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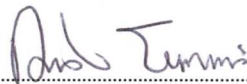
Business Process Document

Methodology for the Demonstration of Compliance with Double Rail Reed Track Circuits On The DC Railway

(Formerly RT/E/C/50003 Methodology For The Demonstration Of Electrical Compatibility With Double Rail Reed Track Circuits On The DC Railway)

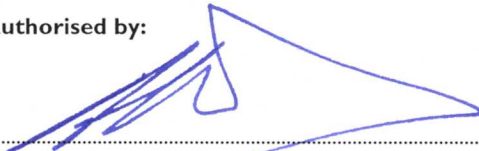
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Issue record

Issue	Date	Comments
1	February 2003	New Code of Practice
2	February 2007	Section 5 Permissible train current limits are slightly different to previous issue Section 6 added to review apportionment margin Section 7 added to cover variants of Reed equipment Section 9.1 revised limits for normal infrastructure Section 9.5 added to refer to safety target Appendix A expanded to include all model details Appendix E added to include examination of fault scenarios

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 electrical compatibility with 'RT' type double rail reed track circuits on the DC electrified 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 reed track circuits applicable to Network Rail controlled infrastructure, for both worst-case intact and faulty infrastructure conditions. This characterisation will take the form of a permissible train current that can then be compared to the emission footprint of an item of rolling stock. This methodology will facilitate the demonstration of compatibility of rolling stock with reed track circuits, as part of a Route Acceptance Safety Case.

2 Scope

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

The methodology considers both intact and faulty infrastructure.

2.1 Installation Types Covered by this Document

This document covers reed track circuits installed in double rail jointed mode on the DC electrified railway. It does not cover track circuits used in jointless mode, specific single rail installations that may be present within dual (AC and DC) immunised areas, or double rail installations in non DC electrified areas (used in tunnels etc.). Installations not specifically included in this document will require a specific assessment based on the configuration as installed. Installations on AC electrified lines are generally installed in single rail configuration and are therefore not covered in this document. These installations are covered in [\[NR/SP/SIG/50002\]](#).

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.

The analysis here assumes that the DC electrification is installed as either a 'high current' or 'standard current' third rail, 750V system [\[NR/E/S/21104\]](#).

2.2 Equipment Types Covered by this Document

The equipment covered within this document is the type 'RT' reed track circuit equipment [\[B147\]](#), 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' reed track circuit equipment is encompassed within the analysis presented here.

This document considers both the rail connected receiver and the intermediate loop receiver configurations.

This document does not cover application specific receivers used in double rail track circuits on the AC railway. Receivers fitted with step up transformers are also excluded. An assessment of more recently developed high power double rail reed track circuits that operate with higher rail to rail voltages than the type 'RT' is included.

3 Source Documents

Network Rail Standards

- [NR/SP/SIG/11752](#) Train Detection, Issue 2, August 2001.
- [NR/SP/SIG/21104](#) Design & Installation of Electric Track Equipment for DC Electrified Lines, Issue 2, April 2006.
- [NR/PS/SIG/11765](#) Impedance Bonds, Issue 1, December 2000.
- [NR/PS/SIG/11763](#) Reed Type RT Track Circuits, Issue 1, December 2000.
- [NR/GN/ELP/27010](#) Compatibility between Electric Trains and the Electrification System, Issue 2, December 2005.
- [NR/SP/SIG/50002](#) Methodology for the Demonstration of Compliance with Single Rail Reed Track Circuits on the AC Railway, Issue 2, February 2007.
- [NR/SP/SIG/50004](#) Methodology for the demonstration of Electrical Compatibility with DC (AC Immune) Track Circuits, Issue 2, April 2006

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Previous Safety Case Documentation

- [10109.4106](#) Double Rail Reed Track Circuit Interference Limits – DC Routes, Issue 3 AEA / ALSTOM, June 1999.
- [120-dr0397](#) Determination of Permissible Rail/Wheel Interface Current Levels for Single Rail Reed Track Circuits on the AC Railway, version b0, AEAT Rail, May 1999.

