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Train Detection (formerly RT/E/S/I 1752)

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

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

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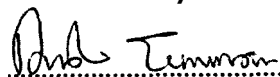
RAILTRACK COMPANY

SPECIFICATION

TRAIN DETECTION

Endorsement and Authorisation

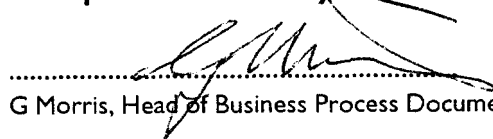
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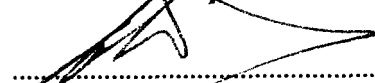
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PART A

SUMMARY

This Specification gives the necessary requirements for train detection systems to satisfy the mandatory requirements laid down in Railway Group Standard GK/RT0011, Train Detection.

ISSUE/REVISION RECORD

This Specification will be updated when necessary by the distribution of the complete document. Amendments will be marked by a vertical black line in the adjacent right hand margin.

Issue	Date	Comments
Issue 1	December 2000	New Document
Issue 2	August 2001	Minor amendment. Part F12 amended to prohibit use of 83.3Hz track circuits on Railtrack infrastructure.

IMPLEMENTATION

The requirements of this Specification are mandatory and shall be implemented from 4 August 2001.

Superseded documents	Issue	Date
RT/E/S/11752	1	December 2000

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PART B OVERVIEW

I INTRODUCTION

A train detection system forms part of or provides input to the signalling system to detect:

- that a train has reached, is passing or has passed a specific position (discrete systems),
- the presence or absence of vehicles within the limits of a track section (continuous systems), or
- the absence of vehicles within an envelope ahead of a train that progresses with the passage of the train (moving block systems).

Where required, a train detection system may additionally detect the direction in which a train is travelling. (In the case of axle counters, this is a requirement of the method of operation.)

Discrete systems include wheel detectors (treadles or electromagnetic proximity devices) and rail circuits. These may be provided in addition to continuous systems.

Systems of continuous train detection, based on track sections, may either provide continuous monitoring (e.g. track circuits), or entrance and exit monitoring (e.g. axle counters).

The function to which a train detection device is most suited is dependent upon its designed failure mode. Systems that fail in the occupied state are capable of proving the absence of a train. For instance, the track circuit is a device designed to continuously prove the absence of a train from a given track section; it cannot absolutely prove the presence of a train, since its designed failure mode is to give the same indication as if a train is present.

Some train detection systems provide an undefined state, in addition to occupied and clear. This can assist, under failure conditions (or operation of a track circuit interrupter), in ensuring that the safest state is achieved for all applications.

1.1 Block Systems

Block systems (which require the absence of a train to be proved) are not within the scope of this document, but their use in controlling the passage of trains between block signals may be facilitated by either:

- continuous train detection (e.g. track circuit block, which includes axle counters), or
- entry and/or exit train detection, by discrete track circuits or other devices.

1.2 Level Crossings

For automatic level crossing operation (including manually controlled crossings equipped with auto raise facilities), train detection is generally required to prove:

- the absence of an approaching train to allow the crossing to be open to road traffic, and
- the presence of the train on the exit side before the crossing can be normalised after operation.

Where additional integrity is required, e.g. for the operation of automatic level crossings (not locally monitored), some form of diversity or duplication of train detection device may be required on the approach to the crossing.

Where operation is monitored locally by the driver observing an indicator, a lesser integrity of train detection may be sufficient to ensure safety.

1.3 Other Functions

The signalling system requires the presence of a train to be detected for various other purposes, such as:

- indicating on the signaller's display system,
- approach releasing a signal,
- allowing a permissive route to be set,
- allowing a ground frame to be released,
- train approaching indication/warning.

Where devices that are designed to fail in the occupied state are used to prove the presence of a train, they are generally required to be proved in the clear state before a train is allowed to approach.

Train detection devices may also be used to calculate the speed or acceleration of a train, e.g. grade crossing predictors, which are designed to give a constant warning time for level crossings.

The length of trains may need to be measured (e.g. using a combination of track circuits) before allowing access to a partially occupied platform.

2 PURPOSE

This document gives the requirements for train detection systems to enable the appropriate system specification for the Total Infrastructure System to be achieved.

It also satisfies the mandatory requirements laid down in Railway Group Standard GK/RT0011 which is legally binding upon Railtrack as a duty holder of a Railway Safety Case.

3 SCOPE

The contents of this document apply to all train detection systems. Interfaces with other asset systems are given in section 5.

Train detection systems include:

- track circuits (see References for the relevant Product Specifications),
- axle counters (see RT/E/S/10129),
- rail circuits (not yet included in this document),
- other types of wheel detector, e.g. treadle, electromagnetic proximity device,
- constant delay systems, e.g. grade crossing predictor, generally for use at level crossings (not yet included in this document),
- block systems, including transmission based systems (these belong to a different asset system, as they are essentially systems for controlling the passage of trains),
- supplementary systems, e.g. track circuit assister interference detector (TCAID), track circuit interrupter, track circuit operating device (T-COD), impedance bonds.

General issues relating to signalling are contained in the following documents, which shall be consulted as necessary:

- Signalling Design Handbook,

- Signalling Installation Handbook,
- Signalling Works Testing Handbook,
- Signalling Maintenance Testing Handbook,
- Signalling Maintenance Specifications, and
- other relevant Railtrack standards.

4 DEFINITIONS

A glossary of general signalling terms is given in GK/RT0002. Those terms are not repeated here except where they have been given a more technical definition for use within this document.

Safety terms are defined in GE/GN8504.

In the definitions that follow, any reference to source indicates that the definition has been taken from an external document.

Note: Where the term 'bond' is used as a noun, it may also be used collectively as a verb. Hence: yellow bond, yellow bonding, yellow bonded. Exception: impedance bond refers to a discrete component only.

TERM	DEFINITION
A.C. ELECTRIFIED AREA	An electrified area equipped for a.c. electric traction; including a buffer zone, where the track circuit equipment is immunised against the a.c. traction frequency, extending generally for at least 3000m along any lines equipped solely for d.c. traction.
A.C. IMMUNE RELAY	A d.c. relay which is immune to operation by a.c. of specified voltage and frequency.
APPARATUS CASE	An apparatus housing which is intended for unprotected outdoor use, is smaller than a building or REB and is usually capable of being transported as a made-up unit. It is usually of metallic construction. The wooden equivalent is commonly known as an apparatus cupboard
APPARATUS CUPBOARD	An apparatus housing which is intended for unprotected outdoor use, is smaller than a building or REB and is usually capable of being transported as a made-up unit. It is usually of wooden construction. The metal equivalent is commonly known as an apparatus case.
APPARATUS HOUSING	This is provided to house relays and / or other equipment at lineside locations or interlockings, and may consist of an apparatus case, apparatus cupboard, disconnection box, equipment room, REB, signal box, control centre, or other equipment building.
APPLICATION CRITERIA	Document(s) specifying the constraints applied to the installation and maintenance of a system or an item of equipment in order that it can be guaranteed to deliver the performance attributes stated in the system or equipment specification.
AUTOMATIC FUNCTION	A signalling function that, under ordinary operation, is operated automatically by the passage of trains and is not interlocked with any other signalling function. The function is generally associated with a particular signal box from which its operation is supervised, unless some form of local monitoring is provided. The state of the function when there are no trains present is designated normal.
AVAILABILITY	The probability that a system will be able to perform its required functions under given conditions at a stated instant of time or over a given time interval assuming the required external resources are provided. [source: BS EN 50129]

TERM	DEFINITION
AXLE COUNTER	A method of train detection. Track mounted equipment counts the number of axles entering and leaving a track section at each extremity. A calculation is performed to determine whether the track section is occupied or clear.
BACK (B) CONTACT	A contact of a relay which is made when the relay is released and broken when it is operated.
BEARER	An item of steel or concrete of non-standard dimensions used to support the track in switch and crossing (S&C) areas. (See also sleeper and timber)
BONDING	The electrical connection from one rail or part of a track circuit to any other rail or part of the track circuit.
BONDING PLAN	A detailed plan of the track layout showing individual rails and position of IRJs, together with track circuit feed and relay connections with polarities, cross bonds, structure bonds, impedance bonds, etc., as applicable. This term may also include track plans and negative Bonding Plans in d.c. electrified areas.
BR930 SERIES (relay)	A miniature plug-in relay in one of the following styles (see RT/E/C/11630): BR930, BR931, BR932, BR933, BR934, BR935, BR936, BR937, BR938, BR939, BR940, BR941, BR942, BR943, BR945, BR946, BR947, BR949, BR960, BR961, BR962, BR963, BR964, BR966 (all variants) or BR968.
CATCH POINT	A point (switch and tiebar only), on running line gradients to de-rail wagons etc., running away in the wrong direction.
CHANGE-OVER CONTACT	See dependent contact
CHECK RAIL	See figure under switches and crossing.
CIRCUIT DIAGRAMS	A collection of individual drawings showing the equipment layout and circuit arrangement associated with a location, an interlocking or signal box.
CLASS I EQUIPMENT	Electrical equipment that requires the connection of the exposed-conductive-parts to a protective conductor connected to earth, to ensure personal safety. See BS 2754.
CLASS II EQUIPMENT	Electrical equipment with double or reinforced insulation, either to prevent contact with exposed-conductive-parts, or to ensure no contact between such parts and live parts. The insulation is not therefore to be pierced by screws. Such equipment is never connected to earth. See BS 2754.
CLEARANCE POINT	The minimum distance from points and crossings at which track section boundaries must be positioned, to prove that a vehicle on one track is clear of a movement on the other.
CLOSURE PANEL (track)	See figure under switches and crossings.
CLOSURE RAIL	See figure under switches and crossings.
COMMON RAIL	The rail of a single rail track circuit that is electrically common to one or more adjacent track circuits or forms the traction return path where an isolated single rail track circuit is provided. In non-electrified areas the common rail is bonded with track circuit bonding. In electrified areas the common rail is known as the traction return rail and carries the traction return current. It is therefore bonded with traction return bonding. Also referred to as single rail or traction rail.

