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Issue	I
Date	December 2000

Reed Type RT Track Circuits (formerly RT/E/PS/11763)

This temporary front sheet facilitates change to the new Network Rail Standards referencing nomenclature.

The Ref above will be formally allocated to this standard when it is next changed in the meantime the contents, date and issue number of this Network Rail Standard are UNCHANGED and with immediate effect it should be referred to as “(new ref) formerly (old ref)”.

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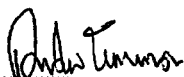


RAILTRACK LINE PRODUCT SPECIFICATION

REED TYPE RT TRACK CIRCUITS

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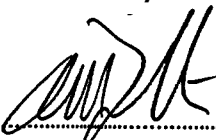
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Summary

This Line Specification states the minimum requirements for Alstom Reed Type RT Track Circuits. It includes lifecycle requirements from design, safety and environmental to installation, testing and maintenance.

Issue/Revision Record

Issue	Date	Comments
1	December 2000	New Specification. The contents are based on Railway Group Code of Practice GK/RC0763 which is to be transferred to Railtrack Line in February 2001.

Implementation

The requirements of this Specification shall apply to all Alstom Reed type RT track circuits supplied for use on Railtrack controlled infrastructure on or after 3 February 2001. It shall also apply to the alteration and maintenance of existing Alstom Reed type RT track circuits from the same date. The following document is superseded:

Superseded document

GK/RC0763 Issue 1 December 1999 - Reed Track Circuits, Type RT

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I INTRODUCTION

I.1 Purpose

This Product Specification gives details of best practice in respect of Alstom Type RT Reed track circuits in order to achieve the requirements of RT/E/S/11752.

I.2 Scope

The contents of this Product Specification apply to all Alstom Reed Type RT track circuits. The more general requirements can be found in RT/E/S/11752. Safety issues specific to Reed applications are included; general safety issues are contained in RT/E/S/11752 and other relevant Railtrack standards.

The following applications are addressed:

- Standard double and single rail Reed track circuit;
- High Performance arrangement of Reed track circuit (single rail);
- High Power variant Reed track circuit (in restricted detail);
- jointless Reed track circuit (in very restricted detail, as not generally permitted for new work).

The earlier Type R Reed track circuit is not covered by this document, though the operating principles are the same and most of the same considerations apply equally to type R as to type RT. However the actual equipment is physically different, and the transmitter and receiver gains, unlike the type RT, are pre-set or semi pre-set.

I.3 Introduction

The Alstom Reed track circuit is an audio frequency track circuit.

I.4 Features

The type RT Reed track circuit is capable of operating in jointless and jointed modes. However due to operating problems in the presence of traction bonding its jointless use is restricted to a few existing installations in non electrified areas. In electrified areas it must be used in jointed mode.

Reed Type RT Track Circuits

The Reed track circuit is immune to 50Hz a.c. and to d.c. interference. It has some immunity to interference from train-borne electrical systems and external electrical systems. However, immunity to power supply frequencies and their harmonics is dependant upon a stable supply frequency of 50Hz, maintained within tight frequency tolerances. Whilst supplies derived from the National Grid are considered to be sufficiently controlled to ensure compatibility, this may not necessarily be so for power supplies used either on board trains or elsewhere within the railway environment. Full track circuit settings are not calculated during design, and shall not be shown in the wiring diagrams. After the initial setting up, no further maintenance adjustments are required at the transmitter end.

A power supply is required at the receiver end as well as at the feed end.

Due to its tuned operation, the Reed track circuit has a long drop-away time (Category C), which requires two slow-to-pick TPRs, as described in RT/E/S/11752, Part F, section 6. The High Performance Arrangement with adjustable track filter is operating Category B and requires one slow to pick TPR. With the exception of T1.21 track circuits, track circuits abutting Category C Reed track circuits also require two slow-to-pick TPRs.

2 APPLICATION AND CONSTRAINTS

2.1 Application

The application of Reed track circuits fulfils the basic requirement for continuous train detection.

Where additional integrity is required, e.g. for the operation of automatic level crossings (not locally monitored), they shall be used in conjunction with some other type of train detection device.

Use of jointless Reed track circuits (or, to a degree, the use of an intermediate receiver) allows a signal overlap to be created simply by overlapping adjacent track circuits, without the need for an additional overlap track circuit. However, intermediate receivers shall not be used to define a precise clearance point.

The use of Reed track circuits is only cost effective where their functional capabilities are of benefit, e.g. to give traction immunity or (where the jointless variety is permitted) to avoid the need for IRJs.

2.2 Constraints

Reed equipment is generally designed for use on single rail or double rail jointed tracks; in plain line and through switches and crossings (S&C), subject to the constraints given in sections 2.2.1 to 2.2.7, in addition to the general restrictions given in RT/E/S/11752.

However, Reed track circuits are not restricted by the following:

- Reed track circuits are generally immune to both a.c. and d.c. interference.
- They may be arranged so that trains run onto the track circuit at either the Tx or Rx end.
- There is no special balancing requirement in respect of check rails and guard rails.

