

Information for printer users

The attached document:

NR/SP/SIG/50011
Issue 1

contains colour on the following electronic pages:

51

Proceed to document ►

Colour pages can be purchased separately from:

The Network Rail Document Centre @ IHS ATP

Please click here to proceed to the Network Rail Standards' 'Who's Who' for their latest contact details.

Ref	NR/SP/SIG/50011
Issue	1
Date	April 2006

Business Process Document

Methodology for the Demonstration of Electrical Compatibility with Axle Counters

Endorsement & Authorisation

Endorsed by:


.....

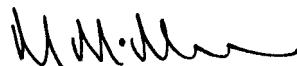
A Simmons, Head of Engineering

Authorised by:


.....

A McNaughton, Chief Engineer

Accepted for issue by:


.....

M McManus, National Standards Manager

This document is the property of Network Rail. It shall not be reproduced in whole or part nor disclosed to a third party without the written permission of the Standard Owner.

© Copyright 2006 Network Rail

Uncontrolled copy once printed from its electronic source.

Published & Issued by: Network Rail 40 Melton Street, London NW1 2EE



Ref:	NR/SP/SIG/5001 I
Issue:	I
Date:	April 2006

Issue record

Issue	Date	Comments
I		New standard

Implementation

The provisions of this code of practice may be used from the date of issue.

Compliance

This Network Rail Specification is mandatory and must be complied with by all parties seeking acceptance from the date of issue.

When this Specification is implemented, it is permissible for all projects, which have formally completed GRIP Level 4, to continue to comply with the Issue of any relevant Network Rail Standards current when GRIP Level 4 was reached and not to comply with requirements contained herein unless the designated [Standard Owner] has stipulated otherwise in the accompanying Briefing Note.

Where the [Standard Owner] has specified that all projects will comply with the requirements, specific authority not to comply can be sought in the usual manner using the appropriate non-compliance authority processes described in Network Rail Standard, [NR/SP/STP/045](#) Managing the Process for Non-compliance Authority (formerly RT/LS/P/045).

Disclaimer

In issuing this document for its stated purpose, Network Rail makes no warranties, express or implied, that compliance with all or any documents it issues is sufficient on its own to ensure safe systems of work or operation. Users are reminded of their own duties under health and safety legislation.

Supply

Copies of documents are available electronically, within Network Rail's organisation. Hard copies of this document will be available to Network Rail employees on request to the Document Controller and to other organisations from IHS Technical Indexes (01344 404409)

Ref:	NR/SP/SIG/50011
Issue:	1
Date:	April 2006

Contents

1	Purpose	4
2	Scope	4
3	Reference documentation	4
4	Description of Axle Counter Systems	6
5	Infrastructure Assumptions and Terminology	19
6	Susceptibility Analysis	24
7	Train Analysis	37
Appendix A	Parameters	43
Appendix B	Assumptions	45
Appendix C	Sources of Technical Work	48
Appendix D	Typical Traction Currents (Phase Angle Controlled and IGBT Drives)	49
Appendix E	AzL70 Axle Counters	52

I Purpose

The purpose of this document is to provide a methodology for the demonstration of electromagnetic compatibility (EMC) of rolling stock with Axle Counters installed on Network Rail controlled infrastructure. Information is drawn from previously accepted safety assessments, which were undertaken to allow for traction and rolling stock to operate over Axle Counters. It also includes work from a German Railway European Working Group, laboratory testing in the UK and an analysis for coupling with the transmission link.

2 Scope

The scope of the document only concerns the following types of axle counters systems installed on Network Rail controlled infrastructure:

- AzL70
- AzL70-30
- AzL90M
- AzLM
- AzSME

3 Reference documentation

3.1 Network Rail Company Standards

RT/E/S/10129	Requirement Specification for Train Detection using Axle Counters, Issue 1, February 1999
RT/E/S/11752	Train Detection, Issue 2, dated August 2001
RT/E/S/10661	Signalling Maintenance Task Intervals, Issue 3, dated April 2003
RT/E/C/11210	Signalling Installation Standards - Appendix 2Q50 Axle Counters: SEL Type, Issue 1, dated August 2000

3.2 Previous Safety Case Documentation

F0095.56.3-3 [Siemens]	Class 333 EMU – R12: Failure of axle counter – Hazard Close-out
SAO-REF AXC-RP-2 [AEAT Rail] MOI10151655 [Siemens]	Class 334 Compatibility with Axle Counter – Final Report, Issue 1, 14 December 2000 Axle Counter Dorset Coast Production Application Safety Case, Issue 2.2, 25 September 2003
SCS-CL(390)-AzLM-Co-34 [AEAT Rail]	Class 390 Compatibility with AzLM Axle Counters – 4 Units Operation, 20 February 2003

3.3 Other Standards

GK/RT0011	Train Detection, Issue 3, August 2000
GK/GN0611	Train Detection, Issue 1, August 2000
GK/RT0027	Resetting and Restoration to Service of Signalling Systems, Issue 2, June 1998
GK/RT0217	Technical Requirements for Axle Counters, Issue 1, dated February 2003
GE/RT8217	Introduction and Use of Axle Counters – Managing the Risk, Issue 2, February 2003
BR13422	50Hz Single Phase AC Electrification: Immunisation of Signalling and Telecommunications Systems Against Electrical Interference, February 1979
BS EN 50159-1	Railway Applications – Communication, signalling and processing systems – Part 1: Safety-related communications in closed transmission systems.