TERM	DEFINITION
COMMON RAIL BONDING (CR)	A track circuit arrangement where only one rail (the Insulated Rail) is used with IRJs to separate the track circuits. The other rail (the common rail) is electrically continuous but is not used for traction return purposes.
CONTINUITY BONDING	Fishplate bonding specifically provided for traction return purposes, i.e. on non-track circuited lines in electrified areas, including non-electrified sidings, etc. Rail to rail bonding is required and cross bonding may also be provided. It is denoted by the addition of a $\lll$ symbol on the bonding plan.
CONTROL AREA	The area of railway controlled or supervised by a particular signal box or control centre, as defined by the signalling Plan. Also known as signal box control area.
CONTROL POINT	A signal box (including control centre), gate box or ground frame (including ground switch panel or shunting frame).
CONTROLLED FUNCTION	A signalling function that, under ordinary operation, is controlled from the signal box (or other control point) to which the function is allocated and may be interlocked with other signalling functions.
CORRECTIVE MAINTENANCE	The maintenance carried out after fault recognition and intended to put a product into a state in which it can perform a required function. (BS EN 50126)
CRITICAL IRJ	A track section clearance point position, which is less than 4880mm from the fouling point, but which meets the requirements of GE/RT8029. 4880mm being the clearance distance as defined by GK/RT0011.
CROSS BOND	A jumper cable cross connecting the common rails or centre points of impedance bonds of parallel tracks to form a mesh of alternative paths, e.g. for traction return current.
CROSSING ANGLE	See figure under switches and crossings.
CROSSING BACK	See figure under switches and crossings.
CROSSING NOSE	See figure under switches and crossings.
CROSSOVER	A crossover consists of two points arranged to link parallel tracks. They are known as facing or trailing, depending on whether a train proceeding in its correct direction along the line can run directly over the facing crossover, or must reverse to cross the trailing crossover.
CUT-SECTION (track circuit)	A method of reducing the continuous length of a track circuit by the use of individual track circuits, each one controlling a common final track repeat relay, or equivalent. These are indicated as one track circuit on the signaller's panel. This is also known as a multi-section track circuit.
D.C. ELECTRIFIED AREA	An electrified area equipped for d.c. electric traction; including a buffer zone where the track circuit equipment is immunised against the d.c. traction voltage, extending generally for at least 3000m along any lines equipped solely for a.c. traction. (The distance is subject to specialist assessment and verification.)
DE-ENERGISED (relay)	See released.
DEPENDABILITY	The ability of a product to perform one or several required functions under given conditions. See also RAMS. (source: BS EN 50126)

TERM	DEFINITION
DEPENDENT CONTACT	A contact set which consists of a front contact, a back contact and one arm shared between them, with not more than one contact path made at any one time. Also referred to as change-over contact.
DESIGN	A wide term including specification and the production of drawings, design details and bills of quantity (including specification of systems or equipment). (source: CDM Regulations - modified)
DESIGN DETAILS (signalling)	Any plans, control tables, engineering details and data, which are required to sufficiently define signalling systems and equipment for production or record purposes.
DISCONNECTION BOX	An apparatus housing for unprotected outdoor use, which is intended to contain mainly terminations and is commonly smaller than an apparatus case.
DIVERSITY	A means of achieving all or part of the specified requirements in more than one independent and dissimilar manner. (source: BS EN 50129)
DOUBLE CUT (circuit)	The inclusion of controls in both feed and return legs in order to mitigate the risk associated with a false feed or earth fault.
DOUBLE RAIL TRACK CIRCUIT	A track circuit, either jointless, or defined by IRJs in both rails at all its extremities. On electrified lines, both rails carry traction return current.
DOUBLE RAIL TRACK CIRCUIT BONDING	A track circuit arrangement where both rails are fitted with IRJs, or tuned zones are used to completely isolate a track circuit.
DOUBLE-COIL A.C. VANE RELAY	A double element relay with separate local and control (or track) coils which are required to attain a particular phase relationship for the relay to operate.
DROP AWAY (DA) VOLTAGE (relay)	The maximum voltage applied to an operated relay coil at which the last front contact breaks.
DROP AWAY TIME (track circuit)	The time between the application of a shunt to the rails and the front contacts of track relay (TR) fully opening. The converse is pick up time.
DROP SHUNT	The maximum value of non-inductive resistance which, when placed across the rails, causes the track relay to fully open its front contact.
DUAL ELECTRIFIED AREA	An electrified area meeting the criteria of both an a.c. electrified area and a d.c. electrified area.
ELECTRIC TRACTION ENGINEER	Engineer responsible for the electric traction fixed equipment.
ELECTRIFIED AREA	An area of railway encompassing all lines equipped for electric traction, extended to include any non-electrified lines or sidings. The area also includes a buffer zone where track circuit equipment is immunised against traction interference, extending generally for at least 800m, or the length of two track circuits with double IRJs, whichever is the further, beyond the end of the electrified line. See also a.c. electrified area, d.c. electrified area and dual electrified area.
ENERGISED	See operated.
FAIL-SAFE	A concept which is incorporated into the design of a product such that in the event of failure, it enters or remains in a safe state. (source: BS EN 50129)

TERM	DEFINITION
FAILURE	The termination of an item to perform a required function. (source: BS4778) See also fault, defect, error, failure, mistake, common cause failure, random hardware failure, and systematic failure and fault, defect, error, failure, mistake.
FALSE CLEAR	A condition where a track section indicates the line is unoccupied when it is occupied by a train.
FEED	Power Supply phase (BX) or positive (B) connection. In some cases may be used as a composite term to incorporate both feed and return (e.g. track circuit feed).
FISHPLATE BOND	Provided to ensure electrical continuity between two rails mechanically connected, e.g. by a steel fishplate, common chairs, or other bolted connection. Also referred to as fishplate type bond, or rail joint bond.
FISHPLATE TYPE BOND	See fishplate bond.
FOULING POINT	The position on a converging, diverging or crossing line beyond which the encroachment of any part of a vehicle would infringe the required passing clearance for a vehicle on the other line.
FREE-WIRED INTERLOCKING	A relay interlocking that comprises individually wired relays rather than pre-wired sets of relays.
FREQUENCY DIVISION MULTIPLEX (FDM)	A data transmission system that uses unique frequencies to separate channels over a single pair of conductors.
FREQUENCY ROTATION	The sequential application of specified frequencies.
FRONT (F) CONTACT	A contact which is made when the relay is operated and broken when it is released.
GEOGRAPHICAL INTERLOCKING	A route relay interlocking in which standard pre-wired sets or relays are provided for each signalling function, arranged and electrically interconnected in a geographical manner.
GRADE CROSSING PREDICTOR	A constant delay device designed to give a predetermined warning time for automatic level crossing operation. It calculates the speed and acceleration of an approaching train by means of a high frequency rail circuit and so determines the time at which the operating sequence should commence.
GUARANTEED POWER SUPPLY	See secure power supply.
HAZARD	A physical situation with a potential for human injury. (source: IEC 61508)
HEEL (of switch)	See figure under switches and crossings.
HIGH CURRENT D.C. ELECTRIFIED AREA	A d.c. electrified area capable of supplying trains with a peak total traction current in excess of 6.5kA.
IMPEDANCE BOND	Special device which presents a low impedance to traction current and a higher impedance to track circuit current.
INFRASTRUCTURE CONTROLLER	A railway business which is responsible for the control and operation of the railway lines, including the track, structures, plant and control equipment. An infrastructure Controller may either own or lease the infrastructure concerned.
INSTALLATION (activity)	See construction.
INSTALLATION (infrastructure)	That part of the signalling system associated with the infrastructure at a particular place.

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TERM	DEFINITION
INSULATED BLOCK JOINT (IBJ)	Non-preferred term; see insulated rail joint.
INSULATED RAIL	The rail of a single rail track circuit that is fitted with IRJs to separate adjacent track circuits. The insulated rail is always bonded with track circuit bonding, as it does not carry traction return current. Also known as signal rail.
INSULATED RAIL JOINT (IRJ)	A method of joining rail ends together whilst maintaining electrical insulation between them. An alternative non-preferred term is insulated block joint (IBJ)
INTERLOCKING (building)	The (generally dedicated) building housing the interlocking system, where separate from the signal box (or other control point).
INTERLOCKING (equipment)	The equipment that performs the role required of the interlocking system.
INTERLOCKING (system)	The safety-critical locking provided between signalling functions in accordance with control tables.
INTERLOCKING AREA	The area of railway controlled by a particular interlocking, extended up to a boundary with each other adjacent interlocking controlled by the same or another signal box.
JOINT HOPPING	Where fast moving short vehicles pass from one track circuit to the next, the difference between the pick up and drop away times can cause the vehicle to momentarily be undetected.
JOINTED TRACK CIRCUIT	A track circuit whose extremities are defined by the use of IRJs.
JOINTLESS TRACK CIRCUIT	A track circuit whose extremities are defined by the use of tuned circuit techniques, The extreme limits of a jointless track circuit area are either defined by the use of IRJs or by the use of a tuned circuit between the rails.
JUMPER	An interconnecting cable (commonly single core) between two termination points within an apparatus housing.
JUMPER CABLE (track circuit / traction)	An interconnecting cable (commonly single core) between two pieces of rail that are not adjacent, for track circuit or traction purposes. This includes midpoint connections to impedance bonds.
LINE CIRCUIT	An external relay circuit, which is not an on-track circuit.
LINESIDE APPARATUS HOUSING	See apparatus housing.
LINESIDE LOCATION	See location.
LOCATION	A group of all signalling lineside apparatus housings (including buildings) at a particular site and the equipment contained therein. (This excludes apparatus housings that perform a main interlocking function, although some interlocking local to ground frames or level crossings may be included.) Alternatively known as lineside location.

