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Module

EBI Track 200 – Application Manual

Endorsement and Authorisation

For endorsement, authorisation and issue record of this document, please refer to NR/L3/SIG/11761.

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Issue record

Issue	Date	Comments
1	April 2012	First Issue
2	December 2015	Updated to include additional information on application, installation etc.

Compliance

This Network Rail standard is mandatory and shall be complied with by Network Rail and its contractors if applicable from 05/03/2016.

When this standard is implemented, it is permissible for all projects that have formally completed GRIP Stage 3 (Option Selection) to continue to comply with the issue of any relevant Network Rail standards current when GRIP Stage 3 was completed and not to comply with requirements contained herein, unless stipulated otherwise in the scope of this standard.

Reference documentation

All reference documentation is detailed in the Standard NR/L3/SIG/11761.

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Contents

1 Background 7
1.1 Scope 7
1.2 Purpose 7
2 Abbreviations & Definitions 9
3 Key Features 11
3.1 Double Rail EBI Track 200 11
3.2 Single Rail EBI Track 200 11
3.3 Digital and Analogue Equipment. 11
3.4 Rolling Stock Compatibility 11
3.5 Set-up Key Management 12
3.6 Product MOD State Marking 12
4 Design and Application 13
4.1 Design and Application Introduction 13
4.2 Frequency Availability/Traction Systems Compatibility 13
4.3 Records 14
4.4 Operating Category and Interface Delay Requirements 14
4.5 Separation of Trackside Units of the Same Frequency 15
4.6 Tail Cables 15
4.7 Steel Sleepers 17
4.8 Tuned Zone Restrictions (Double Rail *EBI* Track 200 only) 18
4.9 Double Rail EBI Track 200 Ban on Temporary Single Rail Mode 18
4.10 Frequency Allocation and IRJ Failure Detection with ETUs/SPETUs 19
4.11 Switch & Crossing (S&C) Application 20
4.12 Track Circuit Lengths 20
4.13 Surge Protected End Termination Units (SPETU) 21
4.14 Impedance Bonds 22
4.15 Interfaces to other Signalling Equipment 24
4.16 Power Supplies 29
4.17 Surge Protection 33
4.18 EMC Compliance 35
4.19 Environmental Emissions 35
5 Scheme/Project Application 35
5.1 Track Circuit Boundary Definition 35

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5.2 Non standard and Exceptional Situations 36
5.3 EBI Track 200 Complex Cases 36
6 Installation 39
6.1 Introduction 39
6.2 Mounting Arrangements 39
6.3 Rail Connections using the Flexo Cable termination. 40
6.4 Tuning Units, End Termination Units and Surge Protected ETUs 42
6.5 Track Coupling Units (TCUs) 48
6.6 Rail Bonding 48
7 Testing and Commissioning Procedure 49
7.1 Introduction 49
7.2 Preliminary Checks 49
7.3 Compatible Styles of Impedance Bond 50
8 Stagework 52
8.1 Temporary Termination of EBI Track 200 Fitted Area 52
8.2 Temporary Track Circuit Cases 52
9 Electrified Lines 53
9.1 DC Electrified Lines 53
10 Product Procurement 54
10.1 Analogue Transmitter Product Modification Chart & Acceptance Status/Constraints 54
10.2 Digital Transmitter Product Modifications & Acceptance Status/Constraints 56
10.3 Analogue Receiver Product Modification Chart & Acceptance Status/Constraints 57
10.4 Digital Receiver Product Modifications & Acceptance Status/Constraints 59
10.5 Tuning Units, End Termination Units and Surge Protected ETUs 59
10.6 Track Coupling Units (TCU) 60
10.7 Line Matching Units (LMU-TX and LMU-TU) 60
10.8 Track Connection Cables 61
11 Special Test Equipment 70
11.1 EBI Track 200 Test Meter (TTM) 70
11.2 Rocoil Rail Current Transducer 70
11.3 Lemflex 70
11.4 Sleeper Insulation Tester 70
11.5 Frequency Selective Voltmeter (FSV) / Frequency Selective Meter (FSM) 70

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11.6 EBI Track 200 PC Application Software 70

11.7 GO/NO GO Test Rig for Tuning Units, End Termination Units and Surge Protected End Termination Units 71

12 Product Reliability 74

12.1 Transmitters / Receivers - Serviceable & Non Serviceable Items (Formerly covered in RIA009) 74

12.2 TUs/ETUs/SPETUs - CLAMPED Inductors (Formerly covered in RIA009) 78

12.3 TUs/ETUs/SPETUs - T1 & T2 Nutting arrangement (Formerly covered in RIA009) 78

12.4 Tuning Unit reliability (Formerly covered in RIA019) 79

12.5 Capacitor Check - Analogue Transmitters (Formerly covered in RIA023) 80

12.6 Exchanging an Analogue RX for Digital RX : Method Statement 81

Appendix A - Typical Track Record Card Front 85

Appendix B - Typical Track Record Card Rear 86

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1 Background

During the Bombardier rationalisation of their TI21 track circuit product range, it has been renamed to the EBI Track 200 track circuit. The existing TI21 equipment is entirely interchangeable with EBI Track 200 equipment irrespective of the age of the equipment or installation.

This Module is part of the Handbook which describes all aspects of the EBI Track 200, and for the purposes of this standard it is referred to as EBI Track 200 or ET200.

During 2014 a new variant of the EBITrack track circuit system called *EBI* Track 400 achieved Product Acceptance in Network Rail. All documentation, manuals, configuration management and product acceptance etc. covering *EBI* Track 400 is managed separately. However there are some common components used by both *EBI* Track 200 and *EBI* Track 400, and where relevant, product descriptions will refer to both product ranges.

1.1 Scope

The contents of this Module apply to all EBI Track 200 audio frequency track circuits. The more general requirements can be found in NR/L2/SIG/11752. Safety issues specific to EBI Track 200 applications are included directly or through reference to the generic EBI Track 200 documentation; general safety issues are contained in NR/L2/SIG/11752 and other relevant Network Rail standards.