3.4 Other Documentation

D351-01 [Alcatel]	Axle Counter AzL70-30 General Description, November 1990
C521-01.5 [Alcatel]	Axle Counter AzL70-30 Commissioning Instructions, November 1990
C521-01.4 [Alcatel]	Axle Counter AzL70-30 Transmission Cables, August 1991
CBS/TS-Ex26.3 [SEL Alcatel]	AzL70 Axle Counter Transmission Cables, June 1985
Recommendation K.26 [ITU-T]	Protection of Telecommunication Lines Against Harmful Effect from Electric Power and Electrified Railway Lines, ITU-T Ditectives - Volume IX, "Testing Methods and Measuring Apparatus", 1989
Wheel Sensors [DB]	Interference Limits and Tests on Wheel Sensors and Axle Counters, V3_0.doc, dated 31/3/03
LRDA D9279 [AEAT Rail]	Permissible Interference Currents for Axle Counters, Issue 4, dated February 2004
AEATR-ES&I-2004-002 [AEAT Rail]	Axle Counter Current Injection and Magnetic Field Measurements, Issue 1, dated January 2004
3CR01800AAAA DEAFQ [Alcatel]	AzLM Product Description, Rev C2, dated 18/10/01
SAO REF-AXC-RPI [Alstom/AEAT Rail]	Alcatel SEL Axle Counters – General Information, Issue 2, dated 10 June 2000
IRSE News, Issue 64	Glasgow Pilot's New Axle Counter, January 2000
4342013/011	Axle Counter Transmission Line Impedance Mismatch Testing Results,

Ref:	NR/SP/SIG/50011
Issue:	I
Date:	April 2006

[WSAR]	Report 2, Issue 1.0, dated 17/6/02
EI0007 [Network Rail]	AzLM ACE to EAK line side data cable, Issue 1, dated 30/4/03
Alcatel-AEAT correspondence	Email from Alcatel (A. Knight) to AEAT (A Hines) "Re: Axle Counters", dated 23/10/03
Alcatel-AEAT correspondence	Email from Alcatel (A. Knight) to AEAT (A Hines) "Re: Time Response", dated 01/12/03
LD40278\92910 [AEAT Rail]	Axle Counter deteriorating earth faults will cause a right side failure before a hazard occurs, 20 May 2004
Signal & Draht, (94)	Analysis of Risks Associated with Axle Counters, Signal & Draht, (94) 11/2002

4 Description of Axle Counter Systems

The following axle counter types used on Network Rail are covered by this document:

- AzL70
- AzL70-30
- AzL90M
- AzLM
- AzSME

The different Alcatel types (AzL types) represent the evolution of the axle counter product used on the UK rail network over the years. The earliest type currently in use, the AzL70, uses detection heads which operate at 5060Hz and was installed on Network Rail lines in the 1970s. This equipment is now obsolete although still in service in Scotland.

From the early 1980s the AzL70-30 with heads operating in the frequency range 28-31kHz was introduced. Most of the early AzL70-30 applications are on non electrified lines although there are significant numbers installed in AC electrified lines. There are a number of more modern systems that have been on trial on Network Rail in more recent years. The AzL90M is a multisection axle counter using the same heads as the AzL70-30. The main difference is in the transmission link.

Whereas the previous types transmitted the axle count information to a remote evaluator in analogue form at frequencies of 5060Hz and 4125Hz, the AzL90M utilises digital transmission and a single evaluator can handle up to 16 detection points and supervise 16 track sections.

The AzL90M was a pilot project to the more recent AzLM which is a development of the AzL90M. The AzLM has been introduced on a significant scale on the AC electrified railway. Again similar heads are utilised at 28-31kHz although they are non ferrite to prevent interference from track brakes utilised on European high speed trains (although track brakes are not currently used in the UK). Data transmission from the trackside heads to the

Ref:	NR/SP/SIG/50011
Issue:	1
Date:	April 2006

evaluator is digital, but using a more robust form than the AzL90M, utilising special safety coding in the telegrams.

The AzSME is a departure from axle counter applications to date on Network Rail, that have only utilised the Alcatel types described above. The AzSME is a Siemens axle counter system utilising detection heads that operate at 43kHz. Transmission from trackside to the evaluator is similar to the AzL70-30 in that it is in an analogue form, although different frequencies are used, nominally 3600Hz and 6520Hz.

Detailed descriptions of the axle counters used on Network Rail, their operation and installation are given in references [MO110151655 \[Siemens\]](#), [D351-01 \[Alcatel\]](#), [C521-01.5 \[Alcatel\]](#), [3CR01800AAAA DEAFQ \[Alcatel\]](#) and [SAO REF-AXC-RPI \[Alstom/ AEAT Rail\]](#). The following is intended to give sufficient background information to consider the application of the compatibility demonstration methodology.

It should be noted that all axle counter systems in operation on Network Rail only have trial certification.

4.1 AzL70 Axle Counter Systems

The AzL70 axle counter consists of:

- The outdoor equipment:
two SK11 rail contacts and one EAK Electronic Junction Box (EJB)
(per detection point at the extremities of the track area);
- the transmission path (4-wire transmission);
- the indoor equipment (evaluator unit).