Industry Data Initiative Documentation

- [ESID9079](#) – “Reed Receiver Test Report - Railtrack Industry Data Initiative”, AEA Technology 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
- [IB147](#) “Type RT Reed Track Circuit Equipment Part 1 Standard Power Jointed Track Circuits” Part 1 Issue 4, Alstom Signalling, October 1991.
- [IEE Proceedings](#) "Determination of Rail Internal Impedance for Electric Traction System Simulations", RJ Hill & DC Carpenter, Volume 138, No. 6, November 1991
- [fax dated 12/5/93](#) “Reed Track circuit parameters” from D. M. Poole to N Rambukwella.
- [E1317AAF](#) “Technical Study Reed FDM & Track Circuits, mains frequency interference.” Version 1.1, WS Atkins, 23rd December 1997.
- [BS EN 50238](#) ‘Railway Applications: Compatibility between Rolling Stock and Train Detection Systems’ 2003.

4 Description of Reed Track Circuits

4.1 General Configuration for DC Electrified Railways

All track circuits in DC electric traction areas and for 800m beyond the limits of the traction area defined by the IRJ's (insulated rail joints) must be immune from DC traction interference [[NR/SP/SIG/11752](#)].

High traction return currents associated with low voltage DC traction systems require a very low impedance path back to the substation if voltage and power losses are to be kept within sensible limits for reliable train operation. This is achieved by using both running rails for traction return wherever possible. Additionally cross bonds are installed between parallel tracks, thereby reducing the overall return path impedance. Double rail track circuits allow both rails to be used for traction return currents. However in switch and crossing areas it is not normally possible to bond the track in double rail form and therefore single rail track circuits have to be installed.

In order to keep adjacent double rail track circuits electrically separate, IRJs (insulated rail joints) are used in both running rails to form jointed track circuits. So that the traction currents can flow past the insulated rail joints, impedance bonds are required at both ends of the track circuit. Cross bonding to parallel tracks must be achieved without providing a substantial connection from one track circuit feed to another track circuit receiver.

An operational explanation of the use of impedance bonds to provide a low impedance path past the IRJs and avoid cross bonding providing connections from one track circuit feed to another is given in [[NR/PS/11765](#)].

Provided that each rail is perfectly bonded and of equal resistance, the traction current will be equally divided and the impedance bonds will be perfectly balanced with no direct current flux in the cores. Unbalanced traction return currents may result from defective bonding but can also occur on long curves where the low rail is shorter and therefore offers less resistance. The effect can be particularly aggravated by the presence of the third rail.

4.2 Track Circuit Equipment

The type RT reed track circuit is a single audio frequency track circuit, designed and manufactured by GEC (now ALSTOM) that is normally installed in double rail mode on the DC railway [[IB147](#)]. The frequencies of operation (363Hz to 423Hz) and respective channel numbers (f211 to f221) are detailed in table 1 below:

Table 1: RT Reed Track Circuit Frequencies

Channel number	Centre Frequency (Hz)
f211	363
f212	366
f213	369
f214	372
f215	375
f216	378
f217	381
f218	384
f219	408
f220	417
f221	423

On DC electrified lines, reed track circuits are usually restricted to the eight channels f211 to f218 [\[NR/PS/SIG/11763\]](#). However, this is not universally the case and it should be assumed that the higher frequency channels f219, f220 and f221 may be used, unless this is supported by route specific infrastructure data.

The type RT reed track circuit equipment is a development of the type R reed remote control equipment and the earlier type 'R' reed 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 narrow bandwidth and a very stable centre frequency. For track circuit equipment, the frequencies are chosen to lie between harmonics of the 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 that feeds audio frequency oscillations into the rail and a receiver at the relay end that is tuned to receive only that specific frequency. Immunity from sources of interference is achieved because the bandwidth of the receiver is so narrow.

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 on non electrified lines. On DC electrified lines it is used in the jointed configuration, however, an intermediate receiver loop can be used in conjunction with the jointed track circuit to give a multisection track circuit. This is used, 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

is variable such that the physical point at which a train is detected cannot be fully predicted. Intermediate loop receiver use is therefore restricted to lower criticality functions and is not a primary train detection facility.

The receiver loop is formed simply with the use of a loop of cable mounted in the four foot. The signal is detected in the rails by means of this loop and is fed via an attenuator filter and the receiver amplifier/filter to the track relay in the same manner as the end receiver. The loop acts as a step-up transformer, the running rails providing the primary turn and a 36 turn receiver loop forming the secondary. When there is no train shunt present, the normal 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. 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 may cause the receiver equipment to malfunction.

Figures 1, 2 and 3 below show the basic arrangements of jointed reed track circuits (feed and receiver ends) and also a block schematic of an intermediate loop.