1.2 Purpose

This Module mandates Network Rail best practice in respect of EBI Track 200 audio frequency track circuit (previously known as TI21) in order to achieve the requirements of NR/L2/SIG/11752.

It further mandates the following list of Bombardier EBI Track 200 Manuals:

Level 1 Documents	
EBI Track 200 Audio Frequency Track Circuit - Technical Manual	M125401A4
EBI Track 200 Audio Frequency Track Circuit - Single Rail Application	M580000626A4
Level 2 Documents	
EBI Track 200/300/400 Application Note : Points and Crossings	IS580081934A4
EBI Track 200/300/400 Track Circuits Guidance Notes for Traction Bonding	IS580001109A4
Level 3 Documents	
EBI Track 200, 300 & 400 Track Circuits - Operation with Concrete Slab Track with Steel reinforcing or Iron Lined Tunnels	IS580001448A4

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Summary of Fusing and Surge Arrestor Arrangements	IS580014943A4
TI21 Test Meter (TTM) Operating Instructions	M6/6/118951
ET200 / TI21 Audio Frequency Track Circuit - Tuning Unit, End Termination Unit and Surge Protected End Termination Unit Test Rig	M124831A4
TI21 Sleeper Insulation Tester (SIT) Operating Instructions	M6/6/122940
EBI Track 200 - Track Circuit Condition Monitoring (Guide to using the CM interface)	IS580012852A4
PC Application Users Manual : Customer Version	M580036853A4
EBI Track 200 TI21 Use of Compensating Capacitors	IS580067915A4
Modifications to EBI Track 200 TI21 Tuning Unit and ETU T1/T2 Connections and Trackside Wiring Recommendations	IS580001669A4

Where requirement conflicts occur, this document is to take precedence over the generic EBI Track 200 Manuals.

It should be noted that the Bombardier Manuals detail a few items of equipment which are not accepted for use on Network Rail. The Acceptance Certificate PA05/04343 provides full details on all Network Rail Accepted *EBI* Track 200 equipment.

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2 Abbreviations & Definitions

Abbreviation	Meaning
Double Rail Track Circuit	A track circuit configuration where, in electrified areas, traction return currents flow in , both rails.
EBI Track 200	This is the new product name for the track circuit system historically known as TI21. Note: Other historical product documentation may still use the original product name of TI21 therefore it is important to realise that the names 'TI21' and 'EBI Track 200' all refer to the same track circuit system.
ETU	End Termination Unit, self contained tuned circuit used to provide a track circuit termination where an electrical separation joint (Tuned Zone) is not required. Also used to connect the Tx to the rails in centre fed EBI Track 200 track circuits.
Frequency N (where N takes a value between A and H)	The Frequency Code or Frequency Letter when applied to a EBI Track 200 track circuit is used to identify its nominal operating frequency. Eight nominal audio frequencies in the range 1549Hz to 2593Hz are used.
GDT	Gas Discharge Tube
IRJ	A physical joint between two lengths of rail, and so designed to keep one length electrically separate from the other.
LMU	Line Matching Unit, used to extend the maximum permissible length of cabling between a Tx and its associated TU or ETU.
LP	Track Circuit configured as Low Power
LP+	Track Circuit configured as Low Power Plus
NP	Track Circuit configured as Normal Power
Rx	Receiver, either Analogue or Digital.
P&C	Points and Crossing
S&C	Switch and Crossing
Single Rail Track Circuit	A track circuit configuration where, in electrified areas, traction return currents flow in one rail only.
SPETU	Surge Protected End Termination Unit, an ETU fitted with surge protection and replaceable fuses for use in single rail applications, where protection is required to prevent damage to internal components from traction short circuits.
TCU	Track Coupling unit, used in some Single Rail EBI Track 200 configurations to connect an associated Tx and Rx to the rails.
TPR	Track Repeat Relay
TU	Tuning Unit, also known as a Track Tuning Unit (TTU), for double rail jointless operation using tuned zones. In this document the term TU is used.
Tuned Zone	Electrical Separation joint achieved using TUs
Tx	Transmitter, either Analogue or Digital.

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Abbreviation	**Meaning**
Aster Type ‘U’, SF15 & 1Watt	Variants of the jointless Aster track circuit used in non traction areas.

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3 Key Features

The application of EBI Track 200 track circuits fulfils the basic requirement for continuous train detection.

The EBI Track 200 track circuit may be used on all types of electrified or non electrified railway and provides a high level of immunity from traction and rolling stock interference.

Jointed or jointless configurations are permissible with the Receiver introducing an inbuilt time delay such that a slow to pick TPR is not normally required.

General track circuit restrictions are given in NR/L2/SIG/11752.

Specific design rules for electrified areas prevent false clearance of a EBI Track 200 track circuit as a result of interference from adjacent Txs or Rxs of the same frequency, via traction bonding or other lines/sidings.

3.1 Double Rail EBI Track 200

The Double Rail EBI Track 200 is primarily a jointless track circuit suitable for use in a.c., d.c. and non electrified areas. In electrified areas, traction return current flows on BOTH rails.

Full product descriptions and application information is detailed in the Bombardier Technical Manual M125401A4

3.2 Single Rail EBI Track 200

The Single Rail EBI Track 200 is a jointed track circuit suitable for use in a.c., d.c. and non electrified areas. In electrified areas, traction return current flows on ONE rail.

Full product descriptions and application information is detailed in the Bombardier Technical Manual M125401A4 and the Single Rail Application Manual M580000626A4

Where the TCU option is implemented not all IRJ failures are detected. Therefore design needs to take account of the risk of pre-shunting resulting from an undetected IRJ failure.

