected until the Signal Engineer has arranged for an independent test.

With all links and fuses for the track circuit and its equipment disconnected:

1. Check that all the equipment is as specified in the installation drawings and that all wires to terminals are correctly tightened.
2. Check that all the rail connections, jumper cables, bonds and insulated joints are correctly installed and that all connections are tight.
3. (Mains feed) Adjust the power input connections to suit the mains supply voltage.
4. Set the feed resistor to mid-value.

Insert the links and correct rating fuse for the track circuit feed unit and “power up”.

5. Adjust the output of the feed unit so that there is the required charge rate to the standby battery (if fitted). See section 5.4 for the setting up of a transformer/rectifier set.
6. Check that the track relay picks up and there is the required minimum voltage across the coil for the type of relay. If the relay does not pick up, adjust the feed resistor or locate any fault and rectify.
7. Check that the rail polarities are correct to the drawings. If not, locate the fault and rectify.
8. Carry out a drop shunt test. The shunt box should be applied to the rails at the relay end of the track circuit (not at the feed end relay if fitted at this stage), starting at a higher value (typically twice the desired shunt) reducing the resistance until the track relay breaks its contacts (NOT when the electrical repeat circuit is lost). Check the value is within the parameters for the type of relay in use. Should the drop shunt value not fall within the values in table 8.4.1 (or the parameters set by the Signal Engineer), then the feed end resistor should be adjusted to increase or decrease the value. Add resistance if the drop shunt is too low, decrease the resistance if the drop shunt is too high. Exercise caution when stepping from $x.0\Omega$ to $x(-1).9\Omega$ to ensure that you do not go through the open circuit setting of the shunt box.
9. Carry out a prevent shunt test. The shunt box is maintained on the rails from the previous step starting with a shunt of zero ohms and the resistance is increased until the relay makes its contact fully. Typically this value can be up to double that of the drop shunt. Exercise caution when stepping from $x.9\Omega$ to $x(+1).0\Omega$ to ensure that you do not go through the open circuit setting of the shunt box otherwise the relay could energise and give a false reading.
10. Carry out the drop shunt test and prevent shunt test at the track feed relay and ensure the values fall in the parameters in section 8.4.1 (or that set by the signal engineer). The residual voltage check need not be carried out. If adjustments are undertaken then the track relay end must be rechecked. Typically the values of the drop shunt and prevent shunt will vary between 0 and 0.2Ω greater than the value in sections 8 and 9
11. Watch the track relay as the feed links are disconnected. The relay should drop away in a positive manner. Measure the voltage across the relay and ensure that it does not exceed the values in the table below. Should the relay not de-energise or the value recorded is greater than that in the table below then the source of the stray voltage should be investigated – see section 6.2.1
12. With the track circuit energised, watch the relay as the rails are shorted together by the use of a 0.5Ω shunt. The relay should drop away in a positive manner. This test should be carried out at each end of the track circuit, in the middle and through any point connections within the track circuit.

Residual voltage values:

BR/BS Specification Relay	Resistance	Pin Code	Desired maximum voltage	Absolute maximum voltage with a single relay
BS1659	9	Shelf Type	0.103V	0.160V
BR938	4	101	0.111V	0.175V
BR939	20	105	0.438V	0.695V
BR966F2	9	110	0.291V	0.462V
BR966F9	60	104	0.840V	1.332V

No values are available for 2 / 2.25 ohm relays but desired value should be no greater than 30% of the voltage on the track relay when it drops out (Test 8 above), and the absolute maximum should be no greater than 70%.

7.2 Track circuit with a relay end resistor

The following procedure should be used to set up a new track circuit. When the set up procedure has been done, the fuses and links should be disconnected until the Signal Engineer has arranged for an independent test. Ideally the use of two shunt boxes is required to set the track circuit up for the first time.

With all links and fuses for the track circuit and its equipment disconnected:

1. Check that all the equipment is as specified in the installation drawings and that all wires to terminals are correctly tightened.
2. Check that all the rail connections, jumper cables, bonds and insulated joints are correctly installed and that all connections are tight.
3. (Mains feed) Adjust the power input connections to suit the mains supply voltage.
4. Set the feed resistor to mid-value.