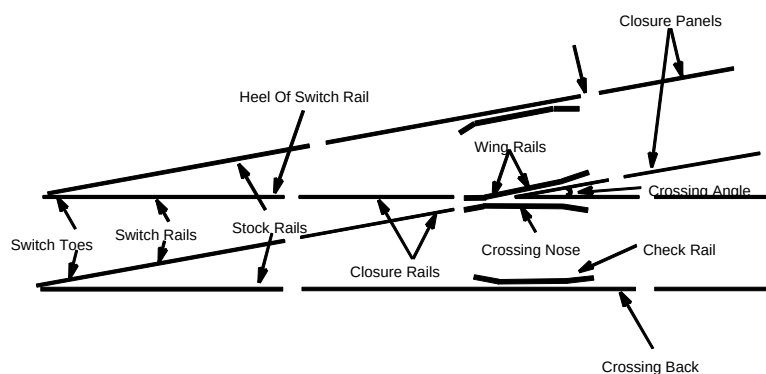
TERM	DEFINITION
LOCATION AREA PLAN	A scale layout plan showing every signalling location, together with their identities, position and type of cases, interlocking boundaries, certain equipment identities (e.g. TFM's) and the area of signalling equipment that is controlled by each location. This plan is generally a sub-version of the scheme plan or signalling plan.
MAINTAINABILITY	The ability of a product under given conditions, to be retained in, or restored to, a state in which it can perform its required function. (source: BS EN 50129)
MAINTENANCE	The combination of all technical and administrative actions, including supervision actions, intended to retain a product in, or restore it to, a state in which it can perform a required function. (source: BS EN 50126)
MOD STATE	See modification status.
MODIFICATION STATUS	The detail that defines the particular version of the design or specification, appropriate to the functional and physical characteristics of an item of equipment or system, and is recorded under configuration control procedures. Colloquially known as mod state.
MODIFICATIONS	Changes to the design details which are required to be carried out after they have been officially issued, usually as a result of installation, testing and commissioning activities.
MULTI-SECTION (track circuit)	See cut-section.
NORMAL (function)	Position of a lever when it is fully back in the lever frame. The un-operated or quiescent state of a two-state system. The state of a train detection system in the absence of a train. The converse is reverse.
ON-TRACK CIRCUIT	An external circuit run to, or via, an item of on-track signalling equipment in a tail cable.
OPERATE TIME (relay)	The time interval between the energisation of the relay coil and the first front contact making. The converse is release time.
OPERATE VOLTAGE (relay)	The minimum voltage applied to a released relay coil at which the last front contact makes. Also known as pick up (pu) voltage.
OPERATED (relay)	The state of a relay when the armature is energised, picked up (PU), or latched, all front contacts are made and all back contacts are broken. Also known as energised, and colloquially as picked or up. The converse is Released.
OVERHANG (VEHICLE)	The distance measured parallel to the rail from the centre of the outermost wheel on a vehicle to the extreme end of the vehicle.
OVERLAY TRACK CIRCUIT	A track circuit which operates within and additionally to another track circuit. It is generally used for detecting the passage of a train past a specific position.
PARALLEL (bonding)	The method of bonding rail sections with diverse parallel electrical paths for availability. track circuit bonding in this mode is non-fail-safe, since failure of a single jumper cable, fishplate bond, or IRJ will not necessarily release the track circuit relay, and hence could result in loss of vehicle detection.

TERM	DEFINITION
PHASE SENSITIVE (track circuit)	An a.c. track circuit whose operation of a double element vane relay is dependent on a correct phase relationship with a local supply. This includes a.c. 50Hz, 83 $\frac{1}{3}$ Hz and VT1 (SP) types of track circuit. Also known as capacitor fed or frequency selective track circuits.
PICK UP (PU) SHUNT	The minimum value of resistance between the two running rails at which the track relay just closes its front contacts.
PICK UP (PU) VOLTAGE (relay)	See operate voltage.
PICK UP TIME (track circuit)	The time between the removal of a shunt to the rails and the first front contact of the track relay (TR) making. The converse is drop away time.
PIN CODE	See registration pin-code.
PREVENTATIVE MAINTENANCE	The maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item. (source: BS EN 50126)
PRIMARY FUNCTION RELAY	The relay by which the logic required to control a signalling function is brought together. It is the first relay in a chain that directly controls all safety-critical signalling functions. It is the only function relay which has back contacts valid for use in safety-critical functions.
RAIL CIRCUIT	Train detection equipment using the rails in an electric circuit, which detects the presence of a train (as opposed to its absence). See also overlay track circuit.
RAIL JOINT BOND	See fishplate bond.
RAIL SECTION (track circuit)	A section of one running rail continuously electrically bonded with its extremities defined by IRJs, and within which all continuity connections are by fishplate bonds. It may extend over several track circuits as the common rail) or only part of a track circuit.
RAMS	An acronym meaning a combination of reliability, availability, maintainability and Safety. See also dependability. (source: BS EN 50126)
RECEIVER (Rx)	An electronic device that converts, filters or decodes into a discrete output, information that has been received from another site.
RECORD	Information bearing media, irrespective of date or physical format, created or received in the course of carrying out the duties and functions of an undertaking, and subsequently retained by the undertaking or its successors as evidence, as a reference source, or to meet legal or regulatory obligations.
RED BOND	A traction bond that has been designated as being dangerous to staff if disconnected. It is marked red to draw attention to its importance and to aid inspection. Special procedures are in place for the reporting of damage to a red bond.
REDUNDANCY	The provision of one or more additional elements, usually identical, to achieve or maintain availability under failure of one or more of those elements. (source: BS EN 50129)
REGISTRATION PIN-CODE	A series of locating pins assembled in a unique pattern to prevent equipment being incorrectly used. The unique pattern also acts as a means of identification for a specific style and variant of a relay. The term registration pin-code is commonly abbreviated to pin-code.

TERM	DEFINITION
RELEASE TIME (relay)	The time interval between the removal of the supply (at rated voltage) to the relay coil and the last front contact breaking. The converse is operate time.
RELEASED (relay)	The state of a relay when the armature is de-energised, dropped away (DA), or unlatched, all back contacts are made and all front contacts are broken. Also known as de-energised and colloquially as dropped or down . The converse is operated.
RELIABILITY	The ability of an item to perform a required function under stated conditions for a stated period of time. (source: BS EN 50129)
RELOCATABLE EQUIPMENT BUILDING (REB)	Apparatus housing to specification BR 1615 or equivalent.
RESIDUAL VOLTAGE	The voltage remaining across the rails or relay of a track circuit after the feed has been disconnected. It may be caused by mutual interference between adjacent single rail track circuits, the battery effect of the track formation, cathodic protection measures, or d.c. traction return or other stray currents.
RETURN	Power supply neutral (NX) or negative (N) connection. The converse is feed.
REVERSE (function)	Position of a lever when it is pulled fully forward in the lever frame. The operated state of a two-state system. The converse is normal.
RIGHT SIDE FAILURE	A failure which does not result in the protection normally provided by the signalling system being reduced.
SAFE STATE	Any one of the following: • the state of the last valid request at the interlocking; or • correspondence with the state of the trackside equipment; or • the most restrictive state.
SAFETY INTEGRITY (SI)	The probability of a safety-related system satisfactorily performing the required functions under all the stated conditions within a stated period of time. (source: IEC 61508)
SAFETY INTEGRITY LEVEL (SIL)	One of four possible discrete levels for specifying the safety integrity requirements of the safety functions to be allocated to the safety-related systems. Safety Integrity Level 4 has the highest level of safety integrity; Safety Integrity Level 1 has the lowest. Safety Integrity Level 0 is non-safety-related. (source: IEC 61508 augmented)
SAFETY-CRITICAL	Carries direct responsibility for safety. (source: BS EN 50129)
SAFETY-CRITICAL FAILURE	Alternative term to wrong side failure.
SAFETY-RELATED	Carries responsibility for safety (direct or indirect). (source: BS EN 50129)
SCHEME PLAN	A longitudinally scaled layout plan, based on the record signalling plan, that is produced to depict proposed new or altered signalling systems.