3.3 Digital and Analogue Equipment.

The original EBI Track 200 track circuit used analogue circuitry at the Tx and Rx, however in recent years digital versions have been introduced. The update to digital technology within the Tx and Rx units has retained the same analogue frequencies on the rails. Therefore the rail/wheel interface is identical irrespective of the version of *EBI* Track 200 equipment in use.

Therefore for installation and replacement purposes, the digital and analogue versions can be considered as functionally identical, although the methods of Rx fitment and adjustment differ.

3.4 Rolling Stock Compatibility

Whilst EBI Track 200 track circuits are generally immune to d.c. and a.c. traction interference, there is a requirement to demonstrate that EMC is not compromised by using the methodology defined in NR/GN/SIG/50008.

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EBI Track 200 track circuits may not be appropriate on non-electrified lines used by lightweight vehicles (e.g. Classes 14X to 16X) or other rolling stock designated as susceptible to poor train shunt.

Where doubt exists concerning the shunting characteristics of rolling stock, reference should be made to their Network Rail Vehicle Acceptance Certificate. However, EBI Track 200 track circuits may be used in the following circumstances:

on uni-directional lines,

where sequential track circuit proving is provided,

or

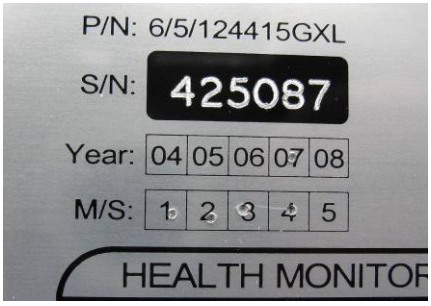
where an assessment shows that all susceptible vehicles permitted to use the line are fitted with Track Circuit Assisters (TCAs).

3.5 Set-up Key Management

Where Set-up keys are purchased from Unipart Rail; the control of issue of the keys shall be in accordance with Network Rail standard NR/L2/SIG/50019.

3.6 Product MOD State Marking

MOD States are marked on each product using a labelling system with a number grid. The last number struck out defines the MOD state of the unit and this can be done in one of two ways. Either the MOD Number is pierced with a sharp point and the MOD strike shows as a punched hole or a label will be specifically printed with the appropriate MOD Strike shown as a line through the MOD Number.



Additionally, where a specific label is printed which shows a Bar Code, the MOD strike is also shown as the last two digits of the Bar Code Number.

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4 Design and Application

4.1 Design and Application Introduction

This Module sets out a number of modifications to the generic Bombardier documents to be applied on Network Rail applications. Generic design requirements are given in M125401A4 and M580000626A4, noting that the track gauge on Network Rail is 1.435m.

Where *EBI* Track 200 track circuits are used to replace other forms of train detection; a Compatibility Assessment shall be carried to meet the requirements of Railway Group Standard GE/RT8270.

4.2 Frequency Availability/Traction Systems Compatibility

During the product acceptance programme for EBI Track 400, it became apparent that the EBI Track frequencies E, F, G and H were not as robust to AC traction interference as frequencies A, B, C & D. This would lead to unacceptably low emission limits being imposed on rolling stock where a single rail traction return configuration was adopted.

NOTE This low limit is necessary to avoid reliability problems associated with right side failure; there is no degradation of the track circuit's immunity to wrong side failure. For this reason, frequencies EBI Track 400 E, F, G and H were not accepted for use in the single rail application under AC traction.

This restriction in the paragraph above applies to all new installations of EBI Track 200 following a Bombardier investigation the robustness of frequencies E, F, G and H in the EBI Track 200 single rail application.

These restrictions are shown in Table 1:

	AC Traction	DC Traction	Dual Traction	No Traction
Double Rail	Frequencies A - H can be used without restrictions	Frequencies A - H can be used without restrictions	Frequencies A - H can be used without restrictions	Frequencies A - H can be used without restrictions
Single Rail	Frequencies A - D can be used without restrictions Frequencies E, F and H can be used provided they are operated on Low Power Plus and the track lengths are restricted to a maximum of 150m. Frequency G can be used provided it is operated on Low Power Plus and the track length is restricted to a maximum of 100m.	Frequencies A - H can be used without restrictions	Frequencies A - D can be used without restrictions Frequencies E, F and H can be used provided they are operated on Low Power Plus and the track lengths are restricted to a maximum of 150m. Frequency G can be used provided it is operated on Low Power Plus and the track length is restricted to a maximum of 100m.	Frequencies A - H can be used without restrictions

Table 1 - Frequency Restriction Rules

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The restriction on track length and the requirement to operate on Low Power Plus provide protection since they have the effect of raising the receiver threshold above the level of traction interference.

Where there are existing single rail EBI Track 200 frequency E to H track circuits operating under AC traction without problems, it is considered that this provides a degree of evidence that the analysis is pessimistic. Consequently retrospective action to change these operational track circuits is not required.

However if a change to the traction conditions is proposed, the allocation of any frequency E to H tracks shall be reviewed.

NOTE Whilst Bombardier recommend that retrospective action is not required with existing operational Single Rail tracks under AC traction, consideration needs to be given to potential reliability problems if new trains are introduced into the network as part of the Rolling Stock compatibility assessment and acceptance.

NOTE For further details the analysis work is summarised in Bombardier paper file ref 580170273.

4.3 Records

Guidance for wiring diagram format is given in the Network Rail typical circuits (NR/GN/SIG/CAT005) and associated *EBI* Track 200 Microstation templates.

Where existing site records show the Analogue Rx, the gain setting straps are generally shown unconnected and the gain setting connections are defined on the track circuit record card. A typical record card is shown in Appendix A. The *EBI* Track 200 SMS should be used to obtain the latest version of the Record card.

Where a Digital Rx is fitted, the associated record card entries, e.g. I mA Threshold for the Threshold Current (Ith), shall be used to record the Digital Rx setup and performance characteristics.

