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Business Process Document

Methodology for the Demonstration of Compliance with Single Rail Reed Track Circuits on the AC Railway

(Formerly RT/E/C/50002 Company Code of Practice Methodology for the Demonstration of Compatibility with Single Rail Reed Track Circuits on the AC Railway)

Endorsement & Authorisation

Endorsed by:



A Simmons, Head of Signal Engineering

Authorised by:



A McNaughton, Chief Engineer

Accepted for issue by:



M McManus, National Standards Manager

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Issue record

Issue	Date	Comments
1	February 2003	New Code of Practice
2	February 2007	Re-issued as Business Process Document also various sections have been added/updated: Section 8 has been added Section 9 has been added Section 10 amended to refer to safety targets

Implementation

(Please include implementation date, if applicable.)

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1 Purpose

The purpose of this document is to provide a methodology to demonstrate compatibility with 'RT' type single rail track circuits on the AC railway on Network Rail controlled Infrastructure. This is achieved by:

- Providing a characterisation of the reed track circuit receiver.
- Providing a characterisation of the infrastructure.
- Providing a methodology to define the susceptibility of a given reed track circuit.

Combining these elements will enable a full characterisation of a reed track circuit applicable to Network Rail infrastructure. This characterisation will take the form of a permissible train current which can then be compared to the footprint of a piece of traction or rolling stock to enable a case to be made. Methods are included to analyse intact and faulty infrastructure.

2 Scope

This document covers RT type reed track circuits installed in single rail mode on AC electrified Network Rail controlled infrastructure. This also encompasses the older type 'R' equipment when installed in single rail mode where these are not fitted with step up transformers.

2.1 Installation types covered by this Document

This document covers reed track circuits installed in single rail mode on the AC railway. It does not cover specific double rail installations that may be present within tunnels etc. Double rail installations will require a specific assessment based on the configuration as installed. Installations on DC electrified lines are generally installed in double rail configuration including impedance bonds and are therefore not covered in this document.

There may be instances of type 'R' reed track circuits that have been installed with step-up transformers fitted to the receiver; these track circuits are also excluded from the scope of this document. These track circuits do not represent a significant population in comparison to the more usual types.

The analysis here assumes that the AC electrification is installed as a 'conventional' system and is valid for rail return, rail and return conductor return and booster transformer schemes. Autotransformer fed sections of railway are not covered by this document and will require a separate analysis and/or a reissue of this document.

2.2 Equipment types included in this Document

The equipment covered within this document is the type 'RT' reed track circuit equipment manufactured by GEC (now ALSTOM). This equipment has an adjustable track filter that affects the sensitivity of the receiver. For the analysis presented here the filter is assumed to be set at its most sensitive setting. At this setting the RT type reed receiver is more sensitive than the earlier type 'R' reed track circuit equipment. Due to this difference in susceptibility characteristic type 'R' track circuit equipment is encompassed within the analysis presented here.

This document does not cover application specific receivers used in double rail track circuits on the AC railway. Application to high power reed track circuits is based on the available data.

3 Reference documentation

Network Rail Company Standards

- [NR/SP/SIG/11752](#) Train Detection, Issue 2, August 2001.
- [NR/SP/ELP/21085](#) Design of earthing and bonding systems for 25 kV AC electrified lines, Issue 2, April 2006.
- [NR/PS/SIG/11763](#) Reed Track Circuits, Type RT, Issue 1, December 2000.
- [NR/SP/SIG/50004](#) Methodology for the demonstration of Electrical Compatibility with DC (AC Immune) Track Circuits, Issue 2, April 2006
- [NR/GN/SIG/11210](#) Signalling Installation, Issue 1, August 2000.