TERM	DEFINITION
SECURE POWER SUPPLY	A power supply system that can be relied upon to keep certain safety-critical signalling functions operating for a predetermined minimum time, in the event of a total failure of the main incoming supply. Also known as guaranteed power supply.
SELECTIVE OPERATION	Operation of a portion of a track circuit by selection of the position of a set of points. Selective operation of track circuits is no longer permitted.
SERIES BONDING	The fail-safe method of bonding track circuits with rail sections connected in series, such that the failure of a single jumper cable, fishplate bond, or IRJ results in de-energisation of the track circuit.
SHORT CIRCUIT BOND	A jumper cable between the rails immediately beyond the final track circuit IRJs, in order to detect double joint failure. This is the only bonding required on non-track circuited lines in non-electrified areas.
SIGNAL BOX CONTROL AREA	See control area.
SIGNAL RAIL	Non-preferred term; see insulated rail.
SIGNALLING PLAN	A longitudinally scaled layout plan defining a signal box control area and showing the signalling functions allocated to the signal box with their identities. Where applicable, it is extended to include the data collection area. This plan is generally a derivative of the scheme plan.
SIGNALLING SYSTEM	Equipment, circuitry and software associated with: • lineside signals; • point operation; • level crossings; • train detection; • trainborne equipment conveying information about the state of the line; • operational telecommunications (excluding electrification control systems and electrification telephones); and • fixed trackside safety systems.
SINGLE CUT (circuit)	The inclusion of controls in either the feed or return leg, but not both, to be used only where there is no significant risk of false feeds or earth faults. (See double cut.)
SINGLE RAIL	Non-preferred term; see common rail.
SINGLE RAIL BONDING CONFIGURATION	A jointed track circuit with IRJs in only one rail (the insulated rail) that is series bonded (except for the presence of spurs of limited length at Switches and Crossings). The other rail, known as the common rail, is electrically common to one or more adjacent track circuits.
SLEEPER	An item of wood, steel or concrete of standard dimensions, used to support and gauge the track. (See bearer and timber.)
SLOW ACTING RELAY	A relay in which both operation and release are intentionally delayed.
SLOW TO OPERATE RELAY	A relay in which the operation is intentionally delayed and the operate time is significantly longer than the release time.
SLOW TO RELEASE RELAY	A relay in which the release is intentionally delayed and the release time is significantly longer than the operate time.

TERM	DEFINITION
SOURCE RECORD (signalling)	The signalling design record that does not bear the certification and from which the medium for production is derived. Examples are a negative or CAD file. See also master record.
SPUR (track circuit)	A section of running rail required to be electrically common to a series bonded rail, but which is not itself in series.
STAGGER (electrical)	The phase or polarity difference between one track circuit and the next, or between the rails on either side of an IRJ within one track circuit.
STAGGER (physical)	Occurs where two IRJs in a pair of rails are not exactly opposite each other, thus creating a dead section between track circuits or within a track circuit.
STATE (of a function)	Position or action of the equipment. Examples of complementary states are: operated / released, normal / reverse, on / off, raised / lowered, locked / free, enabled / inhibited, energised / de-energised. In data driven systems this is stored as variable data.
STOCK RAIL	See figure under switches and crossings.
STRIKE-IN POINT (SIP)	The position on the approach to an automatic level crossing or other installation at which a train initiates the operating sequence.
STRUCTURE BOND	A bond required in A.C. Electrified Areas, that connects adjacent lineside metal structures to the traction return rail system, where required to ensure staff safety through equipotential zoning.
SWITCH RAIL	See figure under switches and crossings.
SWITCH REINFORCING BOND	A jumper cable installed around the switch in S&C, in order to strengthen the fishplate bonds between the switch and crossing components and also to link two spur ends together, so improving the integrity of a parallel bonded rail section.
SWITCH TOE	See figure under switches and crossings.
SWITCHES AND CROSSINGS (S&C)	Sections of track other than plain line. See the figure below for constituent parts.



TERM	DEFINITION
TAIL CABLE	A cable between trackside or on-track signalling equipment and other such equipment or a lineside apparatus housing. For track circuits, see also track cable.
TERMINAL LINE	The length of plain line approaching buffer stops. Single rail traction return is adequate for the final 300m of such lines in d.c. electrified areas, as traction return current is low.
TIMBER	An item of wood of non-standard dimensions, used to support the track in S&C areas. (See also bearer and sleeper.)
TRACK CABLE	A track circuit tail cable which connects directly to the rails.
TRACK CIRCUIT (TC)	An electrical device using the rails in an electric circuit, which detects the absence of trains on a defined section of line.
TRACK CIRCUIT ACTUATOR (TCA)	Non-preferred term, see track circuit assister.
TRACK CIRCUIT ACTUATOR INTERFERENCE DETECTOR (TCAID)	Non-preferred term, see track circuit assister interference detector.
TRACK CIRCUIT ASSISTER (TCA)	A device fitted to a vehicle which cause a 165kHz signal to pass between the wheels of the vehicle and assists in the breakdown of the insulation at the wheel to rail interface due to leaf-fall, rust etc.
TRACK CIRCUIT ASSISTER INTERFERENCE DETECTOR (TCAID)	A device fitted to the track which, when it detects the presence of a 165kHz signal in the rail, causes the track circuit to show occupied.
TRACK CIRCUIT BLOCK	A method of working trains over a section of line where safety is ensured by the use of track circuits or other means of automatic train absence detection and without the use of block instruments.
TRACK CIRCUIT BONDING	The connection of one rail or component of a track circuit to another rail or component, so as to ensure electrical continuity. On rails carrying traction return current its function is performed by the traction return bonding.
TRACK CIRCUIT INTERRUPTER	A device that records the passage of a vehicle by causing a permanent disconnection within the track circuit until the device has been renewed.
TRACK INTERVAL	The distance between the running edges of the nearest rails of adjacent parallel tracks.
TRACK JUMPING	Occurs when a fast moving vehicle passes over a very short track circuit (or a short arm of a longer track circuit) and fails to de-energise the track relay.
TRACK RELAY (TR)	Generally a neutral relay with a low coil resistance and low power consumption, which acts as part of a track circuit. It is either connected directly to the rails, or via a capacitor or tuner unit.
TRACK SECTION	A portion of railway track having fixed boundaries and for which the train detection system provides information on its state of occupancy (occupied or clear) to the signalling system.
TRACTION BOND	A cable specifically provided for continuity of traction return current, although it may additionally carry track circuit current.
TRACTION RAIL	See common rail.

TERM	DEFINITION
TRACTION RETURN BONDING	The bonding required to carry the traction return current on both a.c. and d.c. electrified lines. Traction return bonding is generally parallel bonded.
TRAIN DETECTION SYSTEM	Equipment and systems forming part of or providing input to the signalling systems to detect: - the presence or absence of vehicles within the limits of a track section; or - that a train has reached, is passing or has passed a specific position. Where required, a train detection system may additionally detect the direction in which a train is travelling.
TRAIN WHEEL DETECTOR	Items of equipment that provide the necessary functions to indicate the passage of a train wheel past a particular position on the track.
TRANSMITTER (Tx)	An electronic device that converts, modulates or encodes a discrete input, into a form that is suitable for sending to another site.
TRANSPOSITION BOND	A jumper cable provided where track circuit polarities and / or traction return rails change sides across a pair of IRJs, or transposition joints. Purposes included the correction of track circuit polarity stagger or traction current imbalance, or to facilitate series bonding in S&C.
TRANSPOSITION JOINT	An IRJ where transposition bonds are used to transpose the traction and / or track circuit rails.
TRAP POINT	A point (usually switch and tiebar only), inserted in sidings etc., to unauthorised movements away from a running line.
TREADLE	A mechanical or electrically operated device to detect the presence or passage of a train at a specific position.
WHEEL DETECTOR	See train wheel detector.
WING RAIL	See figure under switches and crossings.
WRONG SIDE FAILURE	A Failure which results in the protection normally provided by the signalling system being reduced. Also known as safety-critical failure.
YELLOW BOND	A jumper cable that is necessary to ensure the electrical integrity of a track circuit that is fully or partially parallel bonded. It is marked yellow to draw attention to its importance and to aid inspection.

5 DEFINITION OF INTERFACES

Train detection systems interface with other asset systems in many areas.

To ensure the safety of the total infrastructure system, it is necessary to control each of these interfaces to an appropriate safety integrity.

