Signalling Design Principle – Train Detection Systems

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Standard governance

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Document history

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Preface

Asset Management Branch (AMB), formerly known as the Asset Standards Authority (ASA) is a key strategic branch of Transport for NSW (TfNSW). As the network design and standards authority for NSW Transport Assets, as specified in the ASA Charter, the ASA identifies, selects, develops, publishes, maintains and controls a suite of requirements documents on behalf of TfNSW, the asset owner.

The ASA deploys TfNSW requirements for asset and safety assurance by creating and managing TfNSW’s governance models, documents and processes. To achieve this, the ASA focuses on four primary tasks:

- publishing and managing TfNSW’s process and requirements documents including TfNSW plans, standards, manuals and guides
- deploying TfNSW’s Authorised Engineering Organisation (AEO) framework
- continuously improving TfNSW’s Asset Management Framework
- collaborating with the Transport cluster and industry through open engagement

The AEO framework authorises engineering organisations to supply and provide asset related products and services to TfNSW. It works to assure the safety, quality and fitness for purpose of those products and services over the asset’s whole-of-life. AEOs are expected to demonstrate how they have applied the requirements of ASA documents, including TfNSW plans, standards and guides, when delivering assets and related services for TfNSW.

Compliance with ASA requirements by itself is not sufficient to ensure satisfactory outcomes for NSW Transport Assets. The ASA expects that professional judgement be used by competent personnel when using ASA requirements to produce those outcomes.

About this document

This standard forms part of the TfNSW suite of railway signalling design principles that detail the specific design requirements. This standard specifically covers train detection systems and associated traction bonding requirements.

This standard supersedes Section 17 – Track Circuits of the RailCorp document ESG 100 Signal Design Principles, version 1.32.

To gain a complete overview of signalling design requirements, this document should be read in conjunction with the suite of signalling design principle standards; refer to T HR SC 10000 ST Signalling Design Principle – Introduction, version 1.0 and traction return design standards.

This standard covers requirements for the provision of the following types of systems used for the purpose of train detection:

- jointed track circuits
• jointless - frequency track circuits
• axle counters
• track circuit and traction bonding

The changes to previous content include the following:
• clarification to existing requirements for the provision of track circuits
• clarification to traction return and traction bonding requirements
• signalling design requirements for axle counter systems
• adaption of requirements specific to axle counters and train detection applicable to suit
  lineside signalling and cab signalling arrangements

This standard is a first issue.
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1. Introduction

Train detection systems are a fundamental component of the total signalling system.

Where the method of safewarking utilises train detection (also known as rail vehicle detection), the train detection system provides the interlocking with the rail vehicle positioning information used as part of signalling route controls.

2. Purpose

This document provides the signalling design principles applicable to the implementation of infrastructure based train detection as part of the trackside signalling system.

2.1. Scope

This document provides requirements for the design of the following train detection systems:

- track circuits
- axle counters

This document does not include the following:

- requirements around the construction and installation of associated train detection systems; refer to SPG 0706 Installation of Trackside Equipment
- non-vital train detection systems such as the systems used in wayside monitoring applications
- requirements for the management of rolling stock that is not compatible with the train detection system
- requirements associated with train detection symbology; refer to T HR SC 00004 ST Signalling Design Requirements – Signalling Symbols
- requirements associated with the preparation of signalling documentation and drawings, refer to SPG 0703 Signalling Documentation and Drawings and T MU MD 00006 ST Engineering Drawings and CAD Requirements

2.2. Application

This document applies to signalling design activities across all phases of the asset life cycle.

This document applies to Authorisation Engineering Organisation (AEO) involved in the design of train detection systems.

This document applies to existing and future signalling systems.
3. **Reference documents**

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

**Transport for NSW standards**

- EGG 1543 Signalling Requirements for Insulated Joints
- ESG 003 Signalling Equipment Configuration Standard
- ESG 007 Glossary of Signalling Terms
- SPG 0703 Signalling Documentation and Drawings
- SPG 0706 Installation of Trackside Equipment
- SPG 0709 Traction Return, Track Circuits and Bonding
- SPG 0729 Signalling Power Systems
- SPG 1858 Track Circuit Types, Characteristics and Applications
- T HR EL 12005 ST Bonding for 1500 V DC Traction Systems
- T HR SC 00006 ST Rolling Stock Signalling Interface Requirements
- T HR SC 01000 SP Common Signals and Control Systems Equipment Requirements
- T HR SC 00004 ST Signalling Design Requirements – Signalling Symbols
- T HR SC 10015 ST Signalling Design Principle – Trainstops
- T MU MD 00006 ST Engineering Drawings and CAD Requirements

4. **Terms and definitions**

Refer to the ESG 007 *Glossary of Signalling Terms*.

The following terms and definitions apply in this document:

- **AEO** Authorisation Engineering Organisation
- **ETCS** European train control system
- **IRJ** insulated rail joint
- **PSU** power supply unit
5. **Train detection provision**

Train detection shall be provided for each defined track section associated with the signalling arrangements and track layout.

The design of a train detection system shall ensure that the limitations of the system are not exceeded.

The design of a train detection system should ensure where practicable that the design considers failure modes and where possible, the availability of the network is maximised.

5.1. **Track section occupancy**

A track section shall indicate as ‘clear’ to the interlocking in the following situations:

a. the section is not occupied by a vehicle
b. the train detection system is not in a disturbed or failed state

Otherwise, the train detection system shall indicate as ‘occupied’. Any anomaly that affects the security of the system shall be detected immediately, leading the section to an occupied state.