2.2.1 General

a) Designs for New Work

Only the following designs provide the required integrity for new work:

- Standard double and single rail jointed Reed track circuit;
- High Performance arrangement of jointed Reed track circuit (single rail);

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- High Power variant jointed Reed track circuit (where specially permitted).

b) Maximum Length

The maximum operational lengths, which are dependent upon the configuration used and minimum ballast resistance that can be expected, are given in section 3.3.

c) Operating Category and Interface Delay Requirements

Due to its tuned operation, the Reed track circuit has a long drop-away time (Category C), which requires two slow-to-pick TPRs, as described in RT/E/S/I 1752, Part F, section 6. The High Performance Arrangement with adjustable track filter is operating Category B and requires one slow to pick TPR. With the exception of TI.2I track circuits, track circuits abutting Category C Reed track circuits also require two slow-to-pick TPRs. Time delays must be considered during the design stage of schemes utilising Reed track circuits. The rules for interface delay requirements and limitations on minimum length are fully covered in section 3.4.

d) Level Crossings

Reed Track Circuits are not generally usable over level crossings for the following reasons:

- Wide variations in ballast resistance due to road debris, salt, etc;
- Bomac units can have unpredictable effects on operating values.

Reed track circuits may be used over crossings not likely to be fitted with Bomac units, e.g. footpath, bridle path, occupation, etc;

e) Steel Sleepers

The operation of Reed track circuits on steel sleepered track may be unpredictable, particularly where loop receivers are used.

f) Track Circuit Interrupters

Reed track circuit bonding shall not be wired in series with track circuit interrupters. A separate relay circuit shall be provided in accordance with RT/E/PS/I 1764.

2.2.2 Electromagnetic Interference

a) Equipment Proximity Restrictions

There are proximity restrictions in the positioning of Reed track circuit equipment and cabling in relation to the following equipment, due to electromagnetic interference. Details are given in section 6, Environmental Requirements.

- Aster Track Circuit Equipment,
- TI.2I Track Circuit Equipment,
- WSL FS Track Circuit Equipment,
- FDM Transmission Systems,
- Reed Point Detection Equipment,
- CCTV Equipment.

b) Compatibility with Types of Traction Unit

See RT/E/S/11752, for guidance on rolling stock compatibility. Reed track circuits are not fully compatible with three-phase traction systems, although the High Performance variant gives some improvement. This variant also gives enhancement for operation by lightweight vehicles (see section 2.2.8).

The frequencies to be used in the presence of three-phase traction may need to be determined for individual traction type. This requires reference to the Rolling Stock Acceptance Board certificate.

c) Adjacent to London Underground Lines

Frequency 218 (384Hz) shall not normally be used on lines adjacent to London Underground lines or lines over which London Underground trains run.

d) Adjoining Other Types of Track Circuit

There are special restrictions when abutting with other types of track circuit, due to interference. In addition, IRJs are required on both rails. The effects of interference are minimised by the application of the following limitations:

- Reed track circuits shall not abut FS2600 track circuits. An individual safety assessment shall be made to justify the minimum distance between Reed track circuits and FS2600 track circuits at each boundary. The assessment shall be approved by the Railtrack Safety Assessment Panel.

- The Reed track circuit has the potential to falsely energise certain d.c. track circuits (diode track circuits) or WR quick release track circuits. Therefore, the only permissible interface between the Reed track circuit and a quick release track circuit is at the feed end of the quick release track circuit. However, as the relay of the diode track circuit is at the feed end, the interface must be at the diode end (the other end).

2.2.3 Electrified Areas

a) General

General track circuit restrictions in electrified areas are given in RT/E/S/11752.

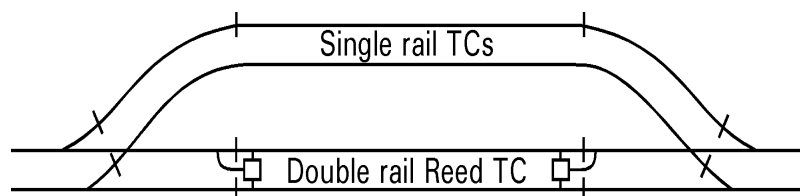
In electrified areas, only jointed track circuits may be used.

With single rail track circuits, traction return cross bonding must be provided at all insulated rail joints (IRJs) in the traction return rail. The traction return rails in adjacent terminal platforms shall also be bonded together at the buffer stop end (see Part F of RT/E/S/11752).

Double rail track circuits require the use of impedance bonds, in accordance with the following rules (see RT/E/PS/11765 for traction cross bonding intervals):

- Not more than 4 impedance bonds may be installed in any centre or end fed track circuit (a centre fed track circuit counts as a single track circuit for the purposes of this restriction).
- No loop is to be positioned over an impedance bond or a traction transposition.