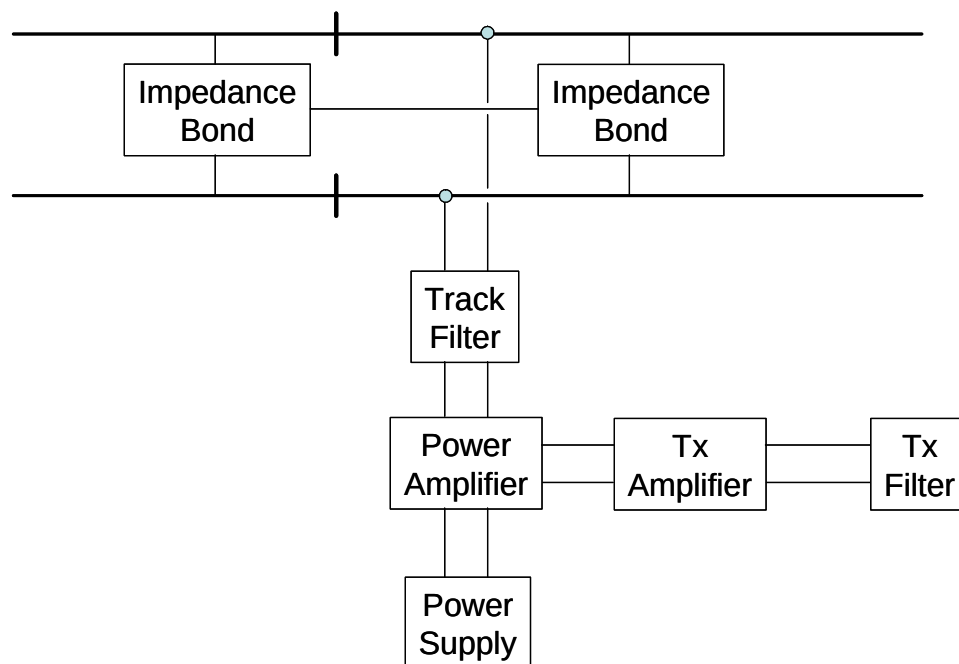


Figure 1: Block Schematic of reed jointed Track Circuit (Feed End)

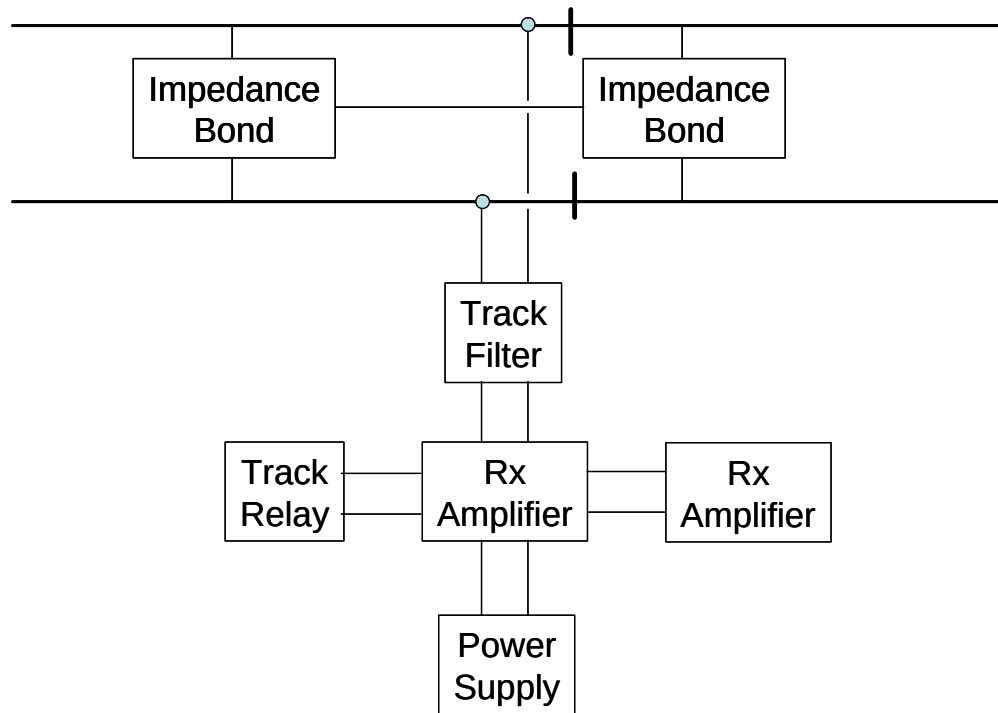


Figure 2: Block Schematic of reed jointed Track Circuit (Receiver End)