Each detection point uses two SK11 rail contacts: each of which comprises an independent pair of transmitter and receiver coils. The two rail contacts are mounted on opposite rails: the transmitter coils on the outside of the rail and the receiver coils on the inside, directly opposite their respective transmitter coils.

The two rail contacts are staggered to enable direction sensing, whilst the use of two transmitter/receiver coil pairs increases integrity of the system. The general arrangement of the AzL70 axle counter is shown in Figure 1.

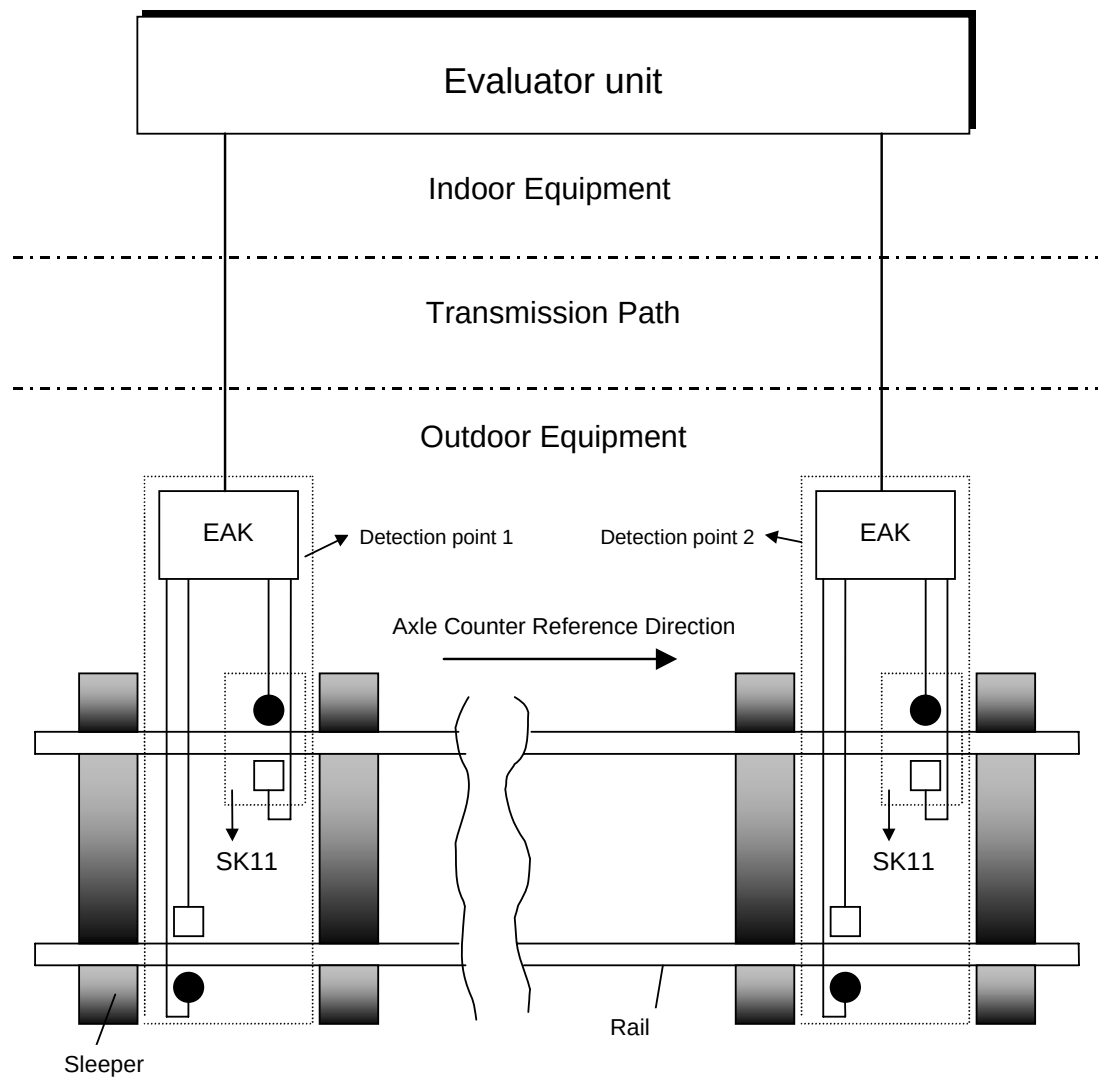


Figure 1 - General Arrangement of the AzL70 Axle Counter

The two transmitter coils are fed with a current at a frequency of 5060Hz and the alternating magnetic field created induces a related current in the receiver coils. It is ensured by the shape and the arrangement of the coils and their ferrite cores that the field set up by each transmitter coil consists of two main magnetic fluxes ($\phi 1$ and $\phi 2$) which pass through the receiver coil in opposite directions.

The magnetic resistance of the two flow paths are of different values, such that when there is no wheel over the rail contact, one of the fluxes ($\phi 1$) predominates. However, when there is a wheel over the rail contact this flux is reduced to about half as a result of the screening effect of the wheel flange.

The two fluxes counteract each other so that no net voltage will be induced in the receiver coil, hence a counting pulse will be generated.