Previous Safety Case documentation

120-dr0394	"Results of Single Rail Reed Track Circuit Tests at the Old Dalby Test Site", AEAT Rail, version a0, dated 27th July 1998.
120-dr0399	"Measurement and Characterisation of Reed Track Circuit Receiver" AEAT Rail, version a0, dated 19th June 1998.
120-dr0397	"Determination of Permissible Rail/Wheel Interface Current Levels for Single Rail Reed Track Circuits on the AC Railway", AEAT Rail, version b0, dated May 1999.
PRJ-SCSE(JUN)-RP-20	"Juniper Project - Reed Track Circuit Interference Limits - AC Routes", AEAT Rail, Issue 3, dated July 1999.
STG-D-EPS(373)RP-18	"Track parameters for Interference studies" N Rambukwella, AEAT Rail, Issue 1, January 1995.
fax dated 12/5/93	"Reed Track circuit parameters" from D. M. Poole to N Rambukwella.
IB147	"Type RT Reed Track Circuit Equipment Part 1 Standard Power Jointed Track Circuits" Part 1 Issue 4, Alstom Signalling, October 1991
120-dr0396	"Suitability Report - Circuit Equations for Reed Track Circuit Installed on the AC Railway" TCI, version a0, dated 11th November 1998.
120-dr0454	"Class 92 Locomotive EMC Safety Assessment Volume 3 – Single Rail Reed Track Circuits Compatibility with Single Rail Reed Track Circuits on the 25kV AC Railway", AEA Technology Rail, version b0, dated May 1999.
STG-D-EPS(373)-RP-29	"Class 373 Support – Reed track circuits infrastructure modifications for increased immunity", BR Research Ltd (now AEA Technology Rail), ref., Issue 1.1, 18th March 1997.
HR/EUKL/NLL/IO/4	"Reed track circuit safety assessment"

Other standards

[BS EN 50238](#)

'Railway Applications: Compatibility between Rolling Stock and Train Detection Systems' 2003.

Network Rail IDI documentation

[ESID9079](#)

"Reed Receiver Test Report - Railtrack Industry Data Initiative", AEAT Rail, , version 2, March 2000.

Other Documents

[HSE Books](#)

"Railway Safety - HM Chief Inspecting Officer of Railways' Annual Report on the safety record of the railways in Great Britain during 1995/6" HSE Books

[E1317AAF](#)

"Technical Study Reed FDM & Track Circuits, mains frequency interference." Version 1.1, WS Atkins, 23rd December 1997.

4 Infrastructure assumptions

The infrastructure assumed during the analysis is as described below, further assumptions are listed in Appendix B:

- Track circuits are installed in single rail mode without the use of impedance bonds.
- The cross bond spacing is assumed to be 750m. The Network Rail company standard [\[NR/SP/ELP/21085\]](#) states the following:

For areas with single rail traction return and rail return only the maximum cross bond spacing should be 500m

For areas with single rail traction return and return conductors only the maximum cross bond spacing should be 500m

For areas with single rail traction return with return conductors and booster transformers the maximum cross bond spacing should be 750m

There may be additional cross bonds within the track circuit but these will not affect the analysis presented since they do not affect the impedance

of the effective traction return rail as seen from the ends of the track circuit.

- The rail impedance at reed frequencies is as quoted in [\[120-dr0397\]](#), i.e. 346 mOhm/km and 0.743 mH/km for a frequency of 400Hz. This is taken from [\[STG-D-EPS\(373\)RP-18\]](#) and is representative of flat bottomed BS113A rails. The expected variation in this value is in the order of 1% over the frequency range of interest 363 - 423 Hz.
- The Signalling Installation Handbook [\[NR/GN/SIG/11210\]](#) states that track circuit lengths can be up to 1000m for standard power track circuits. In this document 1200m is used as the worst case installed track circuit.
- Track filter primary impedance: 2.8 Ohm resistive [\[120-dr0397\]](#) [\[fax dated 12/5/93\]](#). This represents the impedance presented by the primary of the track filter at resonance with the highest sensitivity selected.
- All of the traction current returns to source via the rails. Booster transformers and return conductors are assumed not to exist in the analysis presented. This generally leads to pessimistic results for electrification schemes where booster transformers and return conductors are used. This configuration is the most common arrangement on Network Rail infrastructure. In the case of rail return only systems the results produced from this analysis are realistic.
- The effect of earth masts connected to the traction rail are ignored. The effect of masts would be to reduce the current returning to source via the traction and signal rails. This would reduce the current flow in the signal rail and therefore it is a pessimistic assumption.
- The transmitters of track circuits on adjacent tracks are assumed to be open circuits. This is a pessimism in the analysis since these use the same track filters as the receiver and would conduct some traction generated interference current.
- The effect of the mutual coupling between the rails and the overhead has been ignored. It is considered that these mutual impedances would have a second order effect on the signal rail current. The current flow in the overhead line would induce voltages in the traction and signal rail that were equal in both magnitude and polarity and as such would have no effect on the current flow in the signal rail. The effect of the mutual coupling between the rails would have the effect of reducing the current in the signal rail and therefore this assumption is pessimistic. This has been shown in [\[120-dr0396\]](#).
- The track is assumed to be of standard gauge.