4.4 Operating Category and Interface Delay Requirements

The *EBI* Track 200 track circuit are in operating Category A (slow to pick : 2secs, quick to drop), as described in NR/L2/SIG/11752, Part F. It thus requires no additional delay in the TPR circuit, in any configuration, except when abutting a VT1(SP) or FS2600 track circuit, for which the details are given in NR/L2/SIG/11757 and NR/L2/SIG/11760 respectively.

4.4.1 Track Relay

A 50V line relay to BR 930, BR 931, BR960, BR 961 or BR966 F6 shall be used as the Track Relay; the choice may be made to match other local applications and spares holding. The contact configuration shall be selected to meet circuit requirements. The relay shall be positioned in the same equipment housing as the Rx.

If a BR 961 relay is used, its biased feature is not a safety requirement. As such the requirements for routine servicing of Track Relays shall not apply.

NOTE The relay drive output of the Digital Rx at MOD1 & MOD2 is set at between 40V and 44V, to match the minimum voltage required to fully operate the specified relays (40V) yet minimise power consumption. The Digital Rx at MOD3 is set at between 48V and 52V which provides for improved reliability when used with marginally Out of Specification relays.

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4.5 Separation of Trackside Units of the Same Frequency

The Bombardier manuals define rules for the minimum separation of trackside Tuning Units of the same frequency.

These rules are extended as defined below:

Double Rail track circuits:

- For Transmitter TUs/ETUs operating in normal power mode, check that NO receiver TU/ETU of an identical frequency (of a different track circuit) is closer than 200 metres on the same track.
- For transmitter TUs/ETUs operating in low power or low power plus mode, check that NO receiver TU/ETU of an identical frequency (of a different track circuit) is closer than 50 metres on the same track.

Single Rail track circuits:

- For transmitter ETUs/SPETUs operating in low power or low power plus mode, check that NO receiver ETU/SPETU of an identical frequency (of a different track circuit) is closer than 20 metres on the same track.

4.6 Tail Cables

All cables shall be Type C2 to NR/L2/SIG/00005.

4mm^2 cable may be used as an alternative to 2.5mm^2 if available.

Duplicated track cables for *EBI* Track 200 shall not be used except where permitted with TCU's. See section 6.5.

The Bombardier defined Tx to TU/ETU/SPETU tail cable limit of 30m is eased for the purposes of Network Rail installations.

Extension to a maximum of 50m using 2.5mm^2 cable is permissible, without degrading the operational safety margin of the track circuit, provided the track can be set up in accordance with the manual. There is no tolerance on the upper limit and 50m shall be the absolute maximum permitted for a single tail cable. Where the Tx to rail connection tail cable length would be over 50m, then LMUs shall be used.

The Tx to TU/ETU/SPETU limit applies to Railway Signalling 2 Core 2.5mm^2 Type C2 cable (50/0.25mm) which has a 75mm manufacturing twist and therefore achieves the requirement for twisted pair cable. It should be noted that C2 cables with more than 2 cores may not be treated as twisted pair, since all conductors are laid and twist together in the cable.

These tail cable length rules and the rules for the use of LMU's, applies to both End Fed and Centre Fed tracks.

Check that no signal from a transmitter feed cable can couple into another transmitter feed cable or receiver feed cable of the same frequency.

This creates a risk of falsely feeding a receiver and therefore falsely energising the track relay or equivalent.

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To achieve this, each circuit shall use a separate single twisted pair cable or a multicore cable with twisted pairs in accordance with the rules below.

The twisted pairs shall have a pitch not exceeding 75mm or 120mm for screened cables.

Table 2 – Feed Cable Rules defines the rules which shall be applied.

Hazard / Risk	Feed Cables of the Same Frequency	Feed Cables of Different Frequencies
TX-TX coupling and TX-RX coupling	TX feeds shall be run in separate single twisted pair cable. TX feeds shall not be run in multicore cables. There shall be no extensive lengths of parallel running (i.e. single runs of longer than 50m) in the same troughing/cable route. If a minimum spacing of 200mm can be achieved between feeds of the same frequency, the 50m parallel running limit does not apply. This can be achieved, for example, by using separate, spaced troughing routes or cable hangers giving a cable/function separation of 200mm or greater.	TX and RX feeds may be run in separate single twisted pair cable. Also TX and RX feeds may be run in multicore cable with twisted pairs. However TX and RX feeds shall not be mixed in the same multicore cable for reliability reasons. Note: The 50m limit defined for extensive runs does not apply. The 200mm spacing between TX/RX feeds does not apply.
RX-RX coupling	RX feeds shall be run in separate single twisted pair cable. RX feeds shall not be run in multicore cables. There shall be no extensive lengths of parallel running (i.e. single runs of longer than 50m) in the same troughing/cable route. If a minimum spacing of 200mm can be achieved between feeds of the same frequency, the 50m parallel running limit does not apply. This can be achieved, for example, by using separate, spaced troughing routes or cable hangers giving a cable/function separation of 200mm or greater.	RX feeds may be run in separate single twisted pair cable. RX feeds may also be run in multicore cable with twisted pairs provided that no other functions or other types of track circuit are carried in the cable (except communication cores for track circuit test purposes). Note: The 50m limit defined for extensive runs does not apply. The 200mm spacing between TX/RX feeds does not apply.

Table 2 – Feed Cable Rules

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If screened twisted pairs are used, either in separate screened cables or multicore cables with screened twisted pairs, then the 50m parallel running or 200mm spacing requirement does not apply.

Screened cables, where used, shall have the screen terminated at the TX or RX end in the location case/equipment rooms. The screen shall not be connected as the trackside end of the feed cable.

If junction boxes are used the screen shall be linked through.

Other Examples:
These rules will permit multicore cables with twisted pairs to be used for any frequency provided all of the frequencies are different. If two multicore cables with twisted pairs are used, it is allowable to run the same frequency in the different multicore cables but the 50m parallel running rule shall be applied unless 200mm spacing between the cables can be achieved.