Double rail reed track circuits must not be arranged so that they are either surrounded by a single rail area or a non-track circuited area bonded for traction return, i.e. the following is prohibited:



b) D.C. Electrified Areas

Reed track circuits are generally only found in a double rail configuration in d.c. electrified areas, except where immunity to 25kV a.c. electric traction is also required (see item d). The following rules apply:

- Only DE, MR, P3, S and WH3 style 50 Hz tuned impedance bonds, fitted with the appropriate tuning capacitor, may be utilised.
- Particular care shall be taken to ensure that no false clearance of the track circuit can be obtained via traction return bonding.
- In conductor rail electrified areas, protection boarding shall be fitted to single rail track circuits where specified in Part C of RT/E/S/11752.

c) A.C. Electrified Areas

Single or double rail track circuits may be used in a.c. electrified areas. The following rules apply:

- See Appendix C of RT/E/S/21085 for traction cross bonding intervals. In order to ensure the compatibility of Reed track circuits and particular types of electric train, it may be necessary to impose restrictions on maximum cross bond spacings.
- Intermediate loops are not permitted on single rail track circuits in a.c. electrified areas.
- For double rail track circuits, only style DD, DF, S and WH3 impedance bonds may be used.
- With double rail track circuits, structure bond connections shall be made to impedance bonds. With single rail track circuits, the traction return rail shall, wherever practicable, be positioned on the cess side to enable structure bonds to be kept short.

d) Dual Electrified Areas

Single or double rail track circuits may be used in dual electrified areas. The following rules apply:

- For double rail track circuits, only style S and WH3 impedance bonds may be used.

- If used as single rail track circuits, it is likely that the maximum length of the track circuits will need to be reduced in order to provide an acceptable margin between the traction interference levels and the track circuit's susceptibility. The agreement of the Infrastructure Controller shall be obtained for any proposed single rail use of Reed track circuits in dual electrified areas.
- Intermediate loops are not permitted on single rail track circuits in dual electrified areas.
- Particular care shall be taken to ensure that no false clearance of the track circuit can be obtained via traction return bonding.
- In conductor rail electrified areas, protection boarding shall be fitted to single rail track circuits where specified in Part C of RT/E/S/11752.

2.2.4 Jointed Double Rail Track Circuits

Double rail track circuits can be used in the standard or High Power arrangements (but not High Performance), subject to the following restrictions:

- The constraints on use in electrified areas are given in section 2.2.3.
- Double rail Reed track circuits are not generally suitable for use through S&C, but they are permitted through emergency/engineer's ground frame points or clipped and padlocked (C&P) points.
- The High Power variant (see section 4.5) shall only be used in exceptional circumstances with the agreement of the Infrastructure Controller.

2.2.5 Jointed Single Rail Track Circuits

Single rail track circuits can be used in the standard, High Performance, or High Power arrangements (but only in jointed form), subject to the following restrictions:

- The constraints on use in electrified areas are given in section 2.2.3.
- The High Performance arrangement (see section 4.4) is only available in single rail configuration.
- The High Power variant (see section 4.5) shall only be used in exceptional circumstances with the agreement of the Infrastructure Controller.

2.2.6 Intermediate Simple (Receiver) Loops

Due to the inherent delayed operation of simple intermediate loops the following rules shall be observed:

- The constraints on use in electrified areas are given in section 2.2.3.
- Transmitter to centre of loop distance must be between 60m and 500m.
- Centre of Loop to jointed receiver minimum distance is 500m.
- If the loop is required to define the exact position of a train (e.g. track circuit overlap or strike-in for an automatic level crossing), and the trains run from the transmitter to the loop, then there is an indeterminate shunt zone 10m before the loop in which the loop may or may not be shunted by the rear of the train. If however the train runs from the loop towards the transmitter, then the actual position of the loop needs to be further from the transmitter than the position at which the loop is required to be shunted by 60m plus 1.5 seconds travelling distance at permitted speed.
- Due to the imprecise length of the shunt zone, intermediate receivers must not be used for level crossing run-by protection.
- Intermediate loops are not permitted on single rail track circuits in a.c. electrified areas.
- Intermediate loops are not practical with the High Performance Arrangement as it would be hard to set up the intermediate receiver to the same standards as the ends.

2.2.7 Jointless Reed Track Circuits

Jointless track circuits shall only be used in exceptional circumstances with the agreement of the Infrastructure Controller, subject to the following restrictions:

- They are not permitted in electrified areas.
- They cannot be used through S&C in single rail configuration.

2.2.8 Lightweight Vehicles and Others Susceptible to Poor Train Shunt

Reed type track circuits are not generally permitted on non-electrified lines used by lightweight vehicles in Classes 14X to 16X or other modern rolling stock designated as susceptible. However, these types of track circuit may be used in the following circumstances:

- on uni-directional lines,
- where sequential track circuit proving is provided, or
- where an assessment shows that all susceptible vehicles permitted to use the line are fitted with Track Circuit Assisters (TCAs).

3 FUNCTIONAL REQUIREMENTS

3.1 Principles of Operation

The Reed track circuit equipment type RT, which may be jointed or jointless, is a development of the Reed remote control equipment type R and the earlier type 'R' track circuit. It employs circuits which are tuned to a very high Q factor by means of the electromechanical tuning fork principle, having a pair of vibrating reeds which are used to produce a band pass filter which has a bandwidth of about 1 Hz and a very stable centre frequency. For track circuit equipment designed for UK use, the frequencies are chosen to lie between harmonics of the 50Hz mains power supply frequency and the standard sets of frequencies lie between the 7th and 8th harmonics and between the 8th and 9th harmonics, the narrow bandwidth allowing channel spacings down to 3 Hz.