6. **Track section identification**

A consistent approach to the identification of track sections shall be taken to complement other infrastructure associated with the signalling system.

All track section identification is required to be unique across an interlocking and shall be consistently applied in all associated documentation.

Track section identification shall not use the letters 'E', 'I' and 'O'.

All identifiers of track sections shall end with the letter 'T'.

In lineside and cab signalling areas, track sections are determined by blocks and the associated signal/European train control system (ETCS) marker board (physical or virtual) spacing, braking requirements and protecting ends of authority. The blocks should be arranged to obtain maximum flexibility with the amount of equipment rationalised where possible. The identification shall be denoted by signal placement or ETCS marker board (physical or virtual).

In cab signalling areas, ETCS marker board identification may adopt a different naming convention to signal identification; however the track section identification shall be applied in accordance with the applicable ETCS marker board.
6.1. **Running lines**

Track section identification shall be based on the identification number of the running signal or ETCS marker boards that leads over the particular section of track.

For each track section past a running signal or ETCS marker board, the identification number shall be suffixed by an alphabetic character. Each alphabetic character shall be allocated sequentially in the normal direction of travel always commencing with the letter 'A'; this includes the normal direction for bidirectional lines. See Figure 1 and Figure 2 for examples of this naming arrangement.

![Figure 1 – Track section identification – lineside signalling](image1)

![Figure 2 – Track section identification – ETCS marker boards](image2)

If a running signal or ETCS marker board reads over a diverging junction, in the absence of any other running signal or ETCS marker board numbers on the diverging line, a separate series of alphabetic suffixes shall be allocated sequentially in the normal direction of travel. The last track section of the diverging route shall use the suffix letter 'Z', then sequentially work back to the junction track. See Figure 3 for an example of this arrangement.

![Figure 3 – Track section identification – diverging lines](image3)
6.2. Non-running lines

Where the track arrangement does not provide suitable naming for the defined track sections, identification shall be suffixed by two or more alphabetic characters describing the particular line.

Examples of non-running lines are as follows:

- terminal platforms
- sidings
- yards
- shunting necks

For each track section on its particular line, the track section identification letters shall be suffixed by an alphabetic character. These shall be allocated sequentially in the direction of travel always commencing with the letter ‘A’. See Figure 4 for an example of this arrangement.

![Figure 4 – Track section identification – non-running lines](image)

6.3. Single lines

Isolated level crossing track sections shall be identified as UXT, XT, and DXT for the Up direction control, crossing control and Down direction control track sections, respectively. See Figure 5 for an example of this arrangement.

Overlapping level crossing control track sections shall have unique track section identifiers.
7. **Train detection power supply design**

For power supply requirements, refer to ESG 003 *Signalling Equipment Configuration Standard* and SPG 0729 *Signalling Power Systems*.

Power supply design shall ensure the following:

a. like frequency Tx and Rx on audio frequency track circuits are not fed from the same power supply unit (PSU)

b. failure of a PSU does not affect more than two signals and no more than one line, that is, a PSU does not feed Up and Down train detection equipment

c. axle counter systems shall have a no break supply when the main supply fails

*Note: Axle counters rely on the memory of the evaluator to maintain an accurate representation of the occupied or clear status of the sections monitored. One evaluator can control a number of wheel sensors and sections. The majority of systems have volatile memory and therefore the loss of the power supply will force the monitored sections to the disturbed state.*

8. **Track sections**

Designs shall take into account the engineering limits of the specific train detection type.

Track section boundaries shall be positioned to suit the following:

- block section limits
- applicable movement authorities
- at sets of points where it is necessary for train movements to be able to pass clear of other train movements
- approach control for a level crossing
- operational headway requirements
- facilitating the reset of axle counter track sections
8.1. **Track section lengths**

Track section lengths shall be defined on the signalling plan.

Track section lengths shall be measured from or to the following:

a. insulated rail joint (IRJ)

b. centre of tuned loop

c. centre of axle counter wheel sensor

d. track section termination point

The minimum length for a track section shall be 20 m; refer to T HR SC 00006 ST *Rolling Stock Signalling Interface Requirements*.

*Note: This is to avoid a small track section being bridged by long vehicles resulting in the loss of train detection.*

For axle counter systems the minimum track length shall also take the following into account:

a. maximum train speed

b. evaluator processing time

c. communications delay to interfacing axle counter system

*Note: This is to avoid the loss of train detection due to incorrect track section length.*

The maximum length of a track circuit is defined in SPG 1858 *Track Circuit Types, Characteristics and Applications.*

8.2. **Track section clearance points**

Where train movements pass clear through points and crossings, minimum and maximum distances of track section are as follows:

- The minimum distance between at which a track section limit shall be defined is 3 m outside the track surveyed clearance point.

  *Note: This defined track section limit considers the maximum length of vehicle overhang and the possibility of vehicles sagging back when the brakes of the train are released.*

- Where axle counters are in use, the maximum distance shall ensure an unobstructed view of the entire section through both normal and reverse routes.

  *Note: The maximum track section length considers the ability for a competent person to visually confirm the track section is free from a rail vehicle when resetting an axle counter and when required to manually wind points.*
See Figure 6 for an example of these arrangements and T HR SC 00006 ST for rolling stock and signalling interface requirements.