Axle Counter multi-pair cables (XPS & XPZ) to NR/L2/SIG/30060 are suitable and may be used with the following additional restrictions:

- 0.9mm diameter conductor cable : Track Circuit length limited to 750m
- 1.4mm diameter conductor cables : No additional restrictions

4.7 Steel Sleepers

Steel sleepers may be used anywhere within EBI Track 200 track circuits including EBI Track 200/Aster or EBI Track 200/Aster21 hybrid tuned zones.

NOTE Bombardier document "Use of Aster and Aster 21 in areas of Steel Sleepers" (U580207261-1.1) records measurements of Aster and Aster21 Tuned Zones installed between Saltash and St Germans. It is concluded that the steel sleepers have no additional effect on the operation of Aster and Aster21 track circuits from those installed on concrete or wooden sleepers.

The following additional requirements apply for EBI Track 200 tuned zones with steel sleepers:

- For *EBI* Track 200 the Tuned Zone length is extended from 20m nominal to **22m** ± 0.5m

and

- *all* the sleepers within the zone, and for 3 bays either side, shall be of a Network Rail accepted steel type.

Steel sleepers may be used adjacent to ETUs and SPETUs, and at TCU rail connections without special arrangements.

Track circuits may be operated with a 22m zone on steel sleepers at one end and a 20m concrete/timber zone at the other.

Where lengths of spare/scrap rail have been laid in the 4ft in sections of track installed with steel sleepers; the spare/scrap rail shall be blocked up with an insulating material to prevent it shorting out sections of the track circuit.

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If the running rails' pads and nylons are in poor condition there is a significant risk of bridging out sections of the track circuit through the steel sleepers and electrical contact with the spare/scrap rail.

4.8 Tuned Zone Restrictions (Double Rail *EBI* Track 200 only)

Tuned zones shall not contain the following, due to the effect of extra metalwork on the rail loop impedance or the EMC Compatibility unless compatibility has been demonstrated:

- check/guard rails,
- Selective Door Opening (SDO) Hima-Sella Tracklink 2 / Tracklink 3 equipment,
- AWS, TPWS and ATP track equipment,
- impedance bonds,
- Eurobalises,
- level crossings, foot or barrow crossings,
- breather panels,
- axle counter heads (except AzLM which is specifically permitted),
- Rail greasers,
- RFID (Radio-frequency identification) Tags

NOTE Tests have been undertaken and demonstrated that there are no specific restrictions on placing the Thales AzLM axle counter heads in an EBI *Track 200 tuned zone or in close proximity to an ETU/SPETU.*

An ETU or TU can, however, be mounted in the cattle grid area on either side of a level crossing with the tuned zone outside and leading away from the crossing.

This list should not be considered comprehensive, and there may be other metallic objects such as slab track with steel re-enforcing or steel bridges that may affect the Tuned Zone length. Similarly there may be other types of equipment that have EMC restrictions.

4.9 Double Rail EBI Track 200 Ban on Temporary Single Rail Mode

Double Rail EBI Track 200 track circuits designed for traction return in both running rails shall never be connected in single rail mode.

This is because partially disconnected impedance bonds may saturate due to the out of balance traction return, permitting run round paths through adjacent tracks. Also, where tuned zones exist, there is no means of switching back to double rail mode at the end of the track circuit, causing possible imbalance and saturation of impedance bonds in the abutting track circuit.

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4.10 Frequency Allocation and IRJ Failure Detection with ETUs/SPETUs

The *EBI* Track 200 Technical Manual details the requirements for frequency allocation to maintain IRJ failure detection through the use of pairing frequencies from the group A, C, E, or G with frequencies from the group B, D, F or H.

Non paired frequencies may be used provided the track circuits are terminated by IRJ's in both rails and a diagonal or transposition bond is present.

Figures 1 and 2 show examples where, failure of either joint associated with a transposition bond will be detected since one or both tracks will fail to occupied and the IRJ failure revealed.