A Reed track circuit consists of a transmitter which feeds audio frequency oscillations into the rail and a receiver at the relay end which is tuned to receive only that specific frequency. Immunity from sources of interference is maximised by the very small bandwidth of the receiver filter.

The Reed track circuits, type RT, are provided in both jointed and jointless configurations. Both types use the same transmitter and receiver but differ in the manner in which the audio frequency signal is taken from the rails at the receiver or relay end. For a jointed track circuit, this is done by direct connections to the rails, as with a conventional track circuit, but in the jointless version the audio signal is inductively coupled to a loop which is laid between the rails. The jointed version must be used where insulated block joints need to be provided (e.g. at S&C) and for lines which also require a.c. and/or d.c. immunity. The jointless version was intended for use on continuous welded rail as it obviates the need for insulated joints, but is restricted in use and must not be used in electrified areas. However an intermediate (jointless) simple receiver loop can be used with the jointed track circuit to give a multi-section track circuit for instance to indicate the start of the overlap for a signal when the track circuit end marks the end of the overlap. The shunting zone of the intermediate loop and at the ends of the jointless track circuit are variable such that the physical point at which a train is detected cannot be fully predicted. This must be addressed in individual design.

The feed end equipment is provided in a standard and a high power version, the latter being for use in areas of very low ballast resistance or where the traction return current is exceptionally high. The standard transmitter, which is also used for the High Performance Arrangement is suitable for ballast resistances as low as 2 Ω km. The high power transmitter is for ballast resistances as low as 1 Ω km, and in double rail form allows exceptionally long track circuits where intermediate equipment is inconvenient, as in tunnels.

A Reed jointed track circuit can be used as a single or double rail circuit and can be either end fed or centre fed. The basic layouts are shown in Figures 1 and 2. In d.c. electrified areas, only double rail track circuits are permitted, except at the agreement of the Infrastructure Controller when immunity to 25kV a.c. electric traction is also required.

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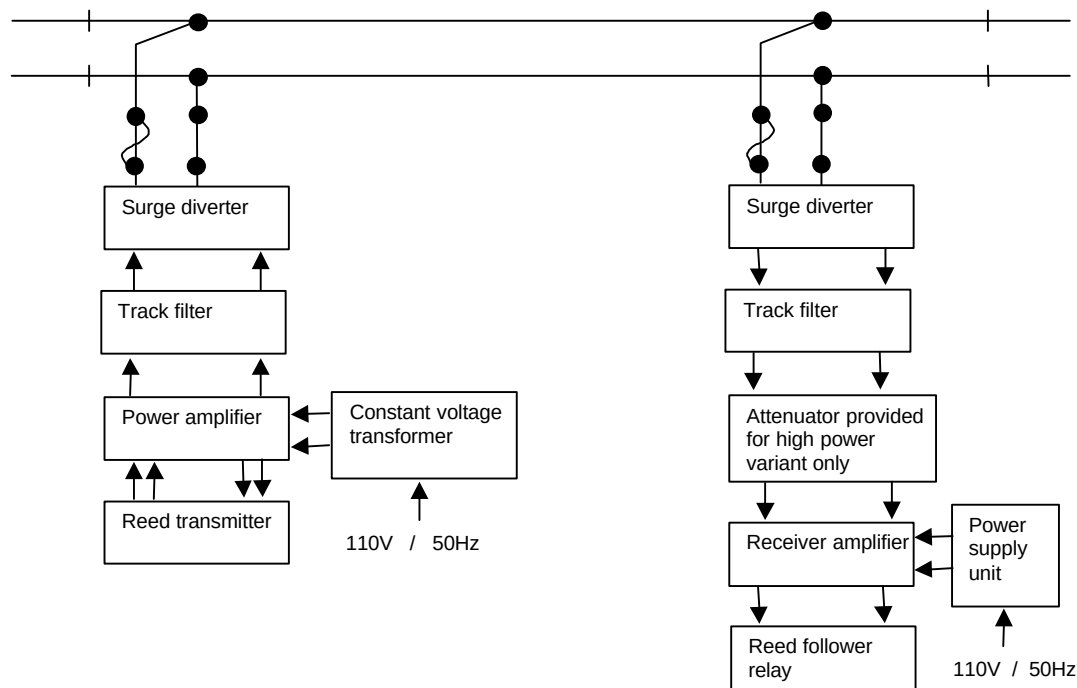


Figure 1 - Block Schematic of Reed jointed Track Circuit (End Fed)