The EAK Electronic Junction Box (EJB) consists of a small enclosure containing electronic cards, which interface to the rail contacts. The cable between the EAK and rail contacts uses screened twisted pair cable and the screen is unearthed and is up to 4m long. The EAK transmits the received decoded information to the evaluator unit via the transmission path. Within the EJB there is an audio frequency generator supplying the transmitter coils of the two rail contacts with an a.c. voltage. The frequency of the generator is determined by an oscillator circuit formed by the two transmitter coils and one capacitor.

In this 4-wire system, two receiver amplifiers amplify the voltage induced in the receiver coils of the rail contacts and each transmits it via a separate line transformer to the transmission line.

The axle pulses, produced by the detection equipment, are thereby transmitted to the indoor equipment using a single frequency for the 4-wire system (5060 Hz). The format of these signals is essentially a pure tone.

The transmission path consists of a cable with communication characteristics. The transmission path could be formed by twisted pair cables or a double pair of a star quad cable. The transmission cable is also used to feed the DC supply to the outdoor equipment. The transmission cables cause a drop in the feeding DC supply voltage and attenuation of the AC voltage from the detection point.

Maximum circuit length depends on the detail of the power supply, and on the impedance matching of the transmission cable used. Other factors may limit the circuit length, e.g. longitudinal voltage limits in AC electrified areas.

The indoor equipment is similar to that used in the AzL70-30 axle counter system, which is described below in section 4.2.

4.2 AzL70-30 Axle Counter Systems

The AzL70-30 axle counter consists of:

- The outdoor equipment:
two SK30 rail contacts and one EAK30 Electronic Junction Box (EJB)
(per ZP30 detection point at the extremities of the track area);
- the transmission path (2-wire transmission);
- the indoor equipment (Evaluator Unit for evaluation and relay interface).

The general arrangement of the AzL70-30 axle counter is shown in Figure 2.