- The sleepers in use are assumed to be concrete or wood, steel sleepers are not included in the analysis presented here.
- UIC 60 Rail is not included in the assessment as presented. The methodology given here is applicable but the parameters of this rail type at the frequency of interest will need to be determined and used in the appropriate calculation.
- The presence of check rails will reduce the effective impedance of the rail to which they are attached. The effect of check rails is not included in this document, however the methodology provided allows for the effect of such differences to be evaluated by the use of a rail impedance appropriate for such configurations.
- A cross bond failure on a section consisting of two or more tracks essentially reduces the configuration to no worse than that of a single track railway in the absence of another infrastructure fault e.g. a broken rail. The analysis presented considers only one infrastructure fault occurring at any one time.

5 Susceptibility analysis

5.1 Receiver analysis

The reed track circuit is a single frequency track circuit that is usually installed in single rail mode on the AC railway. The frequencies of operations are: 363Hz, 366Hz, 369Hz, 372Hz, 375Hz, 378Hz, 381Hz, 384Hz, 408Hz, 417Hz and 423Hz. These frequencies are commonly referred to by their channel numbers f211 to f221 [\[IB147\]](#).

5.2 Receiver components

The reed track circuit receiver is composed of the following components as shown in figure 1.

- Track filter
- Electromechanical filter (the 'Reed' filter)
- Amplifier
- Follower relay

The track filter prevents large amounts of traction return current flowing through the receiver. It consists of a tuned circuit on the primary of a transformer and acts as a broad 'band pass' filter. The frequency of the pass band is adjustable. The resistance in the primary of the filter is able to be set

to 2.8Ohm (setting 23), 5Ohm (setting 22) and 7.2 Ohm (setting 21) [fax dated 12/5/93]. The lower resistance settings correspond to higher sensitivities. The track filter does not introduce any significant time delay into the system.

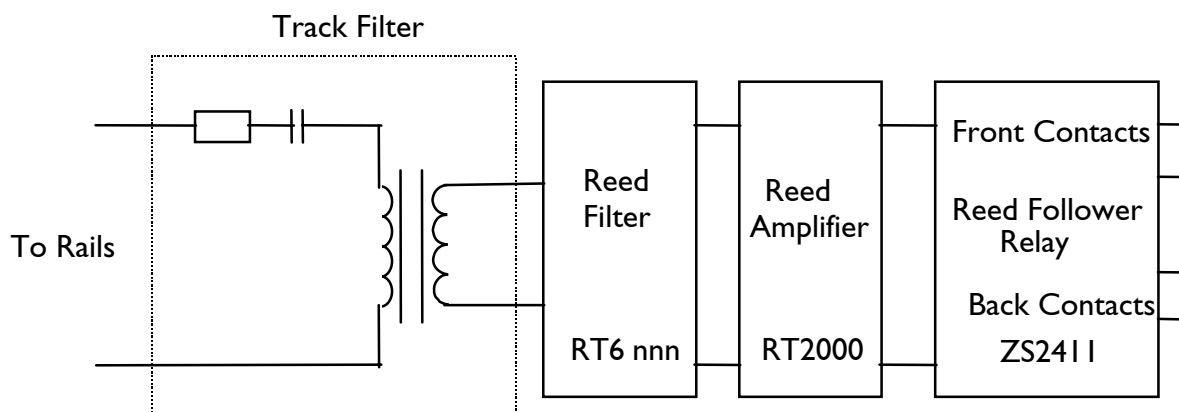


*Figure 1: Constituent parts of the reed receiver
'nnn' refers to the three digit code used for channel identification*

The output from the track filter is fed into the reed filter itself that actually consists of two vibrating reeds coupled via a resilient mounting. This filter has a very sharp frequency response with a quoted bandwidth of 0.5 Hz [IB147]. A typical reed filter characteristic is given in Figure 2.