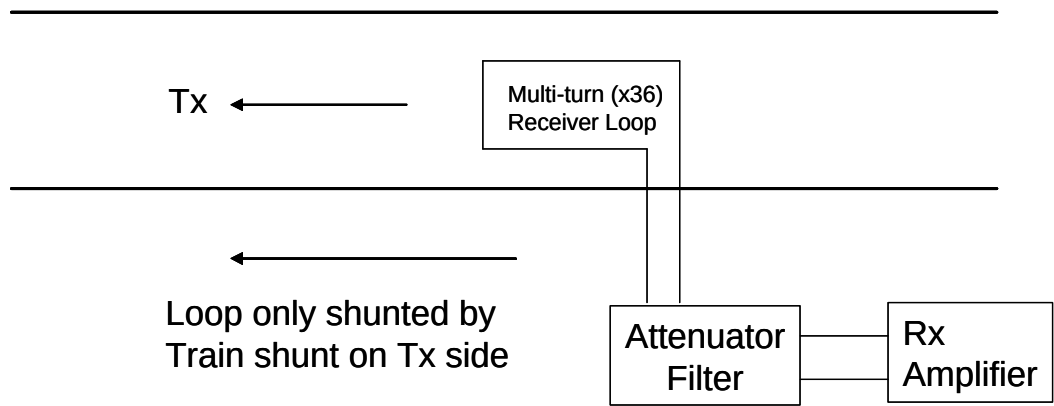


Figure 3: Block schematic of an Intermediate Loop Receiver within a reed Track Circuit

5 Susceptibility Analysis

To determine the susceptibility of reed track circuits to electrical interference on the 750 V DC railway two pieces of existing work are employed.

- The track circuit receiver is characterised in terms of its response to electrical interference. This work is reported in [[NR/SP/SIG/50002](#)].
- The infrastructure is characterised by way of a mathematical model of the railway which includes all of the conductors, cross bonds and impedance bonds. This work is reported in [[10109.4106](#)].

5.1 Receiver Analysis

The reed receivers are the same whether they are used on the AC or DC railways. An extensive analysis into the susceptibility of reed receivers to electrical interference has been carried out in [[NR/SP/SIG/50002](#)]. This forms part of the work undertaken to determine the maximum permissible levels of reed frequency interference that can be tolerated on the AC railway as part of the IDI. Since this work is already documented and approved it is not necessary to repeat it here save for the results of that analysis.

[[NR/SP/SIG/50002](#)] presents two sets of results and these are as follows:

- the maximum permissible reed filter voltage against time;
- the maximum permissible track filter primary current against time.

The results were obtained from testing and are summarised in figs. 4 and 5 below for the reed filter voltage and figs. 6 and 7 for the reed filter primary current.