8.2.1. **Additional requirements in track circuit areas**

Where rail head corrosion is likely to occur due to infrequent use, the track circuit limit shall be defined at a point, which is 23 m beyond the clearance point to enable the longest wagon to stand between the track circuit limit and the clearance point and also remain clear of the junction. This reduces reliance on one wheel set providing a good track shunt in these circumstances. This arrangement is not necessary for points operated by a ground frame located adjacent to the points. See Figure 7 for an example of this arrangement.

8.2.2. **Timing sequence of track sections**

The boundary between any two track sections shall be designed such that when a train traverses the boundary there is no loss of train detection. The consequent track section shall indicate occupied within the interlocking before the preceding track section is allowed to indicate clear (in any direction of travel).
8.2.3. **Track circuit time delay**

All track circuits are required to have a time delay to protect against momentary losses of shunt. Time delays shall be consistent in accordance with ESG 003.

The delay may be an internal function of the track circuit or applied by way of external means.

8.2.4. **Resistance of Track Stick circuit**

Track circuits have been proven unreliable if the stick path of the track stick circuit is of too high a resistance and there is excessive voltage drop when the receiver or relay is being fed through the stick path.

Designs of the track stick circuit shall limit the amount of resistance in the ‘stick’ path of the circuit to ensure that there is no more than 10% of the circuits operating voltage dropped across the stick path.

8.3. **Centre fed track circuits**

The following applies to track circuits:

a. centre feed track circuits shall be of equal lengths

b. a common Tx connection point shall not be used as a clearance point

c. failure of a centre feed and multi-feed Tx shall not affect more than two signals and no more than one road

9. **Trackside equipment location**

The following applies to trackside equipment locations:

a. All non-rail mounted equipment should be in a position of safety wherever possible.

   *Note: If it is not practicable to locate non-rail mounted equipment in a position of safety then alternate arrangements should be made to access the equipment safely.*

b. When choosing suitable positions for non-rail mounted equipment, the position shall not cause cables to run across any cable troughing route or to present a tripping hazard.

   *Note: The positioning of equipment and cables should also take account of possible damage from track maintenance, access and other risks. Suitable measures should be taken to minimise this risk.*

c. Rail-mounted equipment should wherever practicable be fitted to the rail closest to the safe cess or the nearest position of safety unless otherwise justified.
Note: Consideration should be given to works activities such as rail grinding, tamping, and so on to minimise the risk of damage or the requirement for wheel sensor removal to facilitate works.

d. Non-rail mounted equipment such as trackside disconnection points should, wherever practicable, be positioned on the same side as the safe cess or nearest position of safety, unless otherwise justified.

Note: If it is not practicable to locate non-rail mounted equipment in a position of safety then alternate arrangements should be made to access the equipment safely.

10. Track circuits – insulated rail joints

Track circuits refer to those that use insulated rail joints to define the limits of the track section. The location of IRJs shall be shown on the signalling arrangement drawings and be clearly dimensioned.

10.1. Location of insulated rail joints at signals with trainstops

Where possible, the insulated joint should be placed in line with the associated signal and trainstop. Where this cannot be achieved, refer to SPG 0706 Installation of Trackside Equipment for details that permit tolerances in the placement of the signal and trainstop relative to the IRJ.

For the rationale and related factors in the placement of IRJs with respect to the signal and trainstop, refer to T HR SC 10015 ST Signalling Design Principle – Trainstops.

10.2. Location of insulated rail joints at points

The position of IRJs in turnouts shall be in accordance with EGG 1543 Signalling Requirements for Insulated Joints.

Wherever possible, IRJs shall be located in the turnout rails of points unless the turnout rails are in the most used route; see Figure 8.

Figure 8 – Location of insulated rail joints in points
The insulated joint stagger in crossovers shall be the minimum permitted by the type and angle of the 'V' crossing and the track centres at the particular location. The stagger shall also be consistent with any applicable traction return continuity requirements. Any sections of rail that minimise the effectiveness of the track circuit being shunted, due to the electrical stagger, shall be minimised where possible.

Alternatively, where the turnout route is subject to frequent traffic use, the IRJs may be placed in the straight rail of the points only where the turnout rails are subject to heavy side loadings.

10.3. Location of insulated rail joints at level or pedestrian crossings

Notwithstanding the minimum track length requirements, wherever possible, IRJs used to define the track circuit limit for the purpose of ceasing the level crossing operation controls shall not be located more than 5 m from the leading edge of the roadway. This is to minimise delays to road users due to crossings being activated longer than is necessary.

10.4. Location of insulated rail joints at bridges

Insulated joints shall not be installed within 10 m of bridge ends and preferably not within 30 m.

*Note: The change in track stiffness at bridge ends may affect the integrity of the IRJ.*

10.5. Stagger of insulated rail joints

In plain track, the maximum permitted stagger between IRJs where impedance bonds are not present is 2.4 m. See Figure 9 for an example of this arrangement.

The maximum stagger shall mitigate partial or sequential train detection loss.

![Figure 9 – Stagger of IRJ – plain track](image)

In points and other locations where single rail track circuits adjoin and particularly where the traction rail changes sides, care should be taken to provide a small overlap between traction rails; otherwise this can result in arcing. See Figure 10 for an example of this arrangement.
Where impedance bonds are present, either with double rail track circuits or with double to single rail track circuits, the maximum stagger shall not exceed 100 mm so that under failure conditions, the possibility of a feed from one track circuit to the next through a train axle is minimised.