Train detection system shall comply with both the external controlling documents and the relevant clauses within this document, as shown in the table below:

Asset System	Interfaces	RT/E/S/11752 Section	Controlling Documents
Track system	IRJs and insulation of fittings	Part F, 2	RT/CE/S/049 (design)
	standard rail bonding with pre-drilling requirements	Part J, 7 to 12	RT/CE/S/103 (inspection)
	S&C bonding configuration	Part F, 3.3	RT/CE/S/104 (maintenance)
	rail fixing of train detection devices	Part E, 5	RT/CE/S/008 (drilling)
	broken rail detection	Part F, 4.2	
	damage from mechanised maintenance	Part J, 6	
Electric traction infrastructure	single or double rail configuration for traction return	Part F, 3	RT/E/S/21015 (d.c. maintenance)
	impedance bond positioning, with AWS proximity rules in high current d.c. areas	Part F, 7.3 Part H, 5.3	RT/E/S/21085 (a.c. design)
	electromagnetic interference	Part F, 7	RT/E/S/21104 (d.c. design) RT/E/S/21111 (maintenance)
Automatic signals	clear state control	Part B, 1.1	RT/E/C/11600, Parts F and S
	transient operating times	Part F, 6	
Interlocking system	clear and occupied state inputs	Part B, 1	RT/E/C/11600, Part F
	transient operating times	Part F, 6	
	measures to mitigate against false release of interlocking when there is a significant risk	Part H, 2	
Apparatus housing	physical requirements	Part C, 5	RT/E/C/11210 (installation)
	electromagnetic interference	Part F, 9	
Signaller's display system	occupied/undefined state indication	Part H, 1	GK/RT0025
	transient operating times	Part F, 6	RT/E/S/10067 (VDUs)
Power supply system	requirement for secure power supplies and/or battery backed supplies	Part E, 2 Part F, 13	none
	within voltage and frequency tolerances	Part E, 7.1	
	adequately rated for the required load and fused at correct rating to protect the signalling cable	Part C, 1.4	
	earth-free ('IT' system to BS 7671)	Part C, 1.5	
	local earth of correct impedance	Part C, 2.5	

It is similarly necessary to control the interface between the infrastructure and the train. This is the purpose of the following Railway Group Standards:

Rolling Stock	Interfaces	Controlling Documents
Authorised rail vehicles with route acceptance	clearances and positioning of IRJs minimum track circuit lengths, which may be dependent on permissible speed interlocking measures to mitigate against any deficiencies lightweight vehicles track circuit assister (TCA) fitment (and prohibition with Lucas track circuits) rail contamination electromagnetic interference	GK/RT0011 (train detection) GE/RT8029 (clearances) GO/RT3208 (contamination) GO/RT3270 (route acceptance) GM/RT2185 (safety systems) GM/RT2004 (maintenance)

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PART C PERFORMANCE REQUIREMENTS

The configuration of newly specified train detection systems used for any particular application shall fulfil the safety and reliability requirements of the infrastructure controller. This shall be agreed as a result of formalised safety management procedures and will generally require the production of a safety case for the relevant specific or generic application.

I SYSTEM SAFETY

I.1 General

The following features are fully described in Parts D to F, Configuration Parameters:

- Supplementary systems may be necessary to provide the safety integrity required to detect lightweight vehicles.
- Where track sections define clearance points, their extremities must be positioned to give adequate clearance with all permitted types of rolling stock.
- Some delay may need to be incorporated into track section clearance times and, where necessary, the minimum length of track sections restricted, so as to prevent a fast moving train being lost between track sections.
- Where necessary, mitigation measures must be taken to prevent interference between adjacent train detection systems.
- Where susceptible to interference from high powered electric traction units, immunity must be achieved.
- Where mounted in the vicinity of safety-related equipment susceptible to electromagnetic interference, proximity rules must be followed.

I.2 Newly Specified Systems

I.2.1 Safety Integrity Level

The Safety Integrity Level applied to the system shall generally be at least 2, as defined in BS EN 50129.

When used for a high integrity application, the train detection equipment may be used in multiple or in conjunction with other train detection systems in order to provide the required integrity level for the application (i.e. using duplication/diversity).

However, wheel detectors may be used in applications where there is a significantly lower safety integrity level required, in which case there is scope for the use of simple cyclic proving.

1.2.2 Safety Performance Benchmark

The frequency of wrong side failure per track section shall be less than 0.05 failures per million hours, where wrong side failure is defined as a failure that causes the section occupancy status output to be Clear when it should be Occupied or Undefined.

1.2.3 Hazard Analysis

As part of the required safety management hazard analysis, due account shall be taken, in addition to those items already detailed, of the following factors:

- Common mode failures
- Systematic failures
- Failures of time delay adjustment method
- Function confirmatory test periodicity
- Application complexity
- System effects of supply Interruptions, resulting in reset.
- Availability of application documentation, test equipment etc.
- Calibration requirements of test equipment
- Tolerance to cabling and earth leakage faults
- Track mounting arrangements and controls in place to ensure correct mounting throughout the life of the installation, including rail detection.
- Commissioning methods, the test tolerances and drift on bedding in .

1.3 Track Circuits

The following features are fully described in Part F, Track Circuit Configuration Parameters:

- To guard against bond failure causing a vehicle to go undetected, series bonding shall be used wherever practicable. Where impracticable over a length likely to lose a vehicle, yellow bonding must be applied as a mitigation measure.

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- The track relay or receiver must be sufficiently immune to interference voltage so as to prevent false energisation. Track circuit length must be restricted to achieve this.
- Track circuits shall be configured, wherever practicable, such that IRJ failure does not cause a false clearance. This is generally achieved by electrical staggering across the IRJ, either by polarity, phase or frequency difference.

1.4 Overcurrent protection

See section 2.2, below.

1.5 Insulation and Isolation

The circuits connected to the train detection equipment are generally earth-free in order to give a degree of first earth fault tolerance. The equipment shall therefore be suitably isolated from any conductive casing or material that may be intentionally or become unintentionally earthed (e.g. running rail).

There shall be sufficient electrical isolation, in terms of insulation co-ordination (clearance, creepage and through insulation distances), commensurate with the environment, service life and the integrity levels required. Newly specified equipment shall be double insulated to BS 2754, class II.

Exposed terminals must be prevented from making electrical contact with other terminals where there is a risk of a component becoming loose or tools being dropped. The preferred method is by shrouding.

1.6 Surge Arresters

Surge arresters connected to track cables must not be earthed because of the danger from multiple earth faults caused by a traction fault or lightning strike.

1.7 Recommendation on Positioning of Train Detection Equipment

Electrical isolation between track cables and the interlocking environment is desirable in electrified areas. Consequently, equipment connected to track cables should generally be confined to lineside locations. See also section 4 for the positioning of track relays and track section monitoring devices.

2 OCCUPATIONAL SAFETY

2.1 High Voltages

Special precautions shall be taken to protect personnel from the high voltages present on impedance bond coils and other terminals, as well as from traction voltages under fault conditions, including fusing, insulation, labelling and earthing. These shall generally be based on BS 7671.

Installation Procedures require impedance bond primary coils to be shorted out before changing capacitors.

The following voltages may be expected to be present on existing equipment:

Track Circuit Type	Equipment	Voltage
A.C. phase sensitive track circuits	feed end terminals (single rail track circuits)	180V
	feed end terminals (double rail track circuits)	700V
	all impedance bond terminals (where applicable)	600V
	relay end terminals (double rail track circuits)	300V
TI.21 track circuits	all impedance bond terminals (where applicable)	500V
HVI track circuits	all feed end terminals	700V
	all relay end terminals	500V
	track transformer terminals	700V
	rails	150V
Reed track circuits	all impedance bond terminals (where applicable)	300V

2.2 Track Circuit Fusing in Electrified Areas

2.2.1 Standard Track Circuits

Refer to each Product Specification for specific fusing arrangements. To gain maximum protection for staff and equipment in electrified areas, fusing arrangements of track circuit tail cables shall be as follows:

A fuse, preferably fully enclosed to BS 88, is to be provided in the apparatus housing in one leg of the track cables (both feed/Tx and relay/Rx end), as protection against traction faults, as follows:

- Single rail track circuits shall be fused in the insulated rail leg.
- Double rail track circuits shall be fused in the leg connecting to the impedance bond winding.

The removable carrier in the other leg shall be fitted with a shrouded link.

2.2.2 Transformer Coupled Track Circuits

In the case of track circuits that are transformer coupled to the rails, fuses are not required in the track cables. However, shrouded terminals shall be provided in the apparatus case if the nominal voltage exceeds 25V.

2.3 Insulation of Terminals

Track cable terminations in electrified areas (section 2.2) and those in non-electrified areas bearing a nominal voltage that exceeds 25V a.c. or 60V d.c. shall be fully shrouded or situated in dedicated enclosures, as described in Code of Practice RT/E/C/11600. The terminals of all associated track circuit equipment shall also be shrouded or enclosed, except when using the safety procedures for work on electrical equipment.

The shrouding may take the form of a transparent Perspex sheet, which is removable for maintenance purposes.

2.4 Safety Labelling

Due to the high voltage present on impedance bonds and other track circuit equipment, it is necessary to install warning signs on the outside of all lineside apparatus housings containing track circuit equipment.

The "Caution, risk of electric shock" warning signs (Figure E21) depict a yellow triangle with lightning flash, as described in the Installation Specification.

2.5 Safety Earthing

The standard rules for earthing apparatus housings and class I equipment shall be followed, with all earth bonding shown on the wiring diagrams. RT/E/C/11600 gives guidance on how to achieve the requirements of BS 7671.

This earthing invariably requires a lower impedance than any requirement for Fast Transient Earthing, which is desirable to protect electronic equipment from transient interference.

Earth wiring must be as short and straight as practicable.

2.5.1 Electrified Areas

Electrical equipment safety regulations require that personnel shall not be able to touch two separately earthed electrical systems at the same time, as this could expose them to dangerously high voltages under fault conditions.

The traction return rails and associated jumper cables, together with the metallic lineside structures supporting the overhead contact wires/return conductors, etc. in a.c. electrified areas form a single comprehensively earthed system. In d.c. and dual electrified areas, the traction return system must not be earthed, but the same principles apply. The metallic lineside apparatus cases and internal racking etc. must be earthed for staff safety purposes but it is undesirable to connect them to the traction return system since this would expose the safety control equipment to greater interference. However, the traction return rail is connected to equipment in the apparatus case via track circuit tail cables. The following design precautions are therefore necessary in order to assure both staff and system safety in all circumstances:

- Lineside apparatus cases and protective railings must be sited such that it is physically impossible for any person to simultaneously touch both earthed systems (including the body of a rail vehicle).
- Any terminals, fuses or links etc. which are connected to the traction return rail must be shielded against touch.