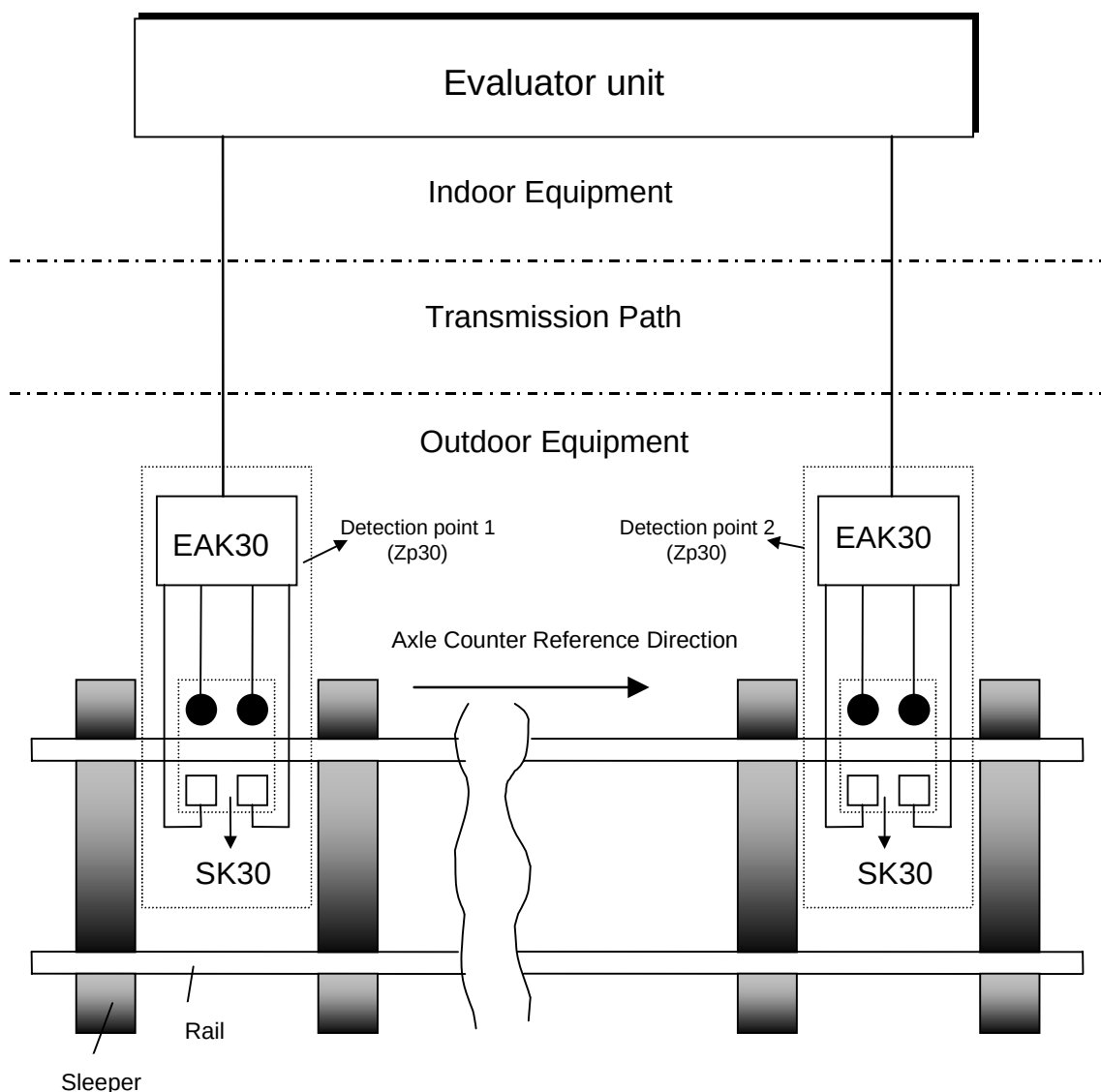


Figure 2 - General Arrangement of the AzL70-30 Axle Counter

Each ZP30 detection point uses two SK30 rail contacts: each of which comprises an independent pair of transmitter and receiver coils. The two rail contacts are mounted on the same rail: the transmitter coils on the outside of the rail and the receiver coils on the inside, directly opposite their respective transmitter coils.

The magnetic field from each transmitter coil couples around the rail with its respective receiver coil, inducing a voltage. The two transmitter coils are fed at different frequencies (28kHz and 30kHz) to avoid mutual interference between the two coil pairs. The use of two coil pairs, separated by approximately 150 mm, allows for direction sensing and increases the integrity of the system.

Ref:	NR/SP/SIG/50011
Issue:	I
Date:	April 2006

The transmitter signal is generated at the nominal value and frequency modulated at +/- 10Hz with a repeat frequency of approximately 30Hz. The nominal frequency is adjusted to give a precise resonance with the transmitter circuit. The arrangement of the coil pairs is such that the phase of the voltage induced in the receiver coil is reversed in the presence of a wheel flange; this being detected by a phase sensitive rectifier in the trackside electronic junction box (EJB type EAK30), which then converts a phase reversal into a wheel DC counting pulse.

The Electronic Junction Box (EJB) consists of a small enclosure containing electronic cards, which interface to the rail contacts. The cable between the EAK and rail contacts uses screened twisted pair cable and the screen is unearthed and is up to 4m long. The EAK transmits the received decoded information to the evaluator unit via the transmission path.

The output of the EJB consists of two signals for the wheel counts at each rail contact (at 4150Hz and 5060Hz) and a supervisory signal (at 2530Hz) which are gated by the shaped pulses and combined in an FDM signal sent to the remote Evaluator unit. The relevant signal will be absent when a train wheel is present.

The transmission path consists of a cable with communication characteristics. The transmission path could be a single twisted pair cable or a single pair of a star quad cable. The transmission cable is also used to feed the d.c. supply to the outdoor equipment. The transmission cables cause a drop in the feeding DC supply voltage and attenuation of the AC voltage from the detection point.

Maximum circuit length possible depends on the detail of the power supply, and on the achievement of the correct impedance matching of the transmission cable used. Other factors may limit the circuit length, e.g. longitudinal voltage limits in AC electrified areas.

The 'indoor' equipment consists of an Evaluator unit (i.e. the rack-mounted logic processor) and a Relay Interface (i.e. the interface to the signalling interlocking equipment). The processing is via analogue electronics and is a single processor system.

The main functions of the indoor equipment are to:

- collect the information from the detection point;
- test the outdoor equipment for correct functioning;
- count the wheel pulses;
- provide the 'track-clear' or 'track-occupied' information, and
- transmit this information to the interlocking equipment.

The Evaluator Unit receives the signals and buffers, demodulates and decodes them, providing the counters with axle count data for entry and exit from the track section. Each Evaluator Unit may accept signals from several trackside units, widely or closely

Ref:	NR/SP/SIG/50011
Issue:	I
Date:	April 2006

spaced as required by the railway layout, marking entry and exit points to the controlled track section.

The output Relay Interface drives the local interlocking or block equipment, giving "track occupied", "track clear" and other status indications. In the event of a miscount, the evaluator will either continue to indicate "track occupied" or else indicate a fault status to the signalling system. This is a "right-side" failure, which will be protected by the interlocking controls.

4.3 AzL90M Axle Counter Systems

The AzL90M is based on a vital 2 out of 2 processor system. The axle counter evaluator (ACE) handles up to 16 detection points (Zp30C) and supervising up to 16 track sections. The basic units of the Az L90M are:

- The outdoor equipment - detection point Zp30C, consisting of two SK30 rail contacts and one EAK30C Electronic Junction Box (EJB) (per ZP30C detection point at the extremities of the track area);
- The data bus (4-wire transmission);
- The indoor equipment (ACE and relay interface).

In the multiple section axle counters AzL90M, a pre-processing of pulses is done in the electronic junction box, eliminating the real time requirements for data transmission to the evaluation unit. The task of the evaluation unit is therefore reduced to polling the information from the electronic junction boxes and evaluating the occupied/clear status of a section or a number of sections based on the incoming information. The general arrangement of the AzL90M axle counter is shown in Figure 3.