10.6. Guard rails

A risk of guard rails enabling track circuit currents to bypass the running rails can be present.

In track circuited areas, guard rails shall be electrically broken into sections of no less than 150 m and no greater than 200 m sections. The electrical break may be by insulated joint, or by the guard rail itself finishing and recommencing as a separate rail.

Guard rails on both rails shall have their isolation points located adjacent, and preferably at the centre of the track circuit.

11. Bonding in direct current electrified territory

In direct current (dc) electrified territory, provisions shall be made for the traction return current in addition to the method of train detection.

The configuration of the bonding at turnouts and crossovers shall be such as to maintain the essential train detection capability and traction return.

Section 11.1 to Section 11.13.5 provide details on train detection bonding requirements only and exclude bonding for traction return. Refer to SPG 0709 Traction Return, Track Circuits and Bonding for more information.

11.1. Turnouts – single rail track circuits

The use of parallel bonding on single rail track circuits may be used in lieu of the twin relay arrangement in the following situations:

- track speed is low, such as in stabling yards
- where the rail that is parallel bonded does not provide any significant reduction in broken rail protection (for example, ends of crossing loops)
Such arrangements shall always have the feed or relay on the 'bonded-in' leg, such that removal of the series bond will fail the track circuit. Bonding shall only be applied at one end of the turnout extremity and shall be a series bond. See Figure 11 for an example of this arrangement.

![Figure 11 – Bonding arrangement – series/parallel arrangement](image)

If the traction return is designed for single rail return, two track relays or receivers shall be provided for the broken rail and broken bond protection at the turnouts. See Figure 12 for an example of this arrangement.

![Figure 12 – Bonding arrangement – two relay parallel arrangement](image)

Contacts of the track relay or receiver shall be wired in series with contacts of the first track relay and preferably switch a common track repeat relay which then controls the relevant circuits.

Track stick proving of signal control relays would only be included in one of the track relays.

### 11.2. Crossovers – single rail track circuits

Where crossovers are provided in single rail track circuited areas, a full parallel bonding arrangement shall be adopted for single rail tracks on crossovers in electrified areas. See Figure 13 for an example of this arrangement.

![Figure 13 – Bonding arrangement – crossover – parallel bonding arrangement](image)
The parallel bond on the signalling rail shall be connected as close as possible to the points crossing to provide maximum broken rail protection on the main line.

The position of IRJs in crossovers shall be in accordance with EGG 1543.

11.3. **Turnouts – double rail track circuits**

Section 11.3.1 and Section 11.3.2 provide examples of options where double rail traction return is provided at turnouts.

11.3.1. **Jeumont and 50 Hz ac track circuits**

Where Jeumont 4 wire receivers are used, parallel bonding shall be used. Bonding should be provided to enable train detection in the event of a broken rail. Refer to Figure 14 and Figure 15 for examples of Jeumont bonding arrangements. Refer to Figure 16 and Figure 17 for other bonding arrangements.

![Figure 14 – Bonding arrangements – Jeumont 4 wire receiver](image1)

Where two wire Jeumont receivers are used, two receivers are preferred for Jeumont track circuits as it provides for broken rail protection.

![Figure 15 – Bonding arrangements – Jeumont double receiver](image2)

![Figure 16 – Bonding arrangements – Double Rail Electrified – AC Track Circuit](image3)
11.3.2. **Crossovers – double rail track circuits**

A full parallel bonding arrangement shall be provided for double rail tracks at crossovers. See Figure 18 for an example of this arrangement.

![Figure 18 – Bonding arrangements – double rail – crossover](image)

11.4. **Long turnouts and crossovers**

On power operated long turnouts and crossovers where main aspects are provided for both routes*, an additional receiver or relay shall be provided at the blockjoint or blockjoints in the turnout path where the distance from the ‘V’ crossing to the blockjoint or blockjoints exceeds 30 m.

*Note: high speed turnouts

Where the distance is less than 10 m, surface run parallel bonding may be installed. For distances between 10 m and 30 m, parallel bonding should be used with the bonds from the blockjoint end buried and connected back along the main line to maximise broken rail detection on the main line.
11.5. Jointless track circuits

Where jointless track circuits are used over turnouts and the tied-in leg is less than 36 m long, parallel bonds at 12 m intervals shall be provided. See Figure 19 for an example of this arrangement.

![Figure 19 – Bonding arrangements – jointless track circuits](image)

Where the tied-in leg is greater than 36 m in length, a receiver shall be provided on each leg. See Figure 20 for an example of this arrangement.

![Figure 20 – Bonding arrangements – jointless track circuits – additional receiver](image)

11.6. Rail connections

To ensure that a track circuit shunts effectively at all extremities, all bonds connecting parallel sections of a track circuit shall be connected to the rails as close as possible to the insulated rail joints as indicated on the track insulation plans.

The cross-sectional area of all bonds connecting traction return rails shall be sufficient to pass the traction return currents in the area.
11.7. **Track circuit polarity**

Track relays of adjacent track sections shall be prevented from incorrect operation due to failure of the insulated joints. Such protection shall be achieved by connecting opposite polarities on either sides of the insulation joint of abutting track sections. See Figure 21 for an example of this arrangement.