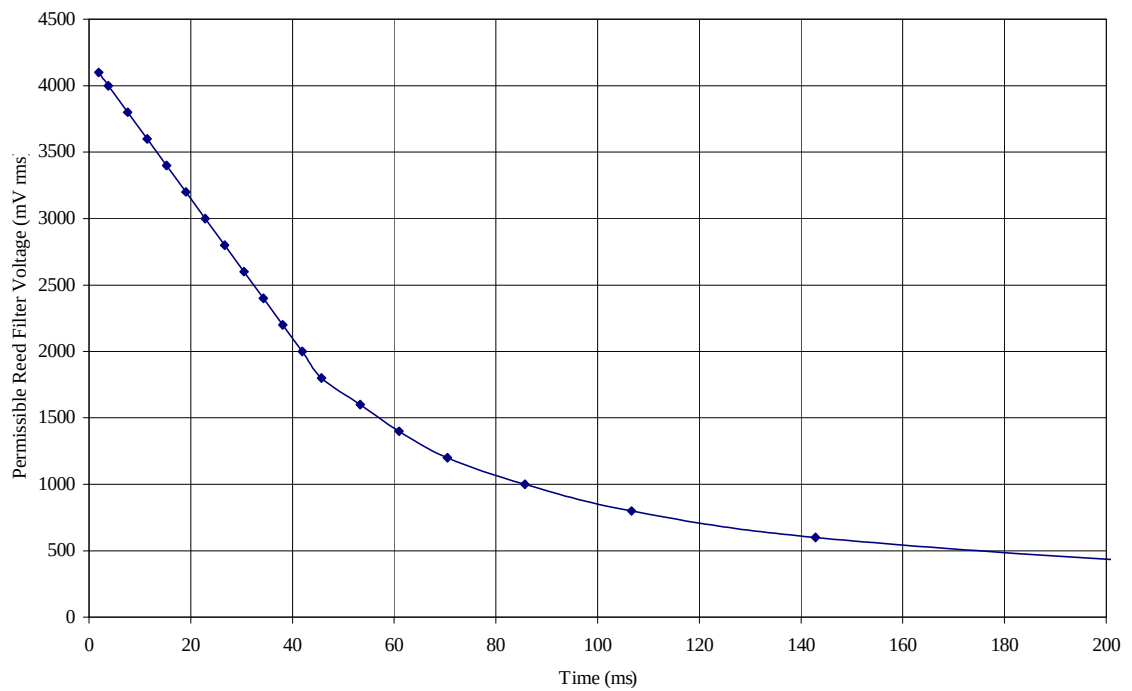


Figure 4: Permissible reed filter voltage vs. time <200ms

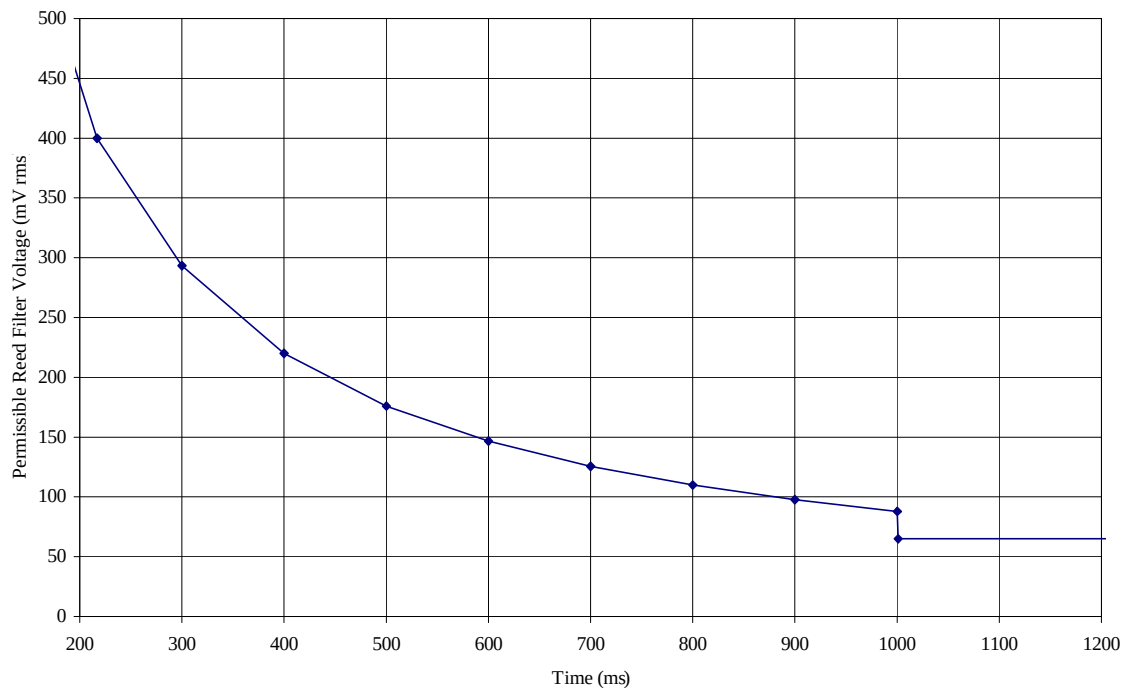


Figure 5: Permissible reed filter voltage vs. time >200ms

The curve is horizontal at durations greater than 1 second since this voltage level is below that at which the receiver would 'drop'. This level is 65 mV rms.

The permissible reed filter primary current is obtained simply by applying the scaling factor of 1.6 mA/mV of the track filter [\[NR/SP/SIG/50002\]](#). This current is shown in figures 6 and 7. Again the curve is horizontal at durations greater than 1 second (steady state) the level being 104 mA rms and derived simply by multiplying the corresponding reed filter voltage of 65 mV by 1.6 mA/mV.