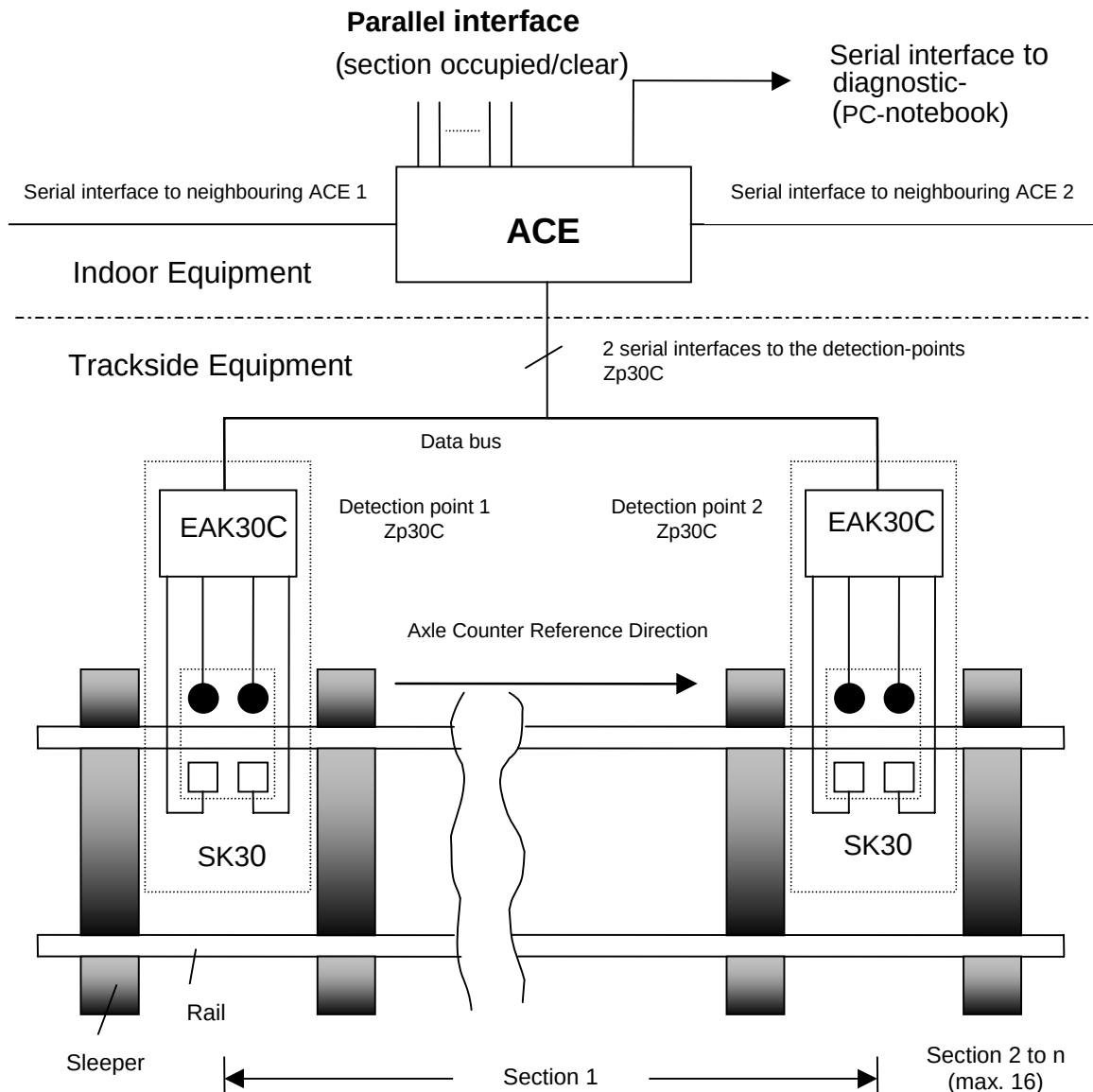


Figure 3 - General Arrangement of the AzL90M Axle Counter

The double rail contact Sk30 is the same as that used in the AzL70-30 and is described in section 4.2. The cabling between the rail contact and the EAK30C Electronic Junction Box is the same as the AzL70-30 with screen unearthed

The analogue wheel pulses from the rail contacts are converted to digital wheel pulses in the transmitter/receiver and are processed further in the counting point processor module (ZpR module which is within the Electronic Junction Box (EJB) EAK30C of Figure 3 above). When polled by the indoor equipment, the counting point processor sends the stored data in the form of serial telegrams, which are modulated in the modem module to the indoor equipment. The telegrams arriving from the indoor equipment are demodulated in the modem module before reaching the counting point processor module.

The counting point processors receive serial command telegrams from the indoor equipment through the modem. If the address contained in the telegrams agrees with the address of the counting point processor, set by means of the programming connector at the input, it sends a reply telegram with its count and supervision data to the indoor equipment.

There are two ZpR modules in each EAK30C. The modem module serves to serially transfer data between the ZpR module and the indoor equipment. The interface conforms to CCITT V.23 (1,200 bits/s). Data transmission between the outdoor and indoor equipment is full duplex on two twisted pairs of telecommunications cable (or signalling cable with telecommunications characteristics).

The axle counter evaluator is a fail safe 2 out of 2 computer and parallel output to the interlocking or other systems.

The main functions of the ACE are:

- Polling up to 16 counting points Zp30C;
- Evaluation of data from the counting points and supervision the track occupancy of the associated sections (up to 16 in total);
- Exchanging axle counter data of the sections common to the neighbouring axle counter evaluator;
- Communicating the non-occupied and occupied information to the interlocking;
- Preparatory reset of the axle counter sections by push button per section;
- Optionally it may be connected to a non-vital remote control PC via an integrated serial data interface. In this case, the following additional functions are available;
- Display of the non-occupied and occupied information on the monitor of the remote control PC;
- Plot of the axle counter section via operator control from the remote control PC.