![Figure 21 – Track circuit polarity – adjacent track circuits](image)

This requirement may be relaxed when any of the following conditions are met:

- track feeds or transmitters are present at the abutting ends of the two track circuits
- where a failed insulated joint shorts the signalling rail to the common traction return rail in single rail track circuit over points
- where the de-energised track relay isolates the adjacent track feed in cut track sections

Polarity reversal does not apply to audio frequency track circuits; however, frequency alternation shall be observed for adjacent audio frequency tracks, whether jointless or jointed, even if there are intervening non-audio frequency track circuits.

Audio frequency track circuits separated by intervening track circuits shall maintain frequency rotation. Where this cannot be achieved and like frequencies abut, the intervening track circuits, the transmitter ends of the tracks shall be located at the boundary with the intervening track.

11.8. **Impedance bonds**

The purpose of an impedance bond is to provide continuity between the track circuits and to distribute traction return current between the running rails.

Impedance bonds place a load on the track circuit. To limit the effect on the track circuit, the following shall be achieved:

- no more than four impedance bonds shall be installed on an ac or audio frequency track circuit
- no more than three impedance bonds shall be installed on double rail Jeumont Schneider track circuits
• impedance bonds shall not be installed closer than 50 m to a tuned loop

  Note: In the case of audio frequency tuned loops, the tuning is achieved by inductance and capacitance. The requirement for the 50 m from a tuned loop is that the inductance of the impedance bond does not de-tune the tuned loop.

For every impedance bond installed on a track, the track length shall be reduced by 100 m.

  Note: The maximum permitted revised track length (m) = maximum track length (m) – (# impedance bond x 100 m).

11.9. Tie-in traction bonding

To minimise return rail resistance effects in multiple track sections it is necessary to distribute the traction return current causing it to flow through all return rails including those on adjacent lines. Tie-in bonding shall be provided at suitable intervals along the track in accordance with SPG 0709.

The following requirements apply to tie-in traction bonding on multiple track lines:

  a. Audio track circuits of the same frequency shall not be tied together.

  b. For double rail track circuits, impedance bonds linked together with cables of the appropriate cross-sectional area shall be provided. See Figure 23 for an example of this arrangement.

  c. Impedance bonds with cables of the appropriate cross-sectional area shall be used to link double rail track circuited lines to axle counter track sections.

  d. Bonding of axle counter tracks to track circuited lines shall ensure no effect to the train detection system or systems.

  e. Bonding between different types of train detection system shall observe the correct method of connecting to each track section type.

  f. Details for the tie-in bonding of single rail track circuits can be found in SPG 0709. Traction return rails shall be connected together at their extremities.

    This is to ensure continuity of the traction return system in case a break occurs in a return rail.

Further requirements for tie-in traction bonding can be found in SPG 0709.
11.9.1. **Cross bonding**

Cross bonding shall be applied at either end of an interlocking, or group of turnouts, where the double rail traction return on both (or more) tracks changes to a mix of single or double rail through the interlocking or group of turnouts.

11.10. **Termination of track sections**

Track sections should be terminated in accordance with Section 11.10.1 to Section 11.10.7. Different interface arrangements exist between the different types of train detection systems provided, single and double rail traction return systems and electrified and non-electrified areas.

11.10.1. **Interfacing jointed to jointed track circuits**

Figure 23 to Figure 25 provide examples of jointed to jointed track circuit interface arrangements, in double and single rail track circuits.
Figure 24 – Double to single rail track circuit

Figure 25 – Single rail track to single rail track circuit
11.10.2. Interfacing jointed to jointless track circuits

Figure 26 and Figure 27 provide examples of impedance bond arrangements at jointed to jointless track circuit interfaces.

**Figure 26 – Double rail track to jointed AF track circuit interface**

**Figure 27 – Single rail to jointed AF track circuit interface**
11.10.3. Interfacing jointless to jointless track circuits

Figure 28 provides an example of a jointless to jointless track circuit interface arrangement.

*Note: Tuned loop length varies according to the configuration and type of track circuit.*

![Figure 28 – Jointless to jointless track circuit interface](image)

11.10.4. Interfacing jointed track circuits to axle counter track sections

Where axle counter track sections abut jointed track circuits, insulated joints shall be provided to ensure correct operation of the track circuit. Bonding shall be provided to ensure continuity of the traction return system.

The axle counter wheel sensor shall be positioned relative to the insulated joints and track circuit connection points in accordance with the manufacturer’s requirements. Sufficient overlap shall be provided between the axle counter wheel sensor and the adjacent track circuit to ensure that continuous train detection is maintained. The wheel sensor should be placed as close as practically possible to the track circuit, minimum of a sleeper bay (that is, min 0.6 m) but may be increased dependent on system processing times specified by the manufacturer.

When double rail track circuits interface with axle counter track sections, an impedance bond shall be required. See Figure 29 for an example.
When single rail track circuits interface with axle counter track sections, an impedance bond is not required. See Figure 30 for an example.

Figure 29 – Double rail track circuit to axle counter section interface

Figure 30 – Single rail track circuit to axle counter section interface
11.10.5. Interfacing jointless track circuits to axle counter track sections

Figure 31 provides an example of a jointless track circuit area interfaced to an axle counter section arrangement.

![Jointless track circuit to axle counter section interface](image)

Figure 31 – Jointless track circuit to axle counter section interface

11.10.6. Other interfaces

The following sections describe interfaces between electrified and track circuited areas, to areas with either no track circuit, non-electrified or axle counter section.