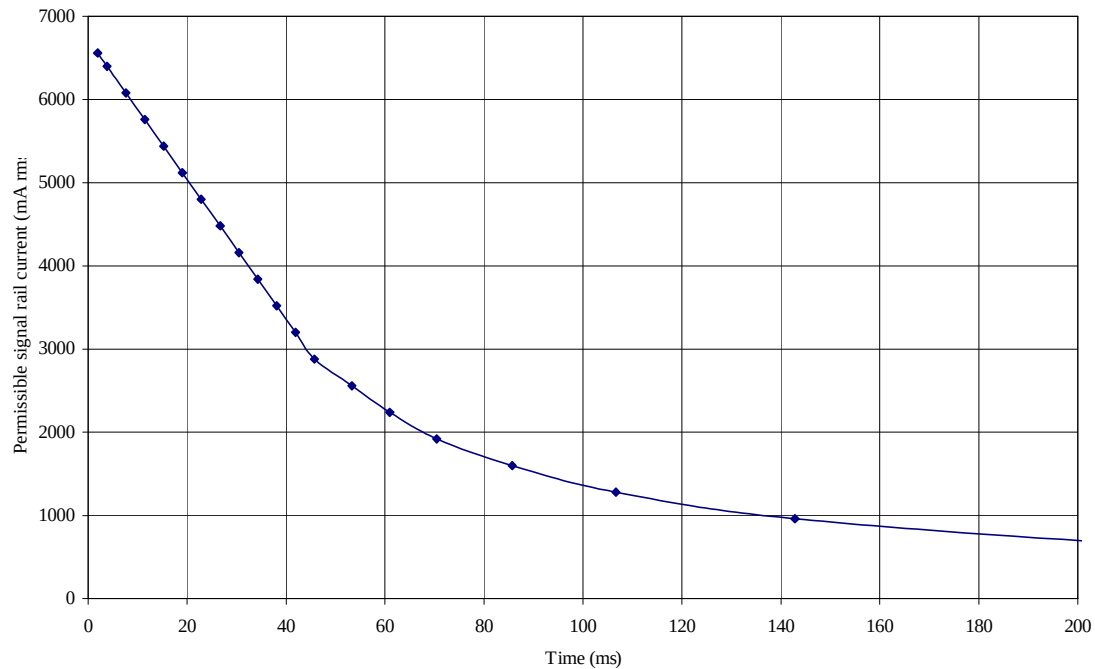


Figure 6: Permissible track filter primary current vs. time <200ms

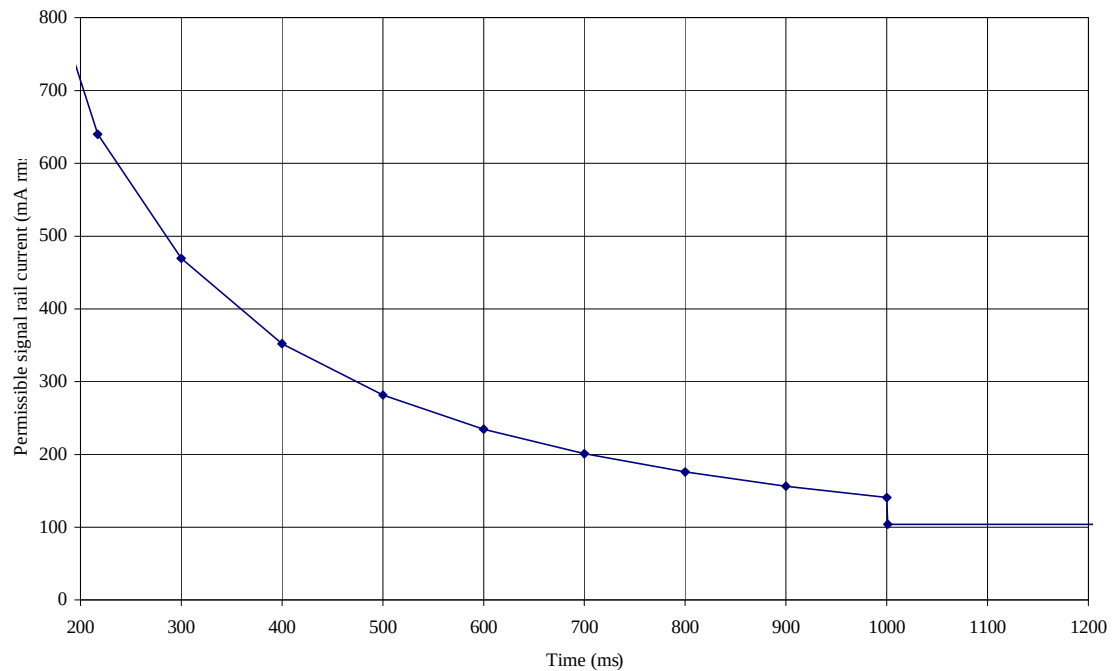


Figure 7: Permissible track filter primary current vs. time >200ms