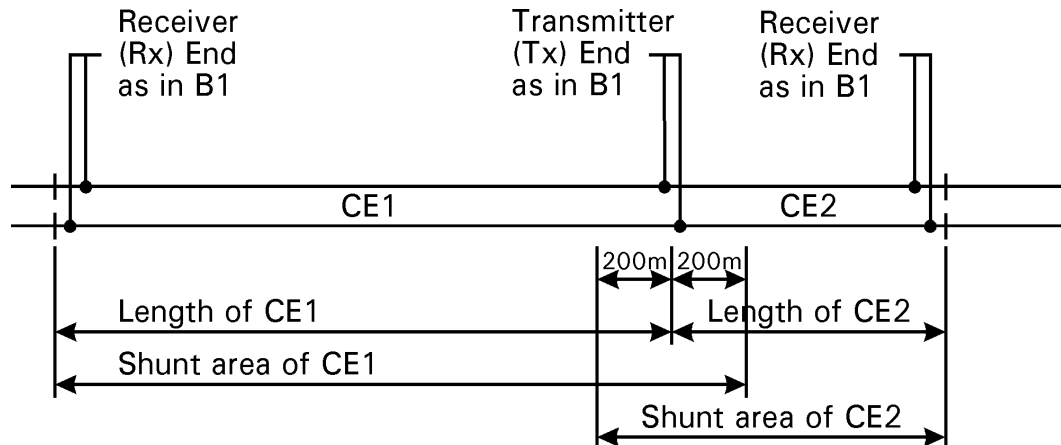


Figure 2 - Layout of Reed jointed Track Circuit (Centre Fed)

A Reed jointless track circuit is always centre fed, except where jointless track adjoins a jointed section, in which case the transmitter or a jointed receiver must be placed at the block joint. The basic configuration of a jointless track circuit is shown in Figure 3.

Additional intermediate Rxs can be positioned within a Reed track circuit (jointed or jointless) with the use of a loop of cable mounted in the four foot. See Figure 4. The signal is detected in the rails by means of this loop and is fed via an attenuator filter and the Rx amplifier/filter to the TR which functions as at a jointed Rx. Note that the use of intermediate loops is not practical with the High Performance Arrangement. The loop acts as a step-up transformer, the running rails providing the primary turn. (For standard arrangement the loop is 36 turns, and for high power set up the loop is modified to 11 turns). The track circuit signal current passes by the loop in one rail, then via the ballast and jointed receiver to return again past the loop in the other rail, thus inducing a voltage of that signal in the loop. Hence no output will result when a train shunts the track circuit on the Tx side of the loop.

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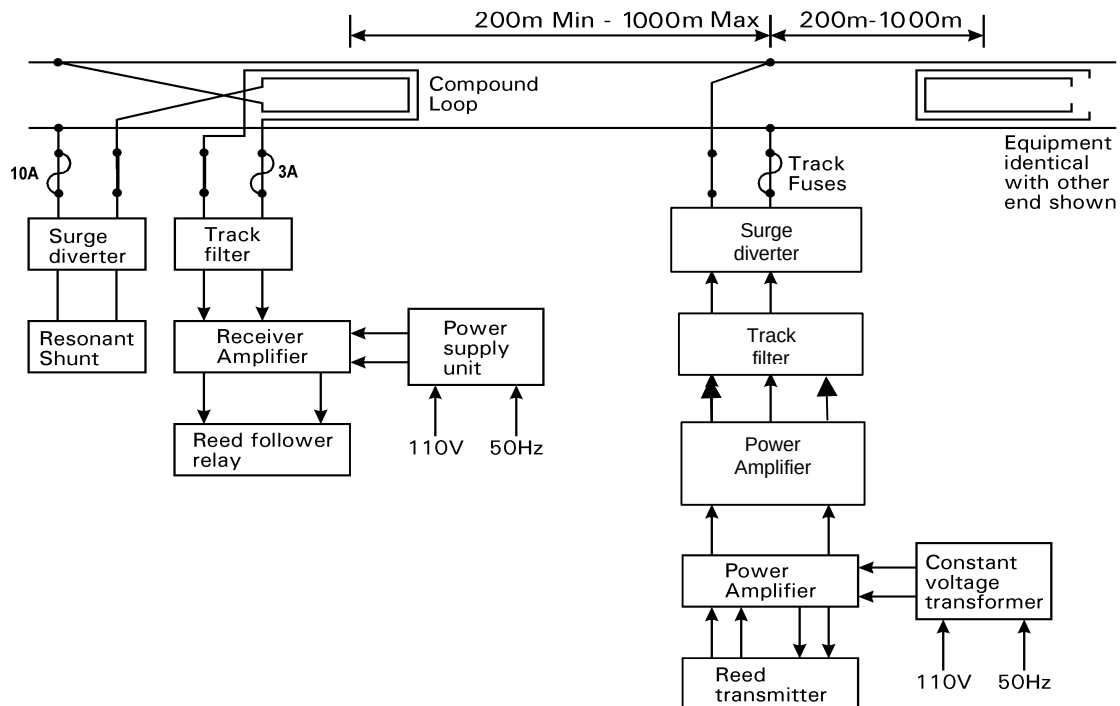


Figure 3 - Block Schematic of Reed Jointless Track Circuit (Centre Fed)