Figure 32 and Figure 33 provide examples of a jointless track circuit areas interfaced to areas where no train detection is provided and where the line is required to carry traction return current.

![Jointless track circuit with impedance bond abutting area where no train detection provided – electrified area](image)

Figure 32 – Jointless track circuit with impedance bond abutting area where no train detection provided – electrified area
Figure 33 – Jointless track circuit with tuning unit abutting area where no train detection provided – electrified area

Figure 34 provides an example of a jointless track circuit interfaced to an area where no train detection is provided, to a non-electrified area.

Figure 34 – Jointless track circuit to area where no train detection provided – non-electrified
Figure 34 and Figure 35 provide examples of jointed track circuits interfaced to areas where no train detection is provided in electrified territory.

![Diagram](image1)

**Figure 35** – Double rail track circuit to areas where no train detection is provided – electrified

Figure 36 and Figure 37 provide examples of jointed track circuits interfaced to areas where no train detection, where the line does not carry traction return currents.

![Diagram](image2)

**Figure 36** – Single rail track circuit to areas where no train detection provided – electrified

![Diagram](image3)

**Figure 37** – Double rail track circuit to areas where no train detection provided – non-electrified
11.10.7. Section huts and substations

Tie-in traction bonds are provided between adjacent running lines or where it is necessary to connect the traction return rails of double rail track circuits to a sectioning hut or substation busbars.

Tie-in bonding shall be extended to form a connection to the sectioning hut or substation busbars.

Danger signs shall be provided at sectioning huts and substations warning against the disconnection of cables.

See Figure 38 for an example of a section hut connection.

Figure 38 – Single rail track circuit to areas where no train detection provided – non-electrified

Figure 39 – Section hut connection
See Figure 39 for an example of a substation connection arrangement.

**Figure 40 – Substation connection**

### 11.11. Track insulation plan

Full details of all tie-in bonding and all other connections to sectioning huts or substation busbars together with cable types and sizes shall be documented on the track insulation plan.

### 11.12. Cabling

Traction and track circuit cables shall not be located on the surface across multiple lines.

Track maintenance on one track which requires disconnection of cables shall not require disconnection on an adjacent track. This adjacent track is required to minimise the impact on the traction return currents and to ensure rail-connected overhead wiring remains safe.

The trackside busbars are the interface between the signals and electrical disciplines. Where traction return cables are provided between busbars, and to the substation or section hut, these buried cables are the responsibility of the electrical discipline.
11.13. Additional bonding requirements

Additional bonding of infrastructure not associated with signalling and control systems may be required to the traction return system.

11.13.1. Spark gaps

Overhead wiring stanchions and other metal structures shall be provided with a rail connection through a spark gap. Refer to T HR EL 12005 ST Bonding for 1500 V DC Traction Systems.

Rail connections shall be provided in accordance with the following:

- to the traction rail (for single rail track circuit)
- to the neutral point of an impedance bond
- in the case of double rail type traction return systems, to the nearest rail
- for audio frequency track circuits, connections of subsequent structures shall remain on the same rail, and change to the opposite rail at the middle of the track circuit
- axle counter territory – any convenient rail location; however, not closer than 500 mm to a wheel sensor

A possibility exists for spark gap connections to provide a bypass path for track circuit current and care should be taken to design spark gap and other bonding arrangements that minimises this risk.

Spark gap connections shall not be made within the tuned loop.

11.13.2. Electrolysis bonds

Electrolysis bond connections shall be made to the following:

- traction rails of single rail track circuit
- neutral points of impedance bonds
- a ‘Store 54’ electrolysis bond choke installed across the rails, as if it were an impedance bond
- axle counter territory – any convenient rail location; however not closer than 500 mm to a wheel sensor

Connection of the Store 54 choke to rail shall use Hypalon insulated cables rated for the expected currents.

Note: Connection from the Store 54 to the electrolysis bond box uses two cables. A smaller cable for voltage sensing that is usually 7/0.85 mm. The second cable carries the electrolysis currents and is usually 7/1.7 mm.
11.13.3. Overhead wiring switches

Rail connections for overhead wiring (OHW) switch connections shall only be made to rails connected for traction return.

These are as follows:

- traction rails of single rail track circuits
- neutral points of impedance bonds
- axle counter territory – any convenient rail location; however not closer than 500 mm to a wheel sensor

OHW switch rail connections shall be made to the nearest traction return point. The location of the switches and suitable traction return points should be considered in the design to minimise the length of cables from the switch to the traction return point. Switches for several tracks may have a common traction return point.

11.13.4. Temporary rail connections

Temporary rail connections for OHW shall only be made to rails connected for traction return. These are as follows:

- traction rails of single rail track circuits
- neutral points of impedance bonds
- axle counter territory – any convenient rail location; however not closer than 500 mm to a wheel sensor

Connections to the closest rail of double rail track circuits are only permitted if the track circuit is not required to be functional.

11.13.5. Friction buffer stops

Friction buffer stops rely on being clamped to the rails to achieve their frictional sliding characteristics. Where friction buffer stops are provided on track circuited lines, insulated joints shall be provided before the buffer stops to ensure the correct operation of the track circuit. Bonding shall be provided to ensure the rails that the buffer stops are mounted on are connected to the traction return system. See Figure 40 for an example of this arrangement.
12. **Traction return**

A minimum of three out of four rails and preferably four out of four rails shall be used for traction return on multiple main lines and two out of two rails on single lines. Single rail traction return may be used in sidings only where multiple parallel roads exist, providing the single rail commences after the division of the entrance neck. Each group of siding traction rails shall be bonded at each extremity to the general traction return network. Bonding cables shall not be relied upon to provide an alternate traction path where rails have been specified above.

