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BSI Standards Publication

Public transport — Road vehicle scheduling and control systems

Part 8: Physical layer for IP communication

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National foreword

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Foreword

This document (CEN/TS 13149-8:2013) has been prepared by Technical Committee CEN/TC 278 “Intelligent transport systems”, the secretariat of which is held by NEN.

EN 13149, *Public transport — Road vehicle scheduling and control systems*, is composed of the following parts:

- Part 1: WORLDFIP definition and application rules for onboard data transmission;
- Part 2: WORLDFIP cabling specifications;
- Part 3: WorldFIP message content (CEN/TS 13149-3);
- Part 4: General application rules for CANopen transmission buses;
- Part 5: CANopen cabling specifications;
- Part 6: CAN message content (CEN/TS 13149-6);
- Part 8: Physical layer for IP communication (CEN/TS 13149-8; the present document).

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Introduction

The Technical Specifications in the EN 13149 series provide rules for data communication systems on-board public transport vehicles. Part 8 together with part 7 and part 9 describes a complete solution parallel to, but independent of, parts 1-3 and part 4-6.

Public Transport (PT) vehicles have an increasing array of information and communications systems, including ticket machines, Automated Vehicle Location (AVL) systems, destination displays, passenger announcement systems, vehicle monitoring systems etc. Other systems are beginning to be included such as advertising screens, tourist guides, WiFi “hotspots” and infotainment.

These systems may be provided by a number of different suppliers, and may need to be integrated. For instance a ticket machine may need location information to update fare stages; next-stop and destination information may be drawn from schedule information held in the ticket machine; and location systems may be used to drive signal priority requests.

In addition, equipped PT vehicles will often have communications facilities to enable voice and/or data to be exchanged with the intermodal transport control system centre, other PT vehicles, PT infrastructure, and roadside devices (for instance in requesting priority at traffic signals). Many types of communication channel are utilised, including public and private wireless communication networks.

Without a clear technology framework, integrating these systems would require complex technical discussions every time a device is procured.

A large number of current and future communication networks will use the Internet Protocol (IP) as a core network technology. Existing parts of EN 13149 are not consistent with an IP network and do not support the use of associated protocols. This makes it difficult for integrated on-board systems to use modern networks efficiently.

If an IP approach is adopted, the PT vehicle begins to look like a local area network (LAN) of connected systems. In this context it is relevant to define a hardware network which makes use of IEEE 802 technologies – these are much the most widespread basis for IP LANs worldwide.

The parts 7 to 9 will describe this adaptation. This will facilitate:

— high quality intermodal passenger services based on intermodal PT information,

— integration of new PT services,

— lower cost, lower risks and a smoother onboard integration of PT equipment,

— more efficient operation and maintenance of onboard PT equipment, and

— more efficient development of PT components.

1 Scope

This Technical Specification specifies the physical layer of an onboard data transmission bus between the different equipment for service operations and monitoring of the fleet. This applies to equipment installed on board vehicles that are operating as part of a public transport network, i.e. in operation under public service contracts. This equipment includes operation aid systems, automatic passenger information systems, fare collection systems, etc.

Equipment directly related to the safety-related functioning of the vehicle (propulsion management, brake systems, door opening systems, etc...) are excluded from the scope of this Technical Specification and are dealt with in other standardization bodies. Interfaces to such equipment or safety-critical networks can be provided through dedicated gateways.

Part 8 covers the link between equipment inside vehicles consisting of one carriage only, e.g. buses and trolleybuses, as well as a set of carriages, e.g. trams and trains.

For the described application, three communication systems are standardised under EN 13149. There is no ranking between the three communication systems.

— Parts 1, 2 and 3 describe the WORLDFIP communication system;

— Parts 4, 5 and 6 describe the CANopen communication system;

— Parts 7, 8 and 9 describe the IP-based communication system.

Part 7[1] of the 13149 series specifies the **Network and System Architecture** for onboard equipment. It describes basic principles of communications including a general description of the network topology, addresses schematics, basic network services, a system overview and basic device architecture.

Part 8 of the 13149 series specifies the **Physical Layer for IP-communication** networks onboard PT vehicles. This part specifies the cables, connectors and other equipment including pin assignment and environmental requirements.

Part 9[2] of the 13149 series specifies in detail the **Profiles** of basic and generic **Services and Devices** as well as profiles of specific services and devices.