4.4 AzLM Axle Counter Systems

The AzLM axle counter consists of:

- The outdoor equipment:
two SK30H rail contacts and one E-ES 30H Electronic Unit
(per ZP30H detection point at the extremities of the track area);
- the transmission path (2-wire transmission);
- the indoor equipment (evaluation and indication - relay interface etc).

The general arrangement of the AzLM axle counter is shown in Figure 4.

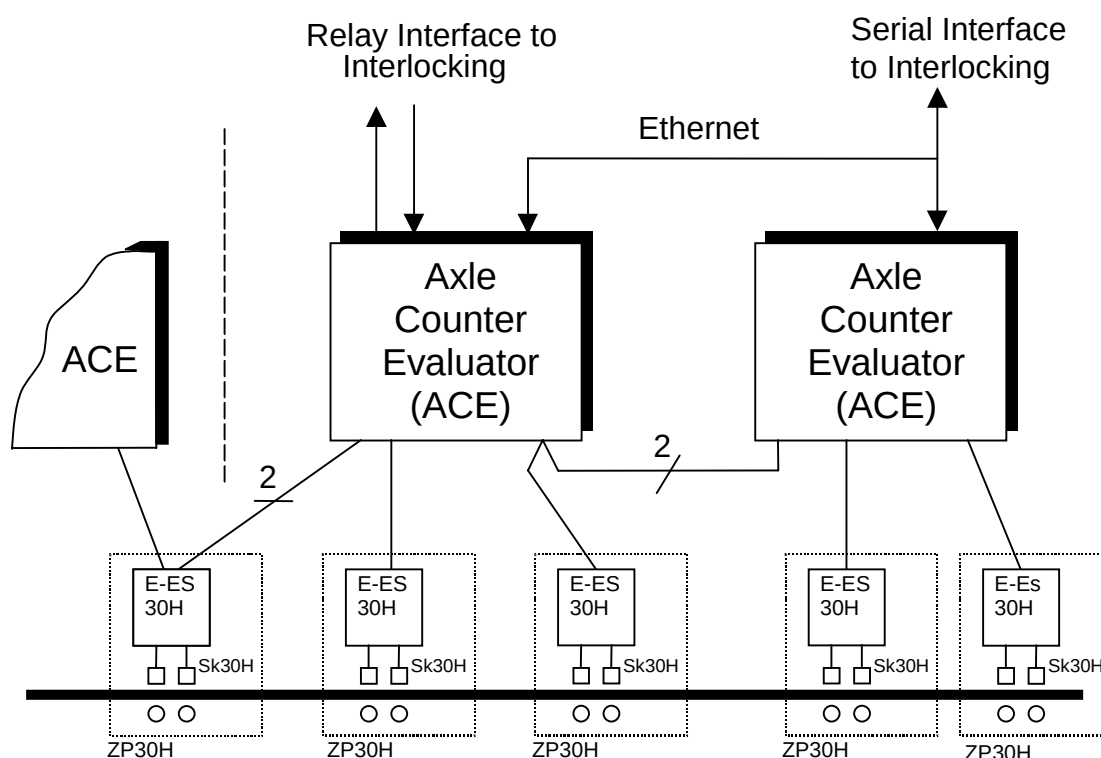


Figure 4 - General Arrangement of the AzLM Axle Counter

The detection point (ZP30H) consists of the rail contact (Sk30H), the electronic unit (E-Es30H) and the mechanical parts (housing, mounting base). The Sk30H rail contact is based on the Sk30 used with the AzL70-30 and the arrangement is the same as shown in Figure 2, however the Sk30H utilises non ferrite coils whereas the previous Sk30 utilised ferrite coils. Also the screening arrangement on the cable between the rail contact and the electronic unit is different on the AzLM. It is still limited to 4m but the screen is terminated with a 360° termination onto an earthing plate at the electronic unit (E-Es30H) which is itself earthed. This provides improved immunity to high frequency interference.

The two transmitter coils are fed as before at frequencies of 28kHz and 30kHz, using the same coding, phase sensitive rectification and generation of a DC wheel pulse see section 4.2. The reason for using non ferrite coils is to make them more robust to the extremely high magnetic field generated by track brakes (used in Europe but not in the UK), although one consequence is a slightly lower induced voltage in the receive coils and correspondingly lower signal to noise ratio at 30kHz.

In contrast to the Electronic junction box of the AzL70-30 which sends wheel count information in analogue form by modulated audio frequencies to the remote Axle Counter Evaluator, the Electronic Unit E-Es30H of the AzLM carries out the counting supervision and telegram generation functions at the trackside by two independent

Ref:	NR/SP/SIG/5001 I
Issue:	I
Date:	April 2006

micro-controllers (similar to the AzL90M). These are supervised by a vital module in the Axle Counter Evaluator (ACE), and the count information is sent to the ACE by an ISDN modem. The AzLM axle counter system including the data transmission is built by the rules and architecture defined in [BS EN50159-1](#). The data transmission is fault tolerant so that it is unaffected by spurious EMI that could cause random errors. The safety of data transmission is guaranteed by special safety coding in the telegram.