12.1. **Traction bonding past the end of OHW**

In places where the OHW ends but the track continues, or a set of points exist where one track is wired for traction but the other track is not, traction return bonding shall be provided. This is to ensure that an overrun of an electric train into the unwired track does not result in dangerously high voltages on the rails.
As the pantographs on a train are located some distance behind the front of the train as well as intermediate pantographs cross feeding other cars, the traction bonding shall extend beyond the end of the OHW, by a distance that considers the number of powered cars that could transit into the non-electrified section.

Beyond the area that needs to be bonded for traction return, insulated joints shall be provided to prevent traction currents flowing in areas where it is not designed for.

13. **Axle counters – design and generic application conditions**

Generic application rules for axle counter systems and the fundamental design principles to be adopted are detailed in Section 13.1 to Section 13.2.3.

These relate to the physical attributes that the system should have and technical application of various systems.

13.1. **Generic application rules**

The high level requirements shall establish the generic system design principles required to safely manage the provision of axle counter systems for train detection.

13.1.1. **Minimum and maximum axle counter sections lengths**

Technical maximum limit does not apply to the length of an axle counter section, provided the following are satisfied:

- meeting the signalling system requirements (operational, performance, reliability, maintainability and so on)
- rail vehicle detection time shall be no greater than 1’s
- capability of the data transmission system
- effect of cable losses on long cable runs
- effect of induced voltage in electrified areas

*Note: Where flexibility can be exercised in signal positioning, advantage should be taken to optimise the design around these factors to enable a simpler and cost effective solution. The method of reset should be considered and other operational advantages may be available in providing extra sections; for example, to prevent a considerable distance (and time impact) when required to examine the line. These factors should be discussed and agreed at the design stage.*

Minimum axle counter section lengths shall comply with Section 8.
13.1.2. Wheel sensor naming convention

Each wheel sensor shall be uniquely identified.

The following requirements apply to wheel sensor naming convention associated with axle counter wheel sensors:

a. Wheel sensors shall be identified by the names of the sections on either side. For example, adjacent sections 3AT and 3BT share be defined 3A3B as the wheel sensor. The first track section of the wheel sensor name shall use the leading track section over the wheel sensor in the defined normal direction of travel. The ‘T’ denoting the track section shall be retained in the interlocking sub-system (data).

b. Where more than one wheel sensor has the same identity (such as a crossover or turnout), then a suitable numerical suffix shall be used. Only the numerical suffix is to be shown on a signalling plan.

c. The wheel sensor at the end of an axle counter area, such as to or from a track circuited or non-track circuit area, shall include the track section in the wheel sensor name. The axle counter wheel sensor names shall not be identified on signalling or concept scheme plans, only on other, detail design artefacts and equipment on site (including lineside unit, case or lid).

d. The model number of the axle counter shall also be shown on the signalling plan, beneath the track section identification.

Refer to Figure 41 and Figure 42 for examples of axle counter track sections represented on signalling plans.
13.1.3. Wheel sensor positioning

A wheel sensor shall be provided at all limits of a track section where wheels can enter or leave the section with the exception of buffer stops and catch points.

The following applies to wheel sensor positioning:

a. axle counter wheel sensors shall be positioned in accordance with Section 8 to define individual track sections

b. the midpoint of the wheel sensor shall be used to reference the track section start or end point

b. wheel sensors shall not be positioned where, due to the method of operation, trains are likely to stop with any wheel stationary over a wheel sensor

Note: This is to reduce the potential for an axle counter disturbance due to minor wheel movements within the detection zone. For example, whilst stopped at a station platform.

c. wheel sensors should be located on the inside rail of curved track

Note: This is to reduce the potential for an axle counter disturbance due to greater rail wear on the outer rail.
Positioning at points and crossings

In areas of points and crossings, wheel sensors shall (in conjunction with interlocking controls) be positioned so as to maintain the critical dimensions required for passing clearances. The positioning of wheel sensors shall conform to Section 8.2.

13.2. Axle counter system design

The design of axle counter train detection systems are covered in this Section 13.2.1 to Section 13.2.3.

13.2.1. System architecture

The following applies to system architecture:

a. The boundaries of each evaluator area shall be chosen for operational benefits and take account of data complexity and the impact of an evaluator failure.

   Note: In large or critical station areas, the effect of disruption should be carefully considered. For example, if bidirectional lines are provided, care should be taken to make sure that a single evaluator failure does not remove all the benefit of the bidirectional facilities.

b. In areas where more than three wheel sensors are used to define a single track section, such as mainline to sidings, then availability of the section shall be taken into account.

c. On main lines, separate evaluators and backplane shall normally be provided for each line, such as up line only, down line only.

   Note: Splitting evaluators and backplanes between normal directions of travel reduces the impact of a common mode failure. Evaluators should be allocated to sections of line so that in failure conditions, disruption and consequential need for mass reset of sections is localised.

d. At the boundary between different axle counter systems, wheel sensors from each system shall be arranged to overlap to ensure continuity of detection.

e. A minimum of 10% spare capacity shall normally be provided for wheel sensors and sections in an evaluator to permit future expansion.