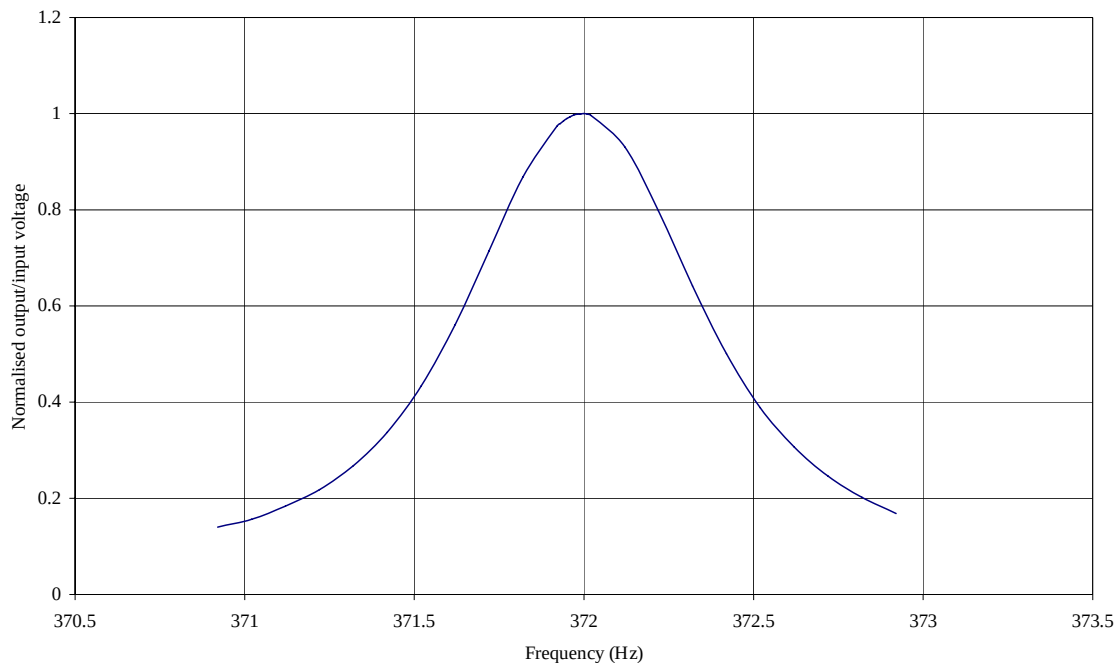


Figure 2: Typical frequency response of reed filter (372Hz filter shown)

Due to the nature of the filter there is a time delay between the application of a signal to the input and the maximum output level being reached. There is also a delay between the input signal being removed and the output decaying to zero.

The reed filter output is then amplified and applied to the follower relay. The reed amplifier also introduces a time delay into the system.

The follower relay is normally connected into the signalling system via a slow to pick track repeat relay to specification BR933 (TPR) [\[NR/SP/SIG/11752\]](#). The analysis here is therefore somewhat pessimistic in ignoring this. TPR fitment is historically difficult to confirm and it is for this reason that this is not assumed in the analysis. The benefit to be gained from the fitment of a single TPR is marginal since under transient conditions the difference in the energy required to close the front contacts of the relay momentarily or to close them for longer than the delay provided by a single TPR is very small. This is demonstrated in [\[120-dr0397\]](#).

5.3 Analysis of receiver components

The track filter is characterised in terms of the ratio of its input current to output voltage. This quantity is found to be independent of the filter setting. The filter

setting will affect the amount of interference current that will flow in the primary of the filter and thus affect the output voltage for a given infrastructure scenario.

Ratio of input current/output voltage for track filter = 1.6 mA/mV [[120-dr0397](#)]

In the case of single rail track circuits the current in the primary of the track filter is that which flows in the signal rail of the track circuit.

The receiver is characterised in terms of its response to interference applied to the input of the reed filter. The characterisation is based on the time for which a signal must be applied in order that the front contacts of the follower relay to just close.

This quantity is expressed as a voltage - time product enabling a time variant susceptibility to be determined.

This voltage time product: 88000 mV*ms [[120-dr0397](#)]

N.B. This value is suitable for use for durations between 200ms and 1 second.

The reed receiver has been characterised for durations shorter than 200ms by testing described in [[ESID9079](#)].

For durations greater than 1 second the maximum permissible reed filter input voltage is taken as the maximum 'drop away' voltage, this being 65mV [[fax dated 12/5/93](#)].

Using this value the permissible reed filter voltage/time curve is as shown in figure 3.