In addition to these requirements, all installations in a.c. electrified areas shall conform to RT/E/S/21085, which are summarised in RT/E/G/00004.

2.6 Conductor Rail Protection Boarding

With single rail track circuits, every effort must be made to keep the traction return rail adjacent to the conductor rail so that an emergency short circuiting bar can be properly applied, as described in GO/RT3091. Designers must therefore ensure that the insulated rail is placed on the side remote from the conductor rail, wherever practicable. This design requirement shall be applied using the minimum number of transpositions. The electrification organisation may also be prepared to assist in difficult cases by changing over the conductor rail.

Where this is not practicable, the permanent way organisation must provide and maintain single protection boarding between the conductor rail and the insulated rail wherever these run adjacent or, alternatively, fit a plastic shroud around the foot of the conductor rail to prevent the application of a short circuiting bar at such locations. The requirement for either must be minimised at the design stage. (When the conductor rail projects into a single rail track circuit and is adjacent to the insulated rail for the distance of the ramp only, protection boarding need not be fitted for this requirement.)

Protection boarding shall also be applied in the other instances detailed in RT/E/C/27020.

2.7 Newly Specified Systems

The design of the System and its components shall be such as to prevent contact with parts energised at 60 V or above during normal installation, testing or maintenance operations. The degree of protection afforded may take into account the training such personnel would have received and the duties they are generally required to perform. Appropriate warnings shall be displayed where a door or access panel allows access to parts energised at 60 V or above.

No voltages higher than 110 V shall be present on any accessible parts.

The design of the System shall be such as to minimise the risk of injury to staff from sharp edges or similar features.

The design of the System shall be such as to minimise the risk of injury to staff from tripping hazards.

The materials of which the System is constructed shall wherever practicable be fire retardant.

The materials of which the System is constructed shall be chosen such that when they are subjected to heat and flame they shall not emit any toxic products and the emission of smoke and fumes shall be minimised.

The System shall be designed to minimise the need for personnel to go on or near the line during installation, testing, commissioning and maintenance and at all other times, and shall minimise the risk to personnel when required to go on or near the line.

Any equipment at the trackside shall not appear similar to any form of signalling indication to drivers of approaching trains.

3 RELIABILITY

Where necessary to achieve the required safety or dependability requirements, Code of Practice RT/E/C/02104, Enhanced Maintenance for Track Circuit Systems, shall be followed.

A reliability target for an individual application of a minimum MTTF (Mean Time to Failure) is to be achieved by the design of component parts of a system in total. This may take into account the replacement of some parts at pre-determined intervals.

Means shall be provided to detect failures in duplicated or redundant systems, such as the following:

3.1 Duplicate Track Circuit Rail Connections

Duplicate connections to the rails are generally the preferred arrangement for all track circuits, except where specified in the relevant Product Specification.

Where duplicate connections are used the method of wiring is as shown in Part J, Installation Specification.

3.2 Parallel (Yellow) Bonding

Details are given in Part F, Track Circuit Configuration Parameters.

4 MAINTAINABILITY

Various techniques are available to enhance maintainability. Some are listed in the Signalling Design Handbook. These shall be incorporated wherever practicable and as agreed with the infrastructure controller.

Examples include the use of disconnection boxes and preterminated track cables, and the provision of condition monitoring and fault diagnostic tools.

Track relays and other track section monitoring devices shall be easily accessible so that their operation can be seen from a point where adjustments can be made and communications are readily available to remote points of adjustment. The difficulty of using radio telephones in metal clad buildings shall be taken into account.

4.1 Communications

It is desirable that communication circuits are available between the feed/transmitter and relay/receiver sites to facilitate setting up and fault finding. The communication circuits may be run in the same multicore cables as the feed, transmitter, relay or receiver circuits.

At certain electronic installations, the data cables carry communication cores which may be used for this purpose.

4.2 Cut Section Monitoring

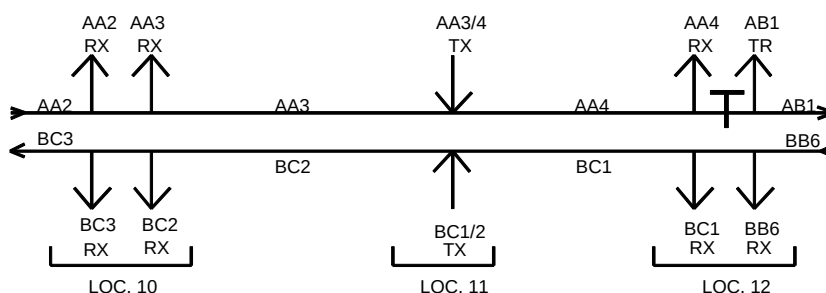


Figure C1

Track circuits, indicated to the signaller as a single entity, must not consist of more than two non-monitored cut sections (where track circuits are centre fed, four receivers (Rxs) may be non-monitored).

Where a monitoring device is provided, it must indicate to the technician the location at which the failed relay/receiver is housed, irrespective of the line affected. With reference to Figure C1, an example of the labelling for an individual display would be Loc 10 (AA2, AA3, BC2, BC3) .

The monitoring device will usually be housed at the nearest interlocking, but this will largely be governed by the routine and out-of-hours fault finding cover arrangements which exist in the vicinity.

The transmission of information to the monitoring device may be achieved by additional FDM channels, a low-cost FDM system approved for use in signalling or telecommunications cables or direct wire circuits.

See Part H, section 4.2.1, for further details of cut sections.

5 ENVIRONMENT

5.1 Environmental Conditions

All train detection equipment shall conform to specification BR967, category D, and, in addition, track-mounted equipment shall conform to BR967, category F.

5.2 Electromagnetic Interference Susceptibility and Emissions

The train detection equipment shall be compatible with the railway environment in terms of susceptibility to, and the generation of, electromagnetic interference. The system shall meet the requirements of the EMC directive 89/336/EEC by complying with DD ENV 50121-4.

Note that acoustic jacketing may be required for certain audio frequency equipment.

5.3 Environmental Descriptions

Train detection systems shall be fit for use in the following environments, so far as they are relevant to the system application criteria:

5.3.1 Track Circuit Systems

The majority of running rails are used to form track circuits to provide a means of proving the absence of trains. The general arrangement is that a low power signal is transmitted from one end of the track circuit, along one rail, to a receiving device. The other rail forms the return path. When the track circuit is clear, the receiver is energised. When a train is between the transmitter and receiver, its axles provide a low impedance circuit between the two running rails, shunting the signal and causing the receiver to de-energise. This state is the occupied condition.

Many different types of track circuit equipment are in use to meet specific site requirements, in particular, only specially immunised systems can be used where a.c. or d.c. electric traction is provided.

The current forming the track circuit signal may be d.c. or a.c. up to 3kHz and may be of complex waveform. Voltages range from a few hundred mV to impulses of 500V. Some types of track circuit form tuned circuits in the rails and circulating track circuit currents can reach 30A.

Track circuits are maintained so that they are guaranteed to detect a specified shunt resistance known as the drop shunt. Although there are detail differences between types, this value is generally not lower than 0.3Ω for any point in any track circuit. An exception exists for a type of system used on non-electrified lines only, which has a short area within the length of the track circuit where 0.25Ω is accepted.

A section of railway track is electrically defined by the provision of insulated rail joints (IRJs), or equivalent, in the rails at either end as shown in Figure C2. A source of electrical energy is connected, via a series impedance, across the rails at one end and a detector, which is receptive to the particular form of electrical energy, is connected across the rails at the other end.

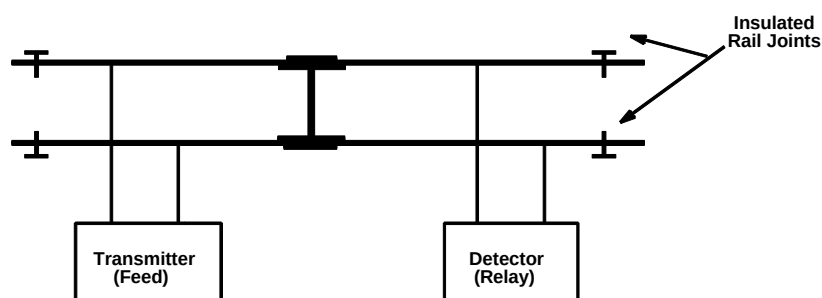


Figure C2

With no train within its boundaries, the detector senses the transmitted electrical energy and energises the repeater circuit. This conveys the absence of a train to the signalling system (i.e. track circuit clear).

A train within the track circuit will cause the rails to be short circuited such that the detector no longer sees sufficient electrical energy; it therefore changes state and informs the signalling system (i.e. track circuit occupied).

It can be seen that an electrical short circuit between the rails, caused other than by a train, or any disconnection within the circuit, will fail the track circuit and inform the signalling system that the track circuit is occupied. Such a circuit configuration incorporates a high degree of fail safe ; it does, however, depend upon good electrical contact between the wheel sets of the train and the rails upon which they run. It also depends upon a continuous low impedance path between the steel tyres of each wheel via the connecting axle.

Track circuits apply this basic principle in a variety of ways for various reasons. The source of electrical energy may be d.c., a.c. at power frequencies, a.c. at audio frequencies, or a series of impulses. The detector may be a simple relay, a more complex a.c. vane relay or a receiver tuned to a particular frequency or pattern of signals. Additional items may have to be added to overcome the problems arising from sharing the rails with heavy currents created by an electric traction system.