This part 8-1 specifies wired communication networks onboard PT vehicles which are based on the Ethernet specification IEEE 802.3 — 10 Base T and 100 Base Tx.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50328, *Railway applications — Fixed installations — Electronic power converters for substations*

IEEE 802.3xx:2000, *Standard for Information Technology – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications*

ECE R118, *Fire protection*

[1] Part 7 is under development

[2] Part 9 is under development

EN 50155, *Railway applications — Electronic equipment used on rolling stock*

EN 60603-7, *Connectors for electronic equipment (IEC 60603-7, all parts)*

IEC 61156-6, *Multicore and symmetrical pair/quad cables for digital communications — Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz — Work area wiring — Sectional specification*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
consist
set of cars able to run in service, smallest entity in service

3.2
PT vehicle
smallest entity of a rolling stock

EXAMPLE bus, trolley bus, tramway, etc

4 Symbols and abbreviations

DC -	DC- in PoE
DC +	DC+ in PoE
ED	End Device
EMC	Electro Magnetic Capability
CFC	Chlorofluorocarbon
PoE	Power over Ethernet
RX-	Receive -
RX+	Receive +
TBD	To Be Defined
TX-	Transmission +
TX+	Transmission -

5 Requirements

5.1 General Remarks

The general requirements for Ethernet are specified in IEEE 802.3xx – the international standard for information technology. The following chapters provide specific requirements for the applications within the scope of this Technical Specification.

It is important to understand that electrical connections onto the communication network have important impact upon the network performance, and that the application is dependent upon the principles relevant to transmission lines rather than simple electrical power circuits.

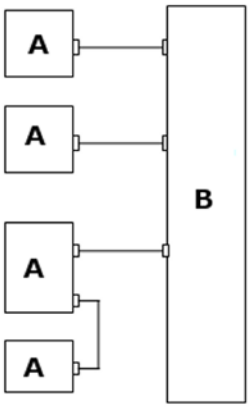
For the purposes of Part 8, all Ethernet ports of devices which are connected to the network shall work in accordance to:

— IEEE 802.3 10 Base-T, or

— IEEE 802.3 100 Base-Tx.

5.2 Network Structure

The general network structure (see figure below) is build up by end devices that are connected via switches.



Key

Box A End Device

Box B Switch

Figure 1 — Ethernet Structure

The following rules should be followed when installing an Ethernet network:

a) the maximum cable length between a switch and a device or between two switches shall not exceed 100m in the half-duplex mode, and

b) the number of connectors (Type 2, see Figure 4) in a cable between a switch and a device or between two switches shall not exceed six (6).

5.3 Cabling

The Ethernet cable used shall fulfil IEC 61156-6 category 5e requirements:

— It should be free from CFCs, halogen, silicone, and lead.

— The cable shall be arranged as a symmetric quad star and shall have suitable shielding for the installation environment (for example, with a primary shield of aluminium laminated foil, either with a copper drain wire or with a secondary braid of tinned copper wires).

— The cable impedance shall be 100 Ohms ± 15Ohms.

— The cross core section area shall be AWG22.

— The service temperature range shall be according to EN 50155 class TX.

— The cable shall conform to flame test requirements according to EN 50328.

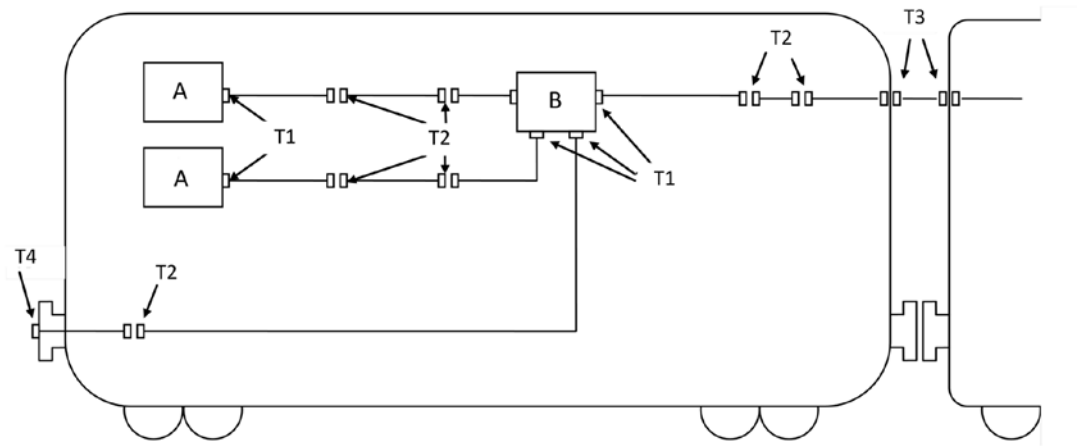
— The cable shall be oil resistant.