Insert the links and correct rating fuse for the track circuit feed unit and “power up”.

5. Adjust the output of the feed unit so that there is the required charge rate to the standby battery (if fitted).
6. Check that the track relay picks up and there is the required minimum voltage across the coil for the type of relay. If the relay does not pick up, adjust the feed resistor or locate any fault and rectify.
7. Check that the rail polarities are correct to the drawings. If not, locate the fault and rectify.
8. Short circuit the rails and measure the current at the feed end (Use the ammeter as the shunt). Adjust the feed end resistor to so that the value is as near as 700mA as possible.
9. At the relay end adjust the resistance so that the track relay voltage is approximately double of the minimum pick up voltage for the relay concerned.
10. Carry out a drop shunt test. The shunt box should be applied to the rails at the relay end of the track circuit, starting at a higher value (typically twice the desired shunt) reducing the resistance until the track relay breaks its contacts (NOT when the electrical repeat circuit is lost). Check the value is within the parameters for the type of relay in use. If the track circuit needs to be adjusted then alter the adjustment resistor until the desired shunt is reached. When setting a track circuit up in this configuration the minimum value should be 1.2Ω . Add resistance if the drop shunt is too low, decrease the resistance if the drop shunt is too high. Exercise caution when stepping from $x.0\Omega$ to $x(-1).9\Omega$ to ensure that you do not go through the open circuit setting of the shunt box.
11. Carry out a prevent shunt test. The shunt box is maintained on the rails from the previous step starting with a shunt of zero ohms and the resistance is increased until the relay makes its contact fully. Typically this value can be up to double that of the drop shunt. Exercise caution when stepping from $x.9\Omega$ to $x(+1).0\Omega$ to ensure that you do not go through the open circuit setting of the shunt box otherwise the relay could energise and give a false reading.
12. Repeat the setting up process for any track feed relays as detailed in section 9 and 10. The residual voltage check (test 13 below) need not be carried out. If adjustments are undertaken then the track relay end must be rechecked. Typically the values of the drop shunt and prevent shunt will vary between 0 and 0.2Ω greater than the value in sections 8 and 9
13. Watch the track relay as the feed links are disconnected. The relay should drop away in a positive manner. Measure the voltage across the relay and ensure that it does not exceed the values in the table below. Should the relay not de-energise or the value recorded is greater than that in the table below then the source of the stray voltage should be investigated – see section 6.2.1
14. With the track circuit energised, watch the relay as the rails are shorted together by the use of a 0.5Ω shunt. The relay should drop away in a positive manner. This test should be carried out at each end of the track circuit, in the middle and through any point connections within the track circuit.

7.3 Completion of initial setting up procedures

When the setting up procedure is complete, if independent testing is not to follow, disconnect the fuses and links.

Commissioning must only be carried out under the guidance of the Tester in Charge.

8 MAINTENANCE

From October 1st 2010 maintenance is subject to the ROGS requirements on minor railways.

8.1 Before Starting Work

Before working on any track circuit, inform the signaller and come to an understanding as to the work to be done. Any work which involves disconnecting a track circuit may lock signals and points and prevent train movements.

8.2 Visual Examination

A track circuit must be maintained so that it is able to detect the presence of trains under all conditions.

1. Check all bonding and jumper cables to ensure they are secure and not broken.
2. Check all feed and relay cable terminations on the track and in the location.
3. If provided, check any disconnection boxes are secured with a cover and padlocked.
4. Check that signal wires, point rodding and other metal services are clear of the rails.
5. Check the insulation of all IRJs.
6. Check any insulation of point stretcher bars.
7. Check any track circuit interrupters are secure and are not broken or cracked
8. Check that the primary cells or track feed unit (including secondary cells) are the correct type and are not damaged.
9. Check that the relay(s) are the correct type and are not damaged.

8.3 Voltage testing

If a track circuit is fed by primary cells, check that the voltage is above the required minimum. Always replace primary cells as soon as there is a noticeable drop in voltage.

If the track circuit is fed from a mains supply, check that the mains voltage is within limits and that the input tapplings (if provided) on the feed unit are correct. Check that the output voltage is within limits and that the output tapplings (if provided) are correct.