5.3.2 A.C. Electrified Areas

The a.c. electrification traction power supply system forms part of the railway infrastructure owned and operated by Railtrack. The system provides nominal 25kV, industrial frequency, supplies to trains via an overhead line contact system. The return path for traction current is via the running rails and either earth or a dedicated return conductor.

In the 1950s, the introduction of overhead 25kV 50Hz a.c. electrification in place of the then standard overhead 1500V d.c. electrification and the 650V d.c. third rail system was driven by the benefit of significantly reduced traction current for a given power output. This enabled supply feeder stations to be sited at greater distances apart (20 to 30 miles) whilst the overhead catenary and its supporting structures could be of lighter construction. The overall result is the reduced cost of electrification.

Traction units continued to use d.c. traction motors which derived their supply via rectification of the a.c. supply indeed, it was the advances in rectification technology with the advent of semiconductors which made the change to a.c. distribution a viable proposition.

The change to industrial frequency a.c. created additional interference problems, primarily associated with electromagnetic induction into lineside control and communication circuits.

The 1990s have seen the emergence of the three phase induction traction motor controlled by sophisticated power electronics packages as a successor to the simple d.c. motor. Whereas with the d.c. traction motor, the traction unit could be regarded as a passive load with interference effects arising from the resulting traction current, the three phase traction package has the potential to itself generate interfering harmonics over a wide spectrum in the traction current. This has necessitated giving much greater attention to the traction package design with respect to track circuits than was previously the case whilst the detailed methodology for such analysis has not reached a level of maturity whereby hard and fast design rules can be laid down.

Trains with induction motor drives are therefore subject to special assessment and authorisation on a route specific basis via individual Safety Case arrangements.

The information provided in this document applies under normal levels of traction current only. It does not apply to fault currents.

a) Booster Transformers and Return Conductors

Although other configurations are practicable, and have been used in the past, the most common arrangement for many years has been that using booster transformers and return conductors as depicted in Figure C3.

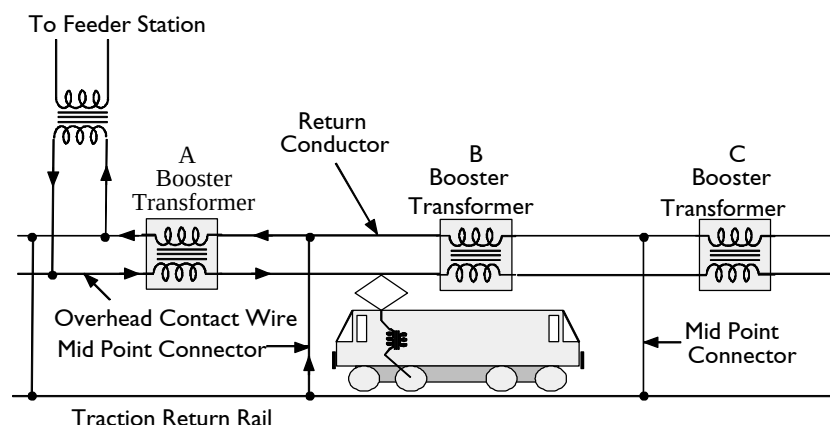


Figure C3

Booster (current) transformers are mounted on the lineside structures at regular intervals along the track and an insulated return conductor is provided in addition to the overhead contact wire from which the traction unit picks up its power. The contact wire supply passes through one winding of the 1:1 booster transformer whilst the return conductor passes through the other winding. The return conductor is bonded to the traction return rail at the mid-point between adjacent booster transformers.

With reference to Figure C3, when the traction unit is drawing current from the overhead contact wire between booster transformers A and B, the overhead contact wire supply current is being drawn through booster transformer A whilst the return current is initially injected into the rails beneath the traction unit. Given that electrical principles demand that an equal and opposite current must flow in the return conductor winding of booster transformer A, the return current from the traction unit is drawn up the respective mid-point connector into the return conductor where it now remains all the way back to the feeder station.

When the traction unit pantograph moves between booster transformers B and C, the overhead contact wire supply current passes through both A and B booster transformers and the return current travels forward of the unit to the mid-point connector between B and C before returning through both A and B booster transformers.

Thus, the effect of this arrangement is to reduce significantly the amount and distribution of traction return current actually flowing in the rails, which minimises induction into the lineside cables and so eases the interference immunisation measures required for the track circuits concerned.

Important Safety Note

Unlike structure bonds (normally zero current) and periodic track-to-track cross bonds (usually an alternative parallel path), mid-point connectors which become detached from the return rail are extremely hazardous if touched. For this reason, they are installed with either RED sheaths or RED markings at the point of rail connection. If observed disconnected, staff shall inform the Electric Control Room immediately. REMEMBER DO NOT TOUCH !!

b) Neutral Sections

The a.c. overhead contact wire supplies of adjacent feeder stations are isolated from each other by neutral sections (sections of electrically insulated catenary which still permit the mechanical passage of the pantograph). To prevent a traction unit from powering itself into a Neutral Section and thereby drawing a damaging arc, the traction unit is automatically powered down and disconnected via an on-board circuit breaker before entering a Neutral Section and is automatically reconnected after passage. This is achieved by positioning permanent inductors on the sleeper ends either side of the Neutral Section which are sensed by bogie mounted receivers on the traction unit as shown in Figure C4. This system is referred to as APC (Automatic Power Control) and uses the same permanent inductor and receiver equipment as used for AWS (Automatic Warning System).

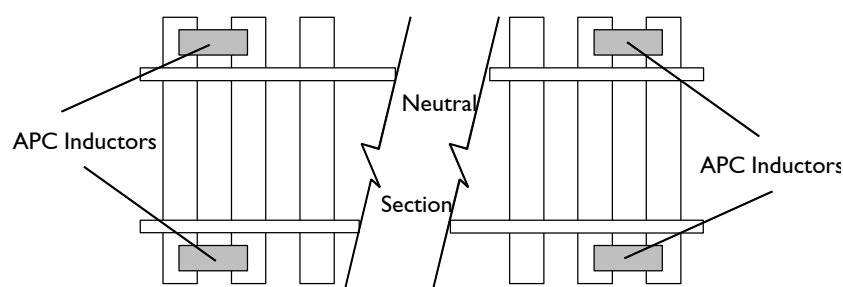


Figure C4

5.3.3 D.C. Electrified Areas

The d.c. electrification traction power supply system forms part of the railway infrastructure owned and operated by Railtrack. The system provides nominal 650/750 V d.c. supplies to trains via a third rail mounted outside the running rails. The return path for traction current is via either or both running rails, dependant upon the site requirements. The traction return system is not intentionally connected to an earth electrode.

Prior to the 1950s, direct current was the only form of electrical energy used for traction purposes in the UK.

It was implemented on major networks, such as London Underground, and other smaller systems, such as Liverpool (Merseyrail), Euston Watford and the North London Lines, using a 650V d.c. third rail system. Similarly, on the former Southern Region d.c. lines a 660/750V d.c. third rail system was installed, where the voltage at each substation along the line is progressively stepped up from 660V to 750V.

The exposed nature of the conductor rails necessitated the voltage being relatively low. Therefore, very high currents were needed to provide the required power requirements. However, this imposed severe limitations on three and four rail d.c. traction systems due to the voltage drop.

The use of overhead catenary wires enabled the supply voltage to be increased to 1500V, and a number of these systems were introduced in the 1930s & 1940s, e.g. Manchester and Sheffield. However, the necessary size of the overhead conductor and the structures to support it proved very expensive.

With the introduction of 25kV a.c. electrification schemes in the 1950s, the current requirements and the resultant volt drop were dramatically reduced for similar power levels, resulting in a reduction in size of overhead conductor and supporting structures. The supply substations could now be sited at much greater distances apart, reducing the overall costs.

All overhead 1500V d.c. systems in the UK have now been converted to 25kV a.c. and only conductor rail d.c. systems remain. These conductor rail d.c. systems continue to provide valuable service and will do so in the future on account of the vast investment which would be needed to change to 25kV a.c. electrification.

Trains with induction motor drives are therefore subject to special assessment and authorisation on a route specific basis via individual Safety Case arrangements.

The information provided in this document applies under normal levels of traction current only. It does not apply to fault currents.

a) Third Rail Conductor Rail System

With reference to Figure C5, the positive conductor rail is supplied from lineside substations and current passes to the traction motors by way of the collector shoes. After passing through the motors, the current returns to the substation through the wheels and axles of the train and through one or both running rails.

It should be noted that substations are connected in parallel to the conductor rail system and a train may be drawing current from more than one substation. As the distance from the nearest working substation increases, the resistance of both the conductor and return rail paths increases. Therefore, the voltage across the traction motor decreases.

Additional IRJs are provided in both rails at the boundary between electrified and non electrified lines in order to minimise traction current returning to the substation via undesirable paths, causing interference and electrolytic corrosion.