— Cables used in buses shall conform to flame test requirements according to ECE R118.

5.4 Connectors

5.4.1 General

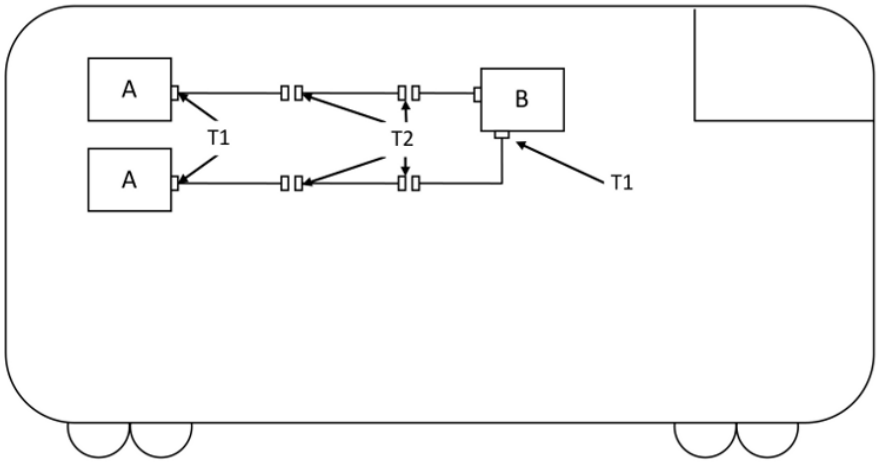
Within a vehicle there are different types of connectors. The figure below identifies type and location of the connectors.



Key

Box A	End Device
Box B	Switch
Connector T1	Type 1
Connector T2	Type 2
Connector T3	Type 3
Connector T4	Type 4

Figure 2 — Connector types within multiple car vehicles



Key

Box A	End Device
Box B	Switch
Connector T1	Type 1
Connector T2	Type 2

Figure 3 — Connector types within single car vehicles

Type 1 connections are used to connect cables to units like switches and end devices. These connectors are typically IP20/30 rated.

Type 2 connections are used in a network cable system within a car. Typical use is between walls. It is recommended avoid using Type 2. These connectors are typically IP20/30 rated.

Type 3 is a network coupling between carriages within a PT vehicle which is not disconnected in normal operation. These connectors may be up to IP65/67 rated.

Type 4 connection is a network connection between carriages within a PT vehicle which may be disconnected during normal operation. These connectors will normally be IP65/67 rated and shall be protected all the time by protection covers.

This section covers connectors of type 1 and 2 which are used in buses, trolleybuses and tramways. Type 3 and 4 connectors are used in coupled tramways and rail vehicles and are not specified in this Technical Specification: these are covered by IEC publications (in particular IEC 61375).

Types of connectors are not mandatory but the following connectors are preferred. When one of the following connectors is used in an application, the accompanying pin assignments shall be used.

5.4.2 Available Type 1/Type 2 Connectors

5.4.2.1 M12

M12 connectors of type 4-pin D-coded shall be used.

The male connector shall be used on cables to a device and the female connector shall be used on end devices and switches.

Pins and sockets in the M12 connector shall be gold plated.

Crimp cable connectors should be preferred.

Pin assignment of M12 circular socket connector:

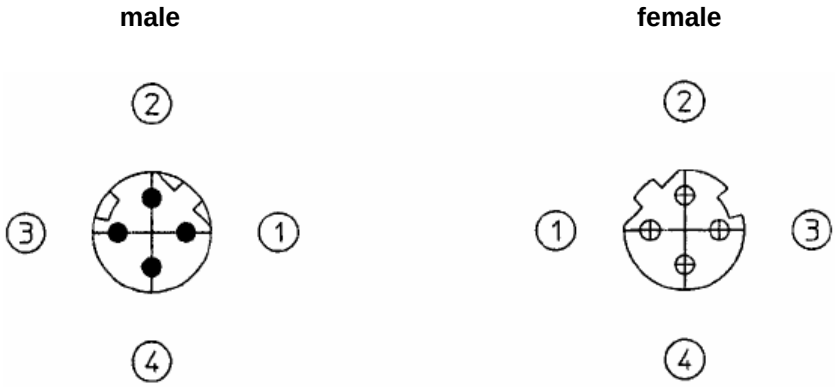


Figure 4 — M12-Connector pinning

The pin assignment for type 1 and 2 connectors is shown in the table below:

Table 1 — M12-Connector pin assignment including PoE for mode A

Pin #	Assignment	Optional Power over Ethernet
1	TX+	Power Side 1
2	RX+	Power Side 2
3	TX-	Power Side 1
4	RX-	Power Side 2

This is a mode A connection as defined by IEEE 802.3at.

5.4.2.2 RJ45

The RJ45 connector is not recommended for operational use in a vehicle. However if it is used it is strongly recommended that the cable is fixed close to the connector to minimise stress on the interconnection.

As a maintenance connector RJ45 is acceptable due to the standard nature of the connection and the infrequent use.

The RJ45 connector is defined in EN 60603-7-x.

5.4.3 Recommendation for connectors within a bus

For bus vehicles M12 connectors are recommended for Type 1 connections.

For bus vehicles no specific connectors are recommended for Type 2 connections. Such a connection should be avoided.

5.4.4 Recommendation for connectors within a light rail vehicle

5.4.4.1 General

For rail vehicles M12 connectors are recommended for Type 1 connections.

For rail vehicles, it is noted that current industry practice is to use proprietary “Quintax” connectors for Type 2 and Type 3 connections.

5.4.4.2 Connectors Summary

Table 2 — Connectors Summary

	Type1	Type2	Type3	Type4
Light rail	OK	OK	OK	OK
Buses	OK	NOK	OK	NOK

5.5 Switches

The Ethernet network is used to connect end devices within a PT vehicle or between carriages within a PT vehicle. End devices are interconnected by the use of switches that provide a certain number of connection ports for end devices.

All Ethernet ports of network switches shall work in accordance to both IEEE 802.3 10 Base T and IEEE 802.3 100 Base-Tx, and shall support full duplex communication.

The ports of the switch shall support auto sensing and should support auto crossing and auto polarity on all ports.

The switches shall provide a minimum of 2 available plugs. One of these plugs shall be dedicated to maintenance purposes and shall be identified as such.

There are a range of different switch performance levels and good design practice will need to take account of the system and services required. There is no mandatory specification on the switch network architecture – for example switch layers, switch QoS parameters, or the use of multiple switches included embedded switches. A system which uses specific functions may have more stringent requirements and Parts 7 and 9 of the EN 13149 series will highlight areas where this may be the case.

5.6 Power over Ethernet

If the switches support Power over Ethernet, they shall comply with the IEEE 802.3af or IEEE 802.3at standards. Within these standards, two modes exist, the mode A and B.

Mode A delivers power on the data pairs of 100 Base-Tx or 10 Base-T. In the case of this document, the mode A shall be applied in order to respect the pinning limitation of the M12 connector (see 5.4.2.1).

Mode B delivers power on extra wire pairs. In this case completely different layouts concerning the cables and plugs are needed. Mode B is not feasible with a normal M12 plug. This document provides no recommendations for this PoE mode.