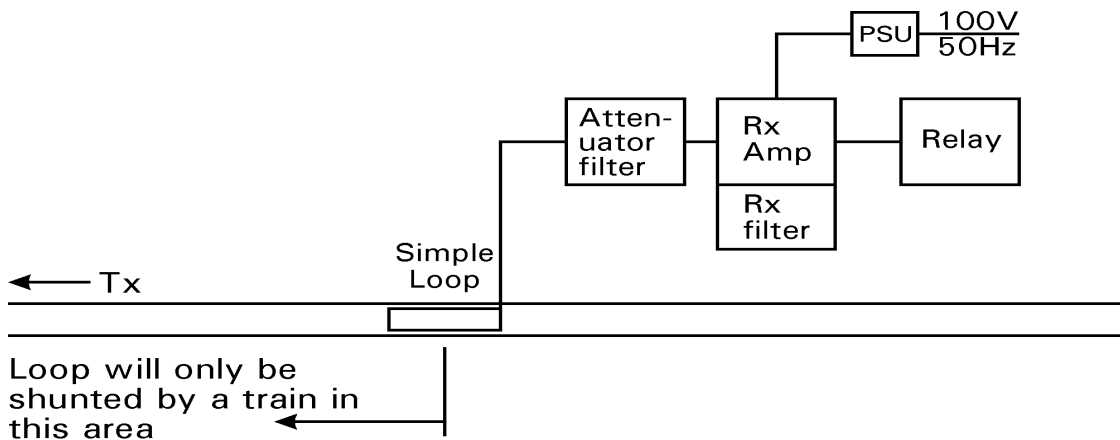


Figure 4 - Block Schematic of Intermediate receiver within a Reed TC

Traction return current (if in balance) will pass by the loop equally and in the same direction in each rail. Voltages induced in the loop will thus be cancelled out. If traction current is significantly out of balance then voltages could be induced in the loop which will cause the receiver equipment to malfunction. Note that intermediate loops are not permitted on single rail track circuits in a.c. electrified areas

The arrangements for the High-Powered track circuit are shown in Figure 8 and Figure 9. These arrangements are exceptional and only relate to a few existing installations. Any new applications shall be implemented only with the agreement of the Infrastructure Controller.

3.2 Bonding Requirements

The limits of Reed track circuits shall be defined by IRJs or by the position of receiver loops.

In single rail mode, IRJs are provided in the insulated rail. In jointed double rail mode, IRJs are provided in both rails, but intermediate receiver loops can also be provided.

In jointless mode, the extremity of each track circuit is defined by a compound receiver loop.

General details of bonding arrangements are contained in RT/E/S/11752, the following being applicable to Reed track circuits:

3.2.1 Electrified Lines

The preferred configuration is double rail, implemented with series bonding on both rails to traction standards. This is generally the only configuration found in d.c. electrified areas.

Only where the double rail configuration is impractical, such as in S&C (unless C&P, etc.), the single rail mode may be used. This shall preferably be implemented with Standard series bonding on the insulated rail and parallel Yellow traction bonding on the common rail (i.e. the traction return rail). In this mode, it shall be accepted that the traction rail bonding precludes detection of rail breakage in the common rail. The special requirements for long spurs are given in RT/E/S/11752, Part F, section 4.5.3.

3.2.2 Non-electrified Lines

The preferred configuration is double rail, implemented with Standard series bonding on both rails.

Only where the double rail configuration is impractical, generally at S&C (unless C&P, etc.), the single rail mode may be used. This shall preferably be implemented with Standard series bonding on both rails, although in complex S&C the common rail may need to be parallel bonded. The series bonded rails shall be fitted with Standard bonding and only the parallel bonded rail with Yellow Standard bonding. In parallel bonded mode, it shall be accepted that the bonding precludes detection of rail breakage in the common rail. The special requirements for long spurs are given in RT/E/S/I 1752, Part F, section 4.5.3.

3.3 Track Circuit Lengths

3.3.1 Standard Double Rail

- End Fed maximum length 1000m
- Centre Fed maximum length 2000m
- Maximum distance between Tx and Rx in centre-fed form 1000m

3.3.2 High Power Double Rail

This variant shall only be used in exceptional circumstances with the agreement of the Infrastructure Controller. It operates with a lower ballast resistance (1Ωkm) than standard (2Ωkm) and also allows a longer end fed track circuit which may be of advantage in tunnels or similar situations where placement of additional feed or receiver equipment is problematic.

- End Fed maximum length 2000m
- Centre Fed maximum length 3000m
- Maximum distance between Tx and Rx in centre-fed form 1500m

3.3.3 Standard Single Rail and High Power Single Rail

- End Fed maximum length 1000m
- Centre Fed maximum length 2000m
- Maximum distance between Tx and Rx in centre-fed form 1000m

The High Power variant shall only be used in exceptional circumstances with the agreement of the Infrastructure Controller. It operates with a lower ballast resistance (1 Ωkm) than standard (2 Ωkm).

3.3.4 High Performance Arrangement (for use on Single Rail track circuits only)

- End Fed maximum length 350m
- Centre Fed maximum length 700m
- Maximum distance between Tx and Rx in centre-fed form 350m

3.3.5 Jointless Reed

Jointless reed shall only be used in exceptional circumstances with the agreement of the Infrastructure Controller. It must **not** be used in electrified areas.

- Centre Fed length: 400m minimum 2000m maximum
- Distance between Tx and Rx: 200m minimum 1000m maximum

3.3.6 Minimum Length

There are special constraints on minimum length relating to operating time.