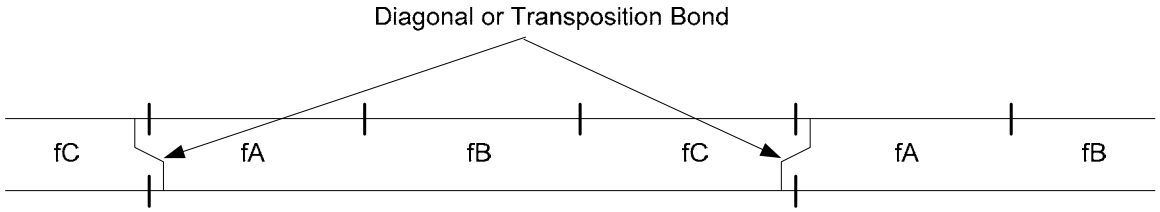

Figure 1 – Frequency Allocation in Single Rail bonded plain line

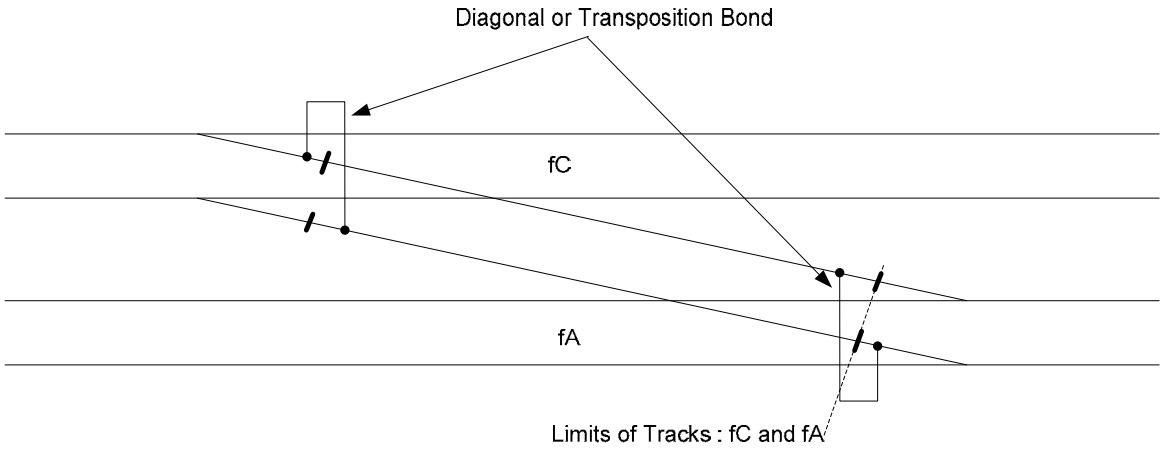

Figure 2 – Frequency Allocation at a Single Rail bonded crossover

NOTE For the example shown in Figure 2, it should be noted that there are further application rules defined in the EBI Track 200 Single Rail manual and the P&C Document providing details on permitted track lengths and TX/RX allocations. Provided these rules are followed, the boundary between the fC and fA tracks is compliant with the application rule RE1 defined in Table 4.2.6 in ET200 Single Rail manual due to the double IRJs and the traction continuity bond that provides the IRJ failure detection at the boundary.

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4.11 Switch & Crossing (S&C) Application

Double Rail jointless EBI Track 200 track circuits are permitted through emergency/engineer's ground frame points or clipped and padlocked (C&P) points, provided that:

- Standard double rail IRJ and bonding arrangements apply through the S&C, which means that a track circuit gap is created over the centre portion of a crossover when reverse. (See Bonding Requirements).
- Double Rail EBI Track 200 track circuits are permitted through S&C layouts (such as single turnouts), provided that the design constraints detailed in M125401A4.

Where parallel bonded spurs are used, these shall be limited to a maximum of 20m. Longer spurs require either series bonding of additional receivers.

See Bombardier single rail manual M580000626A4. It should be noted that this is more restrictive than the requirements stated in NR/L2/SIG/11752.

4.12 Track Circuit Lengths

The ‘Maximum and Minimum Track Circuit Lengths’ stated in M125401A4 shall apply with the following additional Network Rail requirements defined in this section.

4.12.1 Level Crossings

Track lengths through level crossings are the same as for all *EBI* Track 200 track circuits as defined in the Bombardier Technical Manual.

However there is a risk that due to the increased current leakage across the crossing it may be necessary to reduce the track length to obtain reliable operation.

For example:

- road salting in winter
- length of crossing
- makeup of crossing

Under these circumstances ballast resistance measurements should be taken through the crossing to determine the maximum permitted track length for each particular installation. Typically this may be a reduction of 75% from the maximum permitted length.

4.12.2 Poor Ballast Conditions

Maximum lengths should be reduced in locations susceptible to severe dampness, such as tunnels. The fitment of 20µF 500V Compensating Capacitors (Bucking Capacitors, Cat Number: 086/081342) is non preferred and only for sites where other options are not appropriate.

Where Compensating Capacitors are in use and there is a risk of ballast swings resulting from wet/dry ballast conditions; regular monitoring shall be put in place to check that the clear track current is controlled. Swings in excess of 20% shall be investigated as this can cause a rise in the drop shunt value.

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Compensating Capacitors additionally shall not be placed within 100m of an Impedance Bond.

4.13 Surge Protected End Termination Units (SPETU)

The Surge Protected End Termination Unit is an ETU fitted with surge protection (GDT) and replaceable fuses for use in single rail applications, where protection is required to prevent damage to internal components from traction short circuits.

All applications of the SPETU on Network Rail infrastructure shall use the Littelfuse 10Amp 600VAC fuse (KLK D 010, 086/043730)

NOTE Some MOD states of the SPETU are factory fitted with 5A fuses. These shall be replaced by 10A fuses as part of the Project design and application of the SPETU.

In the event of a SPETU failure; if it has been diagnosed that only a single 10A fuse has ruptured, both fuses shall be replaced.

NOTE There is a risk that the remaining working fuse has been stressed and could cause another imminent failure.

In addition the GDT shall be replaced by a 145VDC GDT (086/047392) as a precaution against the old GDT being stressed and damaged during the original fuse blow event.

NOTE Early versions of the SPETU have been delivered with a 95VDC GDT. If the SPETU is reliable there is no need to change the GDT. However if the SPETU fuses fail or there is an opportunity to change the GDT, it shall be replaced with the 145VDC version (086/047392).

A label for the purpose has been added to the later builds of the SPETU as shown in Figure 3.

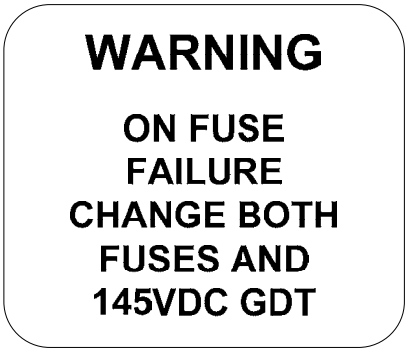

Figure 3 - SPETU Label for Fuse Failure and GDT action

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4.14 Impedance Bonds

4.14.1 Impedance Bonds General

The Bombardier B3 3000 style ferrite cored bond is a dedicated EBI Track impedance bond, which is supplied with eight different tuning modules (A to H), for use in both a.c. and d.c. electrified areas. They provide a maximum continuous total traction current of 3000 amps (1500 amp per half winding). These are the preferred type for EBI Track installations.

The B3 3000 bond shall be fitted with the accepted insulating bond covers to prevent failures resulting from metallic objects shorting the rail connection busbars to the case.

NOTE Network Rail has suffered with failures occurring during rail grinding. There have been instances where this grinding action has caused swarf to short circuit bus bars to the case of the B3 3000 bond causing train delay minutes. Other metallic items such as discarded tin cans etc can cause the same failure effect.