Where secondary cell(s) are provided, check that the voltage and current to the cell(s) are correct.

Check the feed end rail voltage. Generally this will not vary by much if the power source voltage does not change.

Check the relay end rail voltage. This will vary depending on the ballast condition; wet ballast will reduce the relay end voltage thus increasing the likelihood that the relay will drop with no train on the rails (right-side failure). Dry ballast will increase the relay end voltage which could mean that the relay may drop with a train on the rails (wrong-side failure).

The balance of rail voltage must be considered with regard to the drop shunt values shown in section 8.4.1.

8.4 Drop Shunt Testing

The feed voltage to the track circuit must be maintained such that the track relay will detect trains under all circumstances. To ensure this is effective, the track circuit will be tested by placing a test resistance across the rails at the relay end. If a feed end relay is provided, the drop shunt test must be carried out for each relay.

It may also be required to carry out a drop shunt test at the feed end on bi-directional lines to ensure that a train can be reliably detected at each end.



Figure 10 - 0 to 10-ohm Track Circuit Test Shunt Box

8.4.1 Best Practice Drop Shunt Values.

These values may vary for different Railways, particularly with regard to ballast conditions and railways of a narrow gauge.

Track Circuit Type	Minimum	Desired
DC Basic Configuration	0.5Ω	0.8Ω
DC using BR867 feed unit (9-ohm or 20-ohm relay)	0.5Ω #1	0.8Ω
DC using BR867 feed unit (60-ohm relay)	1.2Ω #1	1.5Ω to 1.7Ω
DC with Feed End Relay	0.5Ω	0.8Ω
DC with Relay End Adjustable Resistor	1.0Ω	1.3Ω to 1.5Ω
DC with Relay End Adjustable Resistor & 60-ohm Relay	1.2Ω	1.5Ω to 1.7Ω
Rectified AC (Diode)	0.5Ω	1.5Ω

Notes; #1 – This type of track circuit must not be less than the drop shunt shown.

A typical test shunt box is shown in figure 10. This has settings from 0 to 10-ohms in steps of 0.1-ohms.

8.5 Maintenance Standards

Each Railway should establish a maintenance standard, based on the type of equipment used and other prevailing factors listed in section 8.3.

8.6 Maintenance Intervals

Track circuits must be tested at regular intervals and the results recorded (see section 8.4).

The frequency of maintenance will be different for each Railway, based on the following factors, this list is not exhaustive:

- Usage.
- Weather and/or exposure to salt spray or other corrosives.
- Liability to vandalism.
- Presence of primary or secondary cell(s).
- Operational periods of the railway.

8.7 Maintenance Records

It is recommended that every inspection, test or equipment replacement is recorded in a logbook, record card or database. The best practice method for a track circuit is to record the details on an individual record card which is maintained with the track relay. A copy of this information should be maintained on a central database.

Generally the following items are recorded:

- Date of the test.
- Who undertook the test.
- Mains voltage (if used).
- Track feed voltage.
- Track relay voltage.
- Type, make and serial number of voltmeter used.
- Drop shunt value.
- Pick-up shunt value.
- Ballast condition (wet, dry, frozen etc.).
- Condition of the equipment, including batteries (if fitted).
- Any other information.

8.7.1 Development of Maintenance Plan

The use of the detailed maintenance records will enable the development of a maintenance plan, which will make the best use of the available staff or volunteers.

9 REFERENCES

RSSB Railway Group Standards see www.rgsonline.co.uk

RSPGs and RSPs Issued by the Office of Rail Regulation see www.rail-reg.gov.uk

- [Railway safety principles and guidance Part 1 \(1996\)](#) (HSE 1996)
- [RSPG Part 2B - Guidance on stations \(1996\)](#)
- [RSPG Part 2D - Guidance on signalling \(1996\)](#)
- Railway Safety Publication No 3; [Safe movement of trains](#)
- Railway Safety Publication 4; [Safety critical tasks - Clarification of ROGS regulations requirements](#)
- Railway Safety Publication 5; [Guidance on minor railways](#)

Department for Transport

Railways and Other Guided Transport Systems (Safety) Regulations 2006; Statutory Instrument No 2006/599.

10 APPENDICES

None.