A 'Category C' track circuit (see section 3.4) shall be occupied for at least 550ms when any route is used at permissible speed, as described in RT/E/S/11752, Part F, section 6. This gives rise to a minimum track circuit length, effective where the permissible speed exceeds 70mph, as follows (unless a longer minimum length is applicable to the type of track circuit concerned, such as jointless reed, for which see section 3.3.5):

Permissible Speed	Minimum Length
<75mph	18.3m
75mph	19m
80mph	20m
85mph	21m
90mph	23m
95mph	24m

Permissible Speed	Minimum Length
100mph	25m
105mph	26m
110mph	28m
115mph	29m
120mph	30m
125mph	31m

3.4 Operating Category and Interface Delay Requirements

Due to its tuned operation, the Reed track circuit has a long drop-away time, so the interface delay requirements detailed in Part F of RT/E/S/11752 shall be applied. For minimum length considerations, see section 3.3.6.

Reed track circuits fitted with standard Track Filters RT7202 or RT7212 fall into operating 'Category C', which requires two slow-to-pick TPRs.

Reed track circuits fitted with adjustable track filters RT7203 or RT7213 and commissioned to the High Performance standard fall into operating 'Category B' and require one slow to pick TPR.

The requirements for abutting track circuits are given in RT/E/S/11752, Part F, section 6.

3.5 Allocation of Frequencies

Particular care shall be taken to ensure that:

- track circuits of the same frequency do not run parallel to one other;
- no false clearance of the track circuit can be obtained via traction bonding (only applicable to double rail track circuits in electrified areas);
- track circuits of the same frequency on different lines (e.g. in a four track layout) are arranged with transmitters adjacent to one another, if an IRJ failure on an interconnecting line would infringe the separation rules. Such a failure would then result in a centre fed situation.

3.5.1 Frequencies Available

To provide a series of track circuits, each Tx and Rx filter is tuned to a particular frequency.

- In d.c. electrified areas the channels are generally restricted to f211 to f218, but see section 3.5.5 for the use of channel f219;
- In a.c. and dual electrified areas the channels are generally restricted to f212 to f219.

The frequencies to be used in the presence of three-phase traction may need to be determined for individual traction type. This requires reference to the Rolling Stock Acceptance Board certificate.

In case of difficulty, see section 3.5.5 for availability of channels f220 and f221.

The channels available can be summarised as follows:

Channel	Double Rail in Electrified Areas	Single Rail in A.C. Electrified Areas	Non-Electrified Areas
f211	standard (odd line)	not used	standard (or f219)
f212	standard (even line)	standard (even line)	standard (even line)
f213	standard (odd line)	standard (odd line)	standard (odd line)
f214	standard (even line)	standard (even line)	standard (even line)
f215	standard (odd line)	standard (odd line)	standard (odd line)
f216	standard (even line)	standard (even line)	standard (even line)
f217	standard (odd line)	standard (odd line)	standard (odd line)
f218	standard (even line)	standard (even line)	standard (even line)
f219	restricted availability	standard (odd line)	standard (or f211)
f220	restricted availability	use in case of difficulty	use in case of difficulty
f221	restricted availability	use in case of difficulty	use in case of difficulty

3.5.2 Separation of Frequencies

Even numbered channels are to be used on one line and odd numbered on the other with the following restrictions:

- a) Any two track circuits of the same channel on the same line **must** always be separated by at least **2** track circuits of different channels (3 channel rotation) but, wherever practicable (e.g. on plain line), shall be separated by **3** track circuits (4 channel rotation) to allow for future alterations.
- b) In d.c. electrified areas, separation can also be achieved by using an equivalent number of double rail track circuits of different design. However, single rail track circuits (of any type) do not provide adequate separation and shall be ignored, because they generally occur in S&C where traction return cross bonding is heavy duty and extensive. In a.c. electrified areas, however, separation between single rail Reed track circuits is permitted by using single rail a.c. immune track circuits, as the impedance of the cross bonding tends to be much greater. Subject to the above any even channel may be cross-bonded to any odd channel.

- c) In electrified areas any cross bonding which connects lines of the same group of channels (i.e. odds or evens) shall be arranged so that there would have to be at least two self-revealing or three non self-revealing IRJ failures between track circuits of the same frequency (the insulated rails of single rail track circuits) before a wrong side failure could occur. A self-revealing failure is one which causes a right side failure of one or more track circuits.

Extreme care shall be taken with cross bonding, particularly in d.c. electrified areas at a Track Paralleling (TP) Hut or Substation located at a junction, where it is usual for all the electric traction returns to be connected together.