   Note: Each site should be considered individually; however the cost of providing a larger capacity evaluator at the original design stage is relatively small compared to the cost of replacement later.

f. Evaluators shall not span two interlocking control areas.

   Note: This eliminates the need for special reset controls in order to prevent more than one reset request to an evaluator at the same time.
### 13.2.2. Wheel sensors in crossovers

Within crossovers, axle counter wheel sensors shall be positioned to overlap each other to ensure continuous train detection through the crossover. See Figure 41 for an example of this arrangement. Minimum distance from each wheel sensor and other metal mass shall be maintained in accordance with manufacturer's requirements.

Shared wheel sensors at crossovers shall not be used in case of system disturbance or failure affecting multiple lines.

### 13.2.3. Axle counter data configuration

For data management and configuration requirements refer to T HR SC 01000 SP *Common Signals and Control Systems Equipment Requirements*.

### 14. Obsolete requirements

Section 14.1 to Section 14.3.6 contain requirements that are not applicable for new works; however they provide reference information for retrospective upgrade works.

#### 14.1. Single lines

*Note: previously Section 100.17.1.4.2.*

Wherever possible an ‘in section’ track circuit identification shall be based on kilometrage (or mileage) distances from Sydney.

Track circuits approaching distant signals shall be identified as UAT and DAT for the Up and Down directions, respectively, with sequential alphabetic suffixes if required. For example, UBT and UCT. See Figure 43 for an example of this arrangement.

![Figure 44 – Track section identification – single line](image)

#### 14.2. Location of insulated joints at signals without trainstops

*Note: previously Section 100.17.3.2.*

Ideally the insulated joints shall be located directly in line with the signal to which they apply and preferably not more than 2 m past the signal. See Figure 44 for an example of this arrangement.
14.3. **Track circuit bonding in non-electrified territory**

*Note: previously Section 100.17.6.*

14.3.1. **Introduction**

*Note: previously Section 100.17.6.1.*

Track circuit bonding is provided to ensure train detection and where practical to provide broken rail detection on main lines and high speed turnouts. The configuration of the bonding at turnouts and crossovers shall be such as to maintain the essential train detection capability when there are broken rails or otherwise shall be such as to ensure those broken rails fail the track circuit.

14.3.2. **Turnouts**

*Note: previously Section 100.17.6.2.*

Insulated joints situated in points (leads) shall be located in the least used or lowest speed leg of the points, which will usually be the turnout.

To provide for broken rail and broken bond protection two relays or receivers shall be provided. See Figure 45 for an example of this arrangement.
Bonding would only be applied at the one end of the turnout extremity and would in effect be a series bond.

Contacts of the second track relay are to be wired in series with contacts of the first track relay in the relevant circuits or in a track repeat relay circuit.

Track stick proving of signal control relays would only be included in one of the track relays.

Where the extremities of the track circuit beyond the points are of widely different lengths then it may not be possible to maintain the relays in fine adjustment and the full parallel bonding arrangement shall be applied. See Figure 46 for an example of this arrangement.

![Figure 47 – Connected bonds – parallel to the main line](image)

The parallel bonds shall be connected back along the main line as shown in Figure 46 to provide maximum broken rail protection on the main line.

Figure 46 shows where the extremity of the track circuit in the turnout does not align with the extremity of the track circuit in the main line, and it is not practical to place the two track relays in separate locations.

### 14.3.3. Crossovers

*Note: previously Section 100.17.6.3.*

Full parallel bonding on crossovers in non-electrified areas shall be provided. See Figure 47 for an example of this arrangement.

![Figure 48 – Track circuit bonding at crossovers – non-electrified territory](image)

The parallel bonds shall be connected back along the main line to provide maximum broken rail protection on the main line.
14.3.4. Connection of bonds to rails

*Note: previously Section 100.17.6.4.*

All series and parallel bonds shall be connected to the rails as close as possible to the insulated joints. This shall be clearly depicted on the track insulation plans.

14.3.5. Polarity of adjacent track circuits

*Note: previously Section 100.17.6.5.*

To prevent the incorrect operation of an adjacent track circuit relay due to an insulated joint failure, track circuits of the same type which abut at an insulated joint shall be of opposite polarities. See Figure 48 for an example of this arrangement.

![Figure 49 – Track circuit polarity – adjacent track circuits](image)

This requirement may be relaxed if one of the following is present at the abutting joints:

- a track feed on either side
- in cut section tracks the de-energised track relay isolates the adjacent track feed
- at crossovers with single rail track circuits the failure of a blockjoint applies a short circuit across the tracks

Polarity reversal does not apply to audio frequency jointless track circuits.

14.3.6. Long turnouts and crossovers

*Note: previously Section 100.17.6.6.*

On long motor worked turnouts and crossovers where main aspects are provided for both routes, notably high speed turnouts, an additional receiver or relay shall be provided at the blockjoint or blockjoints in the turnout path where the distance from the ‘V’ crossing to the blockjoint or blockjoints exceeds 30 m. Because of this additional load on the points track circuit, the length of the track circuit may need to be limited for reliable operation. Where this distance is less than 10 m then surface run parallel bonding may be installed. For distances between 10 m and 30 m parallel bonding should be used with the bonds from the blockjoint end
buried and connected back along the main line to maximise broken rail detection on the main line.