4.14.2 Impedance Bonds - Technical Characteristics

The technical characteristics are the B3 3000 Impedance Bond are shown below These values can be used to check whether the Impedance Bond is within specification.

Table 3 – Impedance Bond Tuning Capacitor Values shows the Capacitor Box capacitance values.

Frequency	Capacitance µF	Tolerance
A	308.23**µ**F	± 1.5%
B	167.22**µ**F	± 1.5%
C	222.07**µ**F	± 1.5%
D	130.79**µ**F	± 1.5%
E	373.41**µ**F	± 1.5%
F	191.80**µ**F	± 1.5%
G	259.76**µ**F	± 1.5%
H	147.29**µ**F	± 1.5%

Table 3 – Impedance Bond Tuning Capacitor Values

Inductance Value: The Inductance measurements for the Impedance Bond with No Capacitor Box connected should be between 27.8µH – 28.2µH. If the inductance is measured between the Ears and the Centre Tap, the value will be approximately half of the above.

Impedance Value: The Network Rail requirement for the impedance of the Impedance Bond at the Capacitor frequency is that it shall be a minimum of 8Ω. The Manufacturers specification is 12Ω when measured at the Capacitor frequency.

The *EBI* Track 200 application rules for Impedance Bonds is covered in the Bombardier Guidance Notes for Traction Bonding. In areas where high DC currents

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are expected, for example near feeder stations, it may be necessary to provide additional Impedance Bonds. Provision of these additional Impedance Bonds shall be agreed with the respective E&P Engineer.

Older designs used iron cored impedance bonds resonated by a tuning capacitor, housed in a terminal box, to present adequate impedance to the appropriate EBI Track 200 track circuit frequency. Those used are obsolescent types DD, DE, MR, P3 and S, and the current type WH3, type DD only being used in certain a.c. traction areas since it does not conform to BR863. Where existing types of track circuit are converted to EBI Track 200 and the obsolete impedance bonds are in use, these types of impedance bond shall be replaced by the B3-3000 type to optimise the reliability of the track.

4.14.3 Impedance Bonds - Mounting Arrangements

It is common practice for Impedance Bonds to be fitted in the 4ft.

If the Impedance Bond is mounted on concrete sleepers or on concrete slab track, a resilient rubber mat of a nominal 5mm thickness shall be provided between the concrete and the impedance bond.

NOTE This is to reduce the effect of shock and vibration on the impedance bond due to the passage of trains.

It is permissible for Impedance Bonds to be fitted in the CESS/10ft/6ft without affecting reliability.

However the E&P Engineers cable rating requirements for the side leads and centre tap connections shall be complied with. The traction cables to both rails (side lead connections) shall be the same length, irrespective of routing, to keep the traction current in balance and avoid saturation issues in the Impedance Bonds.

NOTE If there is an ETU/SPETU connected to the capacitor connection stud on the Bond, the total length of each connection from the ETUs/SPETUs to the Rails (via the Impedance Bond) should not exceed 15m and a min of 70mm2 conductor cable should be used.

If mounted in the CESS/10ft/6ft, B3 3000 Impedance Bonds may be mounted back to back on the same mounting post. There are no constraints relating to the physical proximity of the Impedance Bonds, however there shall be a minimum of 1m between rail connections.

A minimum of 2m spacing shall be provided between Impedance Bonds and Points Motors.

Generally 1m spacing between Impedance Bonds and other 4ft mounted equipment is acceptable. This will be constrained by the sleeper spacing nominally 0.6m if the adjacent sleeper is used or 1.2m if a single sleeper gap is provided.

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4.15 Interfaces to other Signalling Equipment

4.15.1 Equipment Mounting and Position Restrictions

Normal power trackside equipment (TUs) connected to transmitters shall not have any trackside equipment (TUs) connected to receivers of the same frequency, closer than 200 metres.

Where a track circuit is configured to operate in Low Power (LP) or Low Power Plus (LP+) mode, the proximity distance may be reduced to 50m. This includes a track circuit's own equipment and also equipment for any other track circuit.

This does not apply to block jointed tracks with detectable IRJ's hence does not apply to ETUs/SPETUs.

There are no proximity restrictions on mounting EBI Track 200 equipment with itself. Specifically it is permissible to mount Receivers of the same frequency on the same mounting plate.

However, there are specific positioning restrictions for the following:

- Aster Track Circuit Equipment,
- Reed Track Circuit Equipment,
- Westinghouse FS2600 Track Circuit Equipment,
- FDM Transmission Systems,
- Reed Point Detection Equipment,
- CCTV Equipment,
- Axle counter equipment
- TPWS TSS & OSS Loops.

EBI Track 200 equipment shall not be mounted in the same lineside apparatus case as CCTV equipment, due to interference from the EBI Track 200 equipment.

Where possible, EBI Track 200 equipment shall not be mounted in the same lineside apparatus case as Reed, FDM, Aster or FS2600 equipment, if another housing is available. If this is unavoidable, the Reed, FDM, Aster or FS2600 equipment shall be mounted at least 150mm clear of any EBI Track 200 equipment, i.e. two relay spaces horizontally or one row vertically.

Where *EBI* Track 200 equipment replaces a like for like Aster frequency unit in an Aster21 configuration; the proximity restriction above does not apply.

Any Reed or FS2600 system wiring (especially d.c. power supplies) shall not run parallel to EBI Track 200 wiring in the same cable ducting.

If necessary, additional cable ducting is to be provided on the other side of a lineside apparatus case to meet this requirement.

For EMC purposes there is an absolute restriction whereby:

- EBI Track 200 Frequency D shall not be located in the same lineside apparatus case or equipment building with FS2600 channel 1.

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- EBI Track 200 Frequency E shall not be located in the same lineside apparatus case or equipment building with FS2600 channel 10.

This restriction also applies to system wiring and cabling and any cross bonding as specified in the FS2600 Standard NR/L2/SIG/11760.