3.5.3 Typical Arrangement for Plain Line

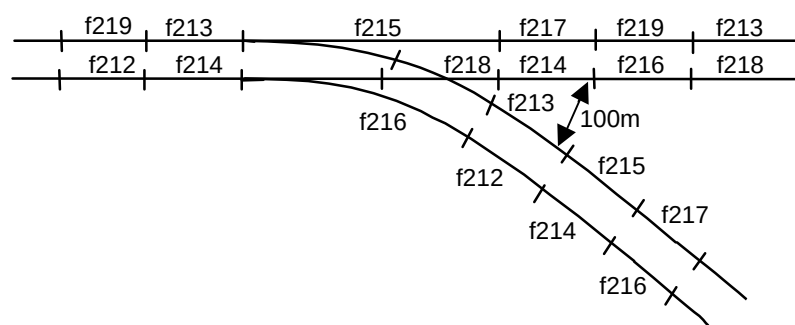
Typical frequency allocation is as follows (but in a.c. electrified areas f219 is substituted for f211):

f211	f213	f215	f217	f211	} Use in 2 line area	} Use in 4 line area	
f212	f214	f216	f218	f212			
f215	f217	f211	f213	f215	}		
f216	f218	f212	f214	f216			

3.5.4 Typical Arrangements for Junctions

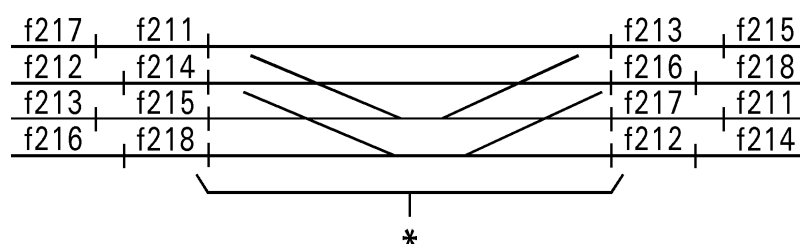
- a) Junctions in 2-Track Areas (except d.c. electrified)

Two or three channel separation (as described in section 3.5.2.a) must be maintained through junctions. In a 2 track area the frequency allocation after the junction shall be as in a 4 track area. The 4 track sequence shall continue while the lines run parallel within 100m, or are connected by traction bonding, and for at least two track circuits after that.



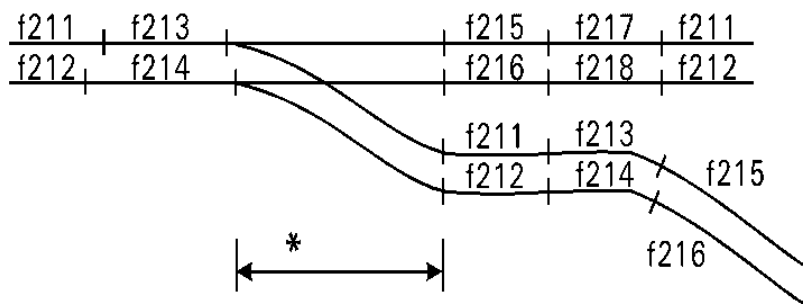
b) D.C. Electrified Areas

In d.c. electrified areas, track circuits in the area marked * in the illustrations in b), c), and d) below must be d.c. immune single rail type. When a Reed sequence re-commences after such a single rail network at a junction, the channels shall be continued in their correct sequence as if the interruption had not occurred, thus:



c) Junctions in 2-Track D.C. Electrified Areas

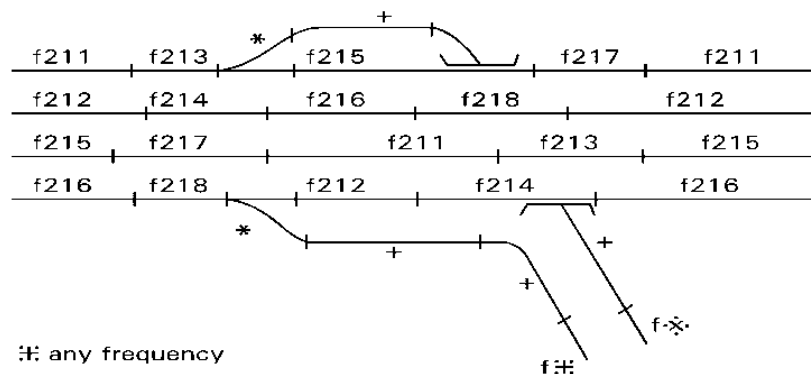
In d.c. electrified areas when Reed track circuits re-commence on the diverging line, the sequence shall be re-started as in a 4-track area. The 4 track sequence shall continue while the lines run parallel within 100m, or are connected by traction bonding, and for at least two track circuits after that, thus:



d) Junctions in 4 Track Areas

Track circuits marked + which either run parallel within 100m to the 4 line area or are cross-bonded to it must not be Reed track circuits. In d.c. electrified areas one complete jointed double rail track circuit must exist after the cross bonding or parallelism. In non electrified areas and in a.c. electrified areas, Reed track circuits may re-commence as soon as the parallelism has terminated.

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- e) Double rail jointed Reed track circuits are permitted through clipped and padlocked points and those controlled by emergency/engineer's ground frames.

3.5.5 Use of Additional Frequencies

The additional channels f220, f221 are manufactured and may be used in a.c. or d.c. electrified areas to overcome channel allocation problems in complex layouts, or where dual immunisation (d.c. and 50 Hz a.c.) is required. Channel f219 may be used in case of difficulty in d.c. electrified areas. Technical advice shall be sought from the Infrastructure Controller before these frequencies are used as additions to the standard allocation.

As tuning capacitors are not available for certain types of impedance bond at these frequencies (see Appendix A), designers shall use them for track circuits without impedance bonds, wherever possible.