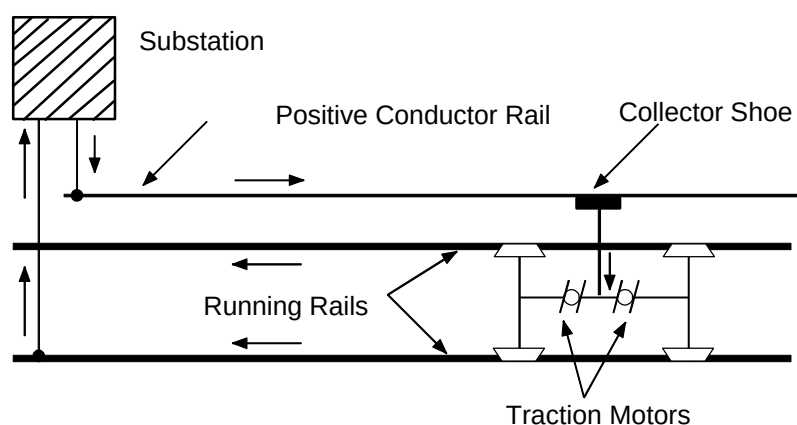


Figure C5

b) Fourth Rail Conductor Rail System

London Underground Limited (LUL) uses a system that allows the traction current to return to the substation through a collector shoe to a negative conductor rail laid in the centre of the four foot. This rail is insulated from the running rails, which are therefore free from traction return current.

Where LUL trains run over Railtrack lines equipped with the third rail system, e.g. Richmond Gunnersbury, Putney Bridge Wimbledon and Queens Park Harrow & Wealdstone, a fourth rail is installed and bonded to whichever of the running rails is used for traction return current, to allow the return current to flow when LUL trains are running. LUL trains are fitted with third and fourth rail shoes, whilst others only use the third rail system.

c) Fourth Rail (Non-Contact Return Reinforcement)

In areas of high traction return currents (currently where class 92, 373 and 465 units run) an additional rail is sometimes provided in the four foot or on the sleeper ends to reduce the resistance of the return path to the substation. This rail has no physical connection with the train, but is electrically bonded to the traction return rail in single rail track circuit areas or the cross bonding connection of an impedance bond in double rail track circuit areas. In other areas, large negative conductor cables may be used in place of a fourth rail.

d) Track Paralleling (TP) Huts

Track Paralleling Huts are usually located approximately midway between traction substations. They enable the paralleling of conductor rails through circuit breakers to reduce the resistance between the substation and the train, thereby improving the voltage seen by the train. The effect can be used either to run longer trains by increasing circuit breaker overload settings or to allow substations to be positioned further apart.

The paralleling of the conductor rail is done through circuit breakers so that disconnections of the parallelism can be made in the event of emergency or maintenance.

e) Track Alive Relays

On parts of the former Southern Region, where regenerative braking is used, some single end fed branch lines have Track Alive Relays installed (one per running line). These relays give a remote indication to the Electrical Control Room that the track is live. This track condition can arise even when the circuit breaker is opened due to current being fed back into the system from a regenerating train.

If the negative lead is disconnected from the track, it can result in the negative lead rising to traction potential.

5.3.4 Dual Electrified Area

Some lines are dual equipped with both a.c. and d.c. traction systems using the running rails as a common return. The traction currents present in the running rails consequently originate from both a.c. and d.c. systems.

Special measures are required to be taken to prevent d.c. return currents from flowing through the earth, or from flowing for long distances into an a.c. electrified area, which would consequently require immunisation. These may include:

- isolation of overhead line structures from earth,
- traction return isolation devices for use whilst a d.c. traction unit is operating.

5.3.5 Immunity from Traction Interference

The introduction of traction units incorporating a.c. asynchronous, three phase and inverter drives, e.g. Networker, Class 373, Class 323 and Class 92, creates new track circuit interference risks arising from the wide frequency spectrum over which such units are capable of generating interfering current. Special additional rules govern track circuit design in such circumstances. This document will be amplified further as developments take place.

Where there is a significant change in the traction loading of an existing system, e.g. three phase drive, it will be necessary to revalidate the track circuit design against the effects of the increased traction return currents.

The Project Manager for the introduction of new traction units is responsible for ensuring that a proper traction safety case is developed and submitted to the Infrastructure Controller for approval. This shall consider all types of track circuit that are approved for use and meet the application criteria for the lines over which the new traction units are to run. Any consequent restrictions on the use of any of these track circuits on such lines shall be listed on the Rolling Stock Acceptance Board (RSAB) certificate and published, without delay, as a revision to the Product Specification of the respective track circuit.

5.3.6 Non-Electrified Lines

Where the lines are non-electrified, traction currents are not normally present in the running rails.

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PART D AXLE COUNTER CONFIGURATION PARAMETERS

The configuration parameters for axle counters are given in Railtrack Company Specification RT/E/S/10129, Train Detection Using Axle Counters.

1 DEFINITION OF CLEARANCE POINTS

Where an axle counter head is used to define a clearance point, the requirements of GK/RT0011, Appendix A, must be satisfied.

See Part F, section 5, for further details.

2 INTERFACING WITH TRACK CIRCUITS

The appropriate sections of Part F, Track Circuit Configuration Parameters, shall be applied.

2.1 Continuity of Train Detection

Where continuity of train detection is required, it shall be ensured that, for the shortest train travelling at permissible speed, the rear track section cannot register clear until the forward one registers occupied, in every instance.

Where necessary, this may be achieved by positioning the axle counter head such that the track sections overlap, or by incorporating additional delay into the track section response as described in Part F, section 6.

2.2 Electromagnetic Interference

See Part F, section 9.3, for restrictions on the installation of axle counter equipment adjacent to track circuits of certain frequencies.

PART E WHEEL DETECTOR CONFIGURATION PARAMETERS

I DESCRIPTION

The wheel detector equipment shall consist of a track mounted sensor unit and may additionally utilise a separately mounted control unit in order to provide the required functions.

The detector shall be capable of sensing train movements over the sensors in either direction (omni-directional). Detection of the direction of the vehicle movement may be a requirement for particular applications.

Where appropriate, this part also applies to mechanical treadles, which generally use at least one stick relay to perform the function of the control unit.

2 APPLICATIONS

Wheel detectors to this Specification may be used in a wide range of signalling applications, and the particular requirements of any application, especially with respect to safety afforded by the configuration, shall be assessed prior to any approval process.

Wheel detectors which comply with this Specification are suitable for high integrity applications (such as for level crossing strike-in). Where the equipment is used in other applications, a lower level of integrity may be justified.

The application is only valid where a secure power supply or suitable battery back-up is available.

3 SENSOR UNIT

The track mounting arrangements for the sensor unit shall take into account any effect this has on the sensitivity of the equipment.

With the exception of those parts essential for the function of mechanical wheel detection (e.g. striker arms), all track mounted equipment, including any cover (see section 6.4) shall not be foul of the Structure Gauge. Any part of the mechanism designed to come into contact with the detected wheel, shall not have any significant effect on the wheel, taking into account the maximum permissible line speed.

Track mounted equipment shall not be prone to damage by the passage of vehicles, which may result in a reduction in the integrity of the wheel detector.

Possible proximity to live conductor rails and the depth to which space underneath rails is required shall be taken into account with respect to the safety and practicability of installation and maintenance activities, without an isolation of the traction supply.

The design of the sensor and any track mounting shall have due regard for its vulnerability to vandalism and, where appropriate, shall be able to withstand the weight of a human being (typical 100 kg) without sustaining damage or detriment to performance.

Entry into the equipment enclosure shall be effected by the use of hand tools, and a method of sealing to detect and deter unauthorised access shall be provided.

4 CONTROL UNIT

Where the equipment configuration includes a separately mounted control unit (or units), then this shall be suitable for mounting in a place of safety with respect to maintenance activities.

5 RAIL / WHEEL PARAMETERS

The sensor unit shall be designed to operate with rail sections which are in use by Railtrack, in accordance with GC/RT5019.

Track mounting of sensors shall not result in stresses that reduce the life of the rail.

Holes drilled in the rail shall be minimised and meet the specification of the infrastructure controller in accordance with the requirements defined in GC/RT5019.

The detector shall be capable of operation when the sensor is fixed on either rail, under all permitted cant conditions. Full details of any restrictions due to track curvature or cant are to be supplied as part of any approval submission.

The detector shall be suitable for operation by all types of traction and rolling stock wheelsets to BS 5892 and with a diameter greater than 250mm, without adjustment.

The detector shall be capable of operating correctly for all acceptable parameters for new and worn wheel, flange and rail profiles as defined in GM/TT0089 and GC/RT5019, including wheel flats, cracks and cavities up to the level where vehicles or rails would be required to be immediately taken out of service.

The wheel detector operation shall not be affected by reasonably expected variations in relative flange position, with respect to the rail, such as hunting, track spread and the tendency for the flange to climb.

In all cases, correct detection of train wheels shall not be compromised by a tolerance of ± 2 mm in the positioning of the track mounted sensor, with respect to any parameter, given in the fitting instructions.

6 OPERATION

6.1 General

Specific application requirements shall be agreed between the infrastructure controller and supplier, commensurate with achieving the safety and reliability requirements of this Specification.

Direction sensing may be specified when required for particular applications.

6.2 Interface

The output interface of the wheel detector must be suitable for the form of interlocking that uses the output data, with respect to ratings, number of normally open/closed contacts, timing and safety integrity requirements.

For maximum versatility, the following requirements shall be complied with:

- The outputs shall be insulated from any other conductive parts of the equipment and each other.
- Each output shall be capable of switching one 5W relay, with an operating voltage of 24V to 50V d.c. and a typical time constant of 30 ms.

Where direction sensing is required, this shall be provided either by additional outputs or by inhibiting the output, for the passage of wheelsets in the non-sensed direction (as specified for the particular application).

The change of state of the outputs shall be completed within 250 ms of initiation by the presence of a wheel within the specified detection distance from the sensing element.