The transmission line cable to be used for AzLM axle counter installations should have a characteristic impedance of 130Ω at 40kHz as specified by the manufacturer. Although it has been shown that cables with a lower characteristic impedance provide adequate reliability and safety due to the fault tolerant nature of the transmission. Transmission distances up to 9.2km (locally powered) are available using a railway signalling cable although this length can be increased through the use of ISDN signal amplifiers (PCM transformers).

However, it should be noted that cable lengths may be sectioned into shorter isolated sections to reduce longitudinal voltage risks in A.C. electrified areas (usually around 2km).

The basic indoor equipment (the ACE), comprises:

- Vital computer module;
- Power Supply;
- Serial I/O;
- Parallel I/O.

Data from the trackside equipment is received via serial I/O modules. These are pre-processor boards which convert the serial data from the detection points to the I/O busses of the vital module. The computer module is designed as a vital 2 out of 2 computer system. Vital processing by means of software comparison is achieved by exchanging messages between the computer channels. The track occupancy information is output from the vital module via parallel I/O pre-processor modules via the same CAN bus as for the serial I/O. Each parallel I/O module gives track clear indications, and inputs a vital contact to clear a section. There are also non vital outputs available and the facility for an Ethernet interface.

4.5 AzSME Counter Systems

The AzSME axle counter consists of:

- The outdoor equipment:
two DEK43 rail contacts and one trackside connection box, which together are referred to as the Wheel Detection Unit type ZP43V;
- the transmission path (2-wire transmission);
- the indoor equipment - Evaluator Unit (evaluation and relay interface).

The general arrangement of the AzSME axle counter is shown in Figure 5.

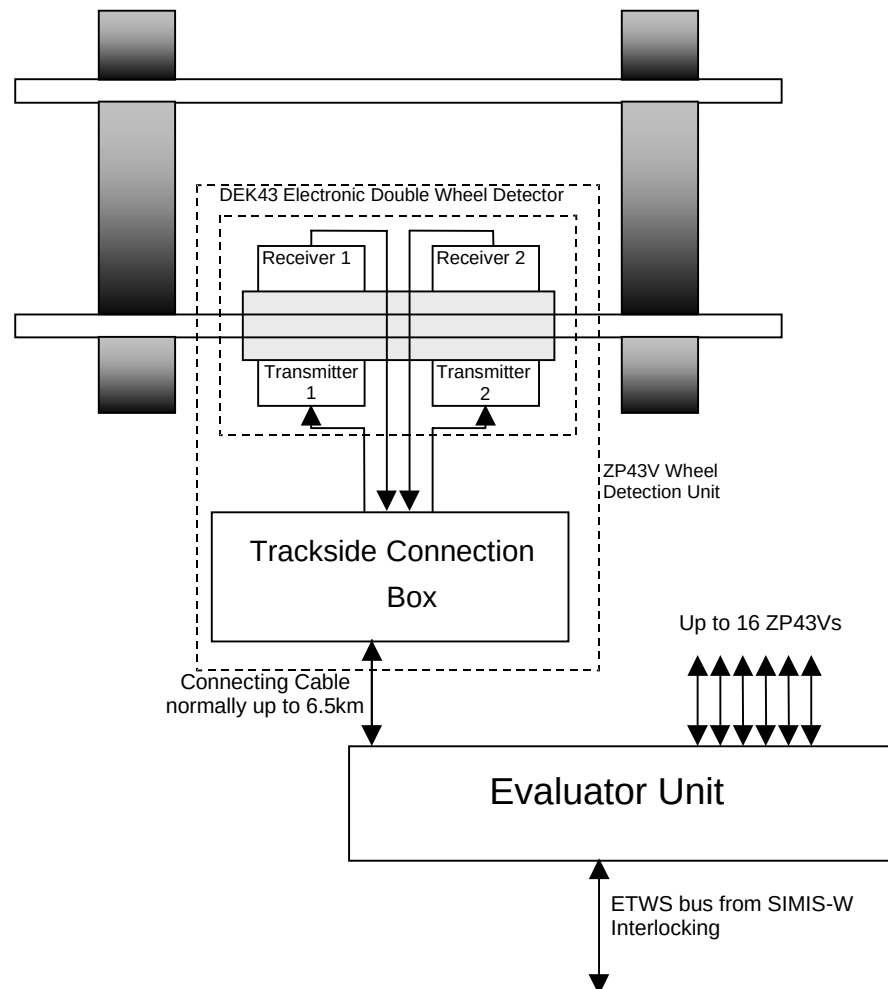


Figure 5 - General Arrangement of the AzSME Axle Counter

The ZP43V Detection Unit uses two DEK43 rail contacts each of which comprise an independent pair of transmitter and receiver coils mounted in a similar manner to previous rail contacts. This allows axles to be counted and direction of travel to be determined. Both transmitter coils are driven from circuitry in the trackside connection box at 43 kHz.

The coils are positioned in such a way that presence of a wheel increases the coupling between the sender and receiver coils and the voltage induced in the receiver coils increases accordingly. These receiver voltages are processed within the Detection Unit and are rectified to produce a DC voltage proportional to the amplitude of the AC voltage from the receiver. This DC voltage is input into a voltage-frequency converter, the frequency of which is controlled by the amplitude of the DC voltage.