4.15.2 TPWS TSS & OSS Loops

All TPWS loops shall be positioned with at least 1m clearance longitudinally from any *EBI* Track 200 tuned zone or *EBI* Track 200 transmitter end tail cables except for frequency D.

Frequency D shall be positioned with at least 5m clearance longitudinally from any *EBI* Track 200 tuned zone or *EBI* Track 200 transmitter or receiver tail cables.

Localised false TPWS activations caused by *EBI* Track 200 frequency drift or close proximity to large metal structures shall be resolved by replacement and/or repositioning of the *EBI* Track 200 transmitter and associated End Termination Unit or Tuning Unit. False activation sites where this is not the case, but that are compliant to all fitment restrictions, shall be reported for investigation.

EBI Track 200 Frequency D transmitter end tail cables shall not be positioned:-

a) between TPWS Normal Direction Overspeed loops (f1 and f2)

b) beyond a TPWS Normal Direction Overspeed Arming loop (f1) in the opposite direction to which the loop applies, within the distance in which the on-board timer will remain energised at the line speed for that direction.
A distance of 55m for bi-directional lines and 38m for other lines shall be used to establish a generic exclusion zone for both freight and passenger trains travelling in the defined opposite direction. Where conflicts occur, to avoid un-necessary moving of equipment, distance S in Table 9 of NR/L2/SIG/10138 shall be used to establish the site specific absolute minimum exclusion zone. Where no relevant speed is specified in the Sectional Appendix then 50mph shall be assumed.

c) beyond a TPWS Normal Direction Train Stop Arming loop (f3) in the opposite direction to that which the loop applies, for a distance of 2m.

The frequency D constraint is because the *EBI* Track 200 Frequency D 2610Hz upper sideband 25th harmonic matches the 65250Hz OSS & TSS Normal Direction Trigger frequency, causing false activation of train brakes.

4.15.3 Train Detection Interfaces

There are special restrictions when abutting with other types of train detection systems due to application constraints or EMC interference.

4.15.3.1 *EBI* Track 400

EBI Track 200 can interface with *EBI* Track 400 utilising block joints at the interface or with tuned zones.

Block joint interfaces shall follow the *EBI* Track 200 rules for interfaces with alternative technologies.

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Two Tuned Zone interfaces provide jointless interfaces between *EBI* Track 200 and *EBI* Track 400. See Figure 4 and Figure 5 below.

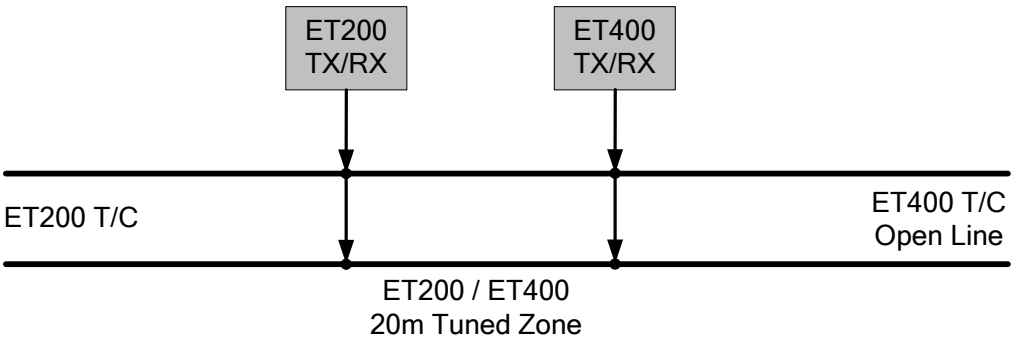

Figure 4 – *EBI* Track 200 -> *EBI* Track 400 Open Line frequencies.

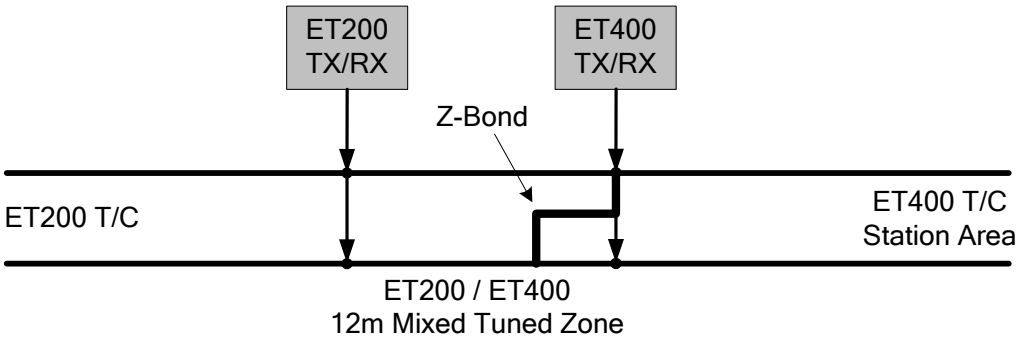

Figure 5 – EBI Track 200 -> EBI Track 400 Station Area frequencies.

Reference should be made to the *EBI* Track 400 Manuals for all rules relating to the Tuned Zone design and associated track lengths/constraints.

4.15.3.2 Aster Type 'U' Jointless / Style SF15 & 1Watt

The following *EBI* Track 200 and Aster track circuits combinations shall not abut each other in accordance with Table 4.

EBI Track 200	Aster track circuit	Additional Conditions
Frequency A	Aster SF15/U 1700 Hz	When the abutment is at an IRJ
Frequency B	Aster SF15/U 2300 Hz	When the abutment is at an IRJ
Frequency C	Aster SF15/U 2000 Hz	When the abutment is at an IRJ
Frequency D	Aster SF15/U 2600Hz	When the abutment is at an IRJ
Frequency D	Aster 1W type 2580Hz	When the abutment is at an IRJ

Table 4 – Prohibited *EBI* Track 200 and Aster track circuits abutments at IRJs

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