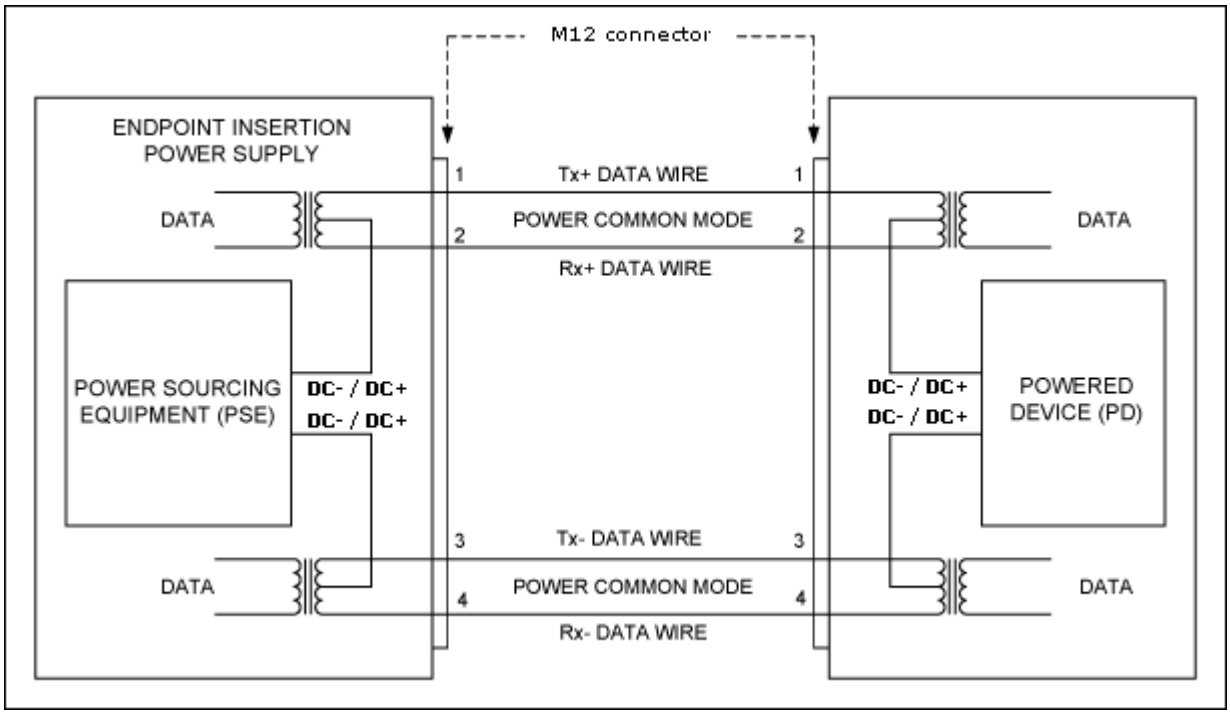


Figure 5 — Power over Ethernet in mode A with M12 connectors

The PoE pin assignment for type 1 and 2 connectors is shown in the table below (compare Table 2):

Table 3 — PoE pin assignment in mode A

Pin #	Assignment	Optional Power over Ethernet
1	TX+	DC-
2	RX+	DC+
3	TX-	DC-
4	RX-	DC+

This is a mode A connection as defined by 802.3af/t.

5.7 Shielding and Grounding

All Ethernet end devices and their Ethernet connector shells shall be equipotentially bonded to the (metal) vehicle body.

The Ethernet cable between two end devices, between an end device and a switch, and between two switches shall be continuously shielded from end device (or switch) to end device (or switch). This implies that the Ethernet cable shield is not interrupted even if it spans over adjacent vehicle bodies. Equipotential bonding between adjacent cars is consequently a demand. Actual implementation of the equipotential bonding shall follow common practice and regulations.

5.8 Additional test requirements

In rail applications it may be necessary to test against EN 50155.

Annex A
(informative)

EBSF normative reference

The table below has been compiled by the European Bus System of the Future (EBSF) project (June 2012). It is included to assist users in considering other aspects of a solution that need to be addressed.

Category	Procedure	Mandatory (minimum acceptable for EBSF)	EBSF Recommendation
Electrical	ISO 7637-2 ISO 16750-2	Level III Level E (10V/32V for supply voltage	
Climatic	ISO 16750-4 IEC 60068–2	Industrial Range	Levels F-C or H-G * Parts 1 Ae and 2 Be (T°C), 14 (T°C cycles), 78 (Damp Heat)
Mechanical	ISO 16750-3 IEC 60068–2	Level D	Level S Parts 27 (shocks), 64 (vibration), 32 (fall)
Protection degree against foreign objects, water and access	ISO 20653	IP40	IP5K2 or IP5K4K*
Chemical	ISO 16750-5	None	Level B
Electrostatic Discharge	ISO 10605	None	Level III
Electro Magnetic Compatibility	2009/19/EC(72/245/EC) ECE R10 revision 3	e-marking or E-marking	Bulk current injection up to 200 mA and field strength up to 200 V/m
Fire	ECE R118 UL94	E-marking or Level V0	
Radio electrical interferences	CISPR 25 2010/368/EC	None None	§6.4, level 4 x
* in case of a component with external part.			

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[1] ISO 7498:1984, *Information processing systems – Open systems Interconnection – Basic Reference Model*

[2] EN 61076-2-101, *Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors - Detail specification for M12 connectors with screw-locking (IEC 61076-2-101)*

[3] 72/245/EEC, *Bus EMC standard, E-marking*

[4] ISO 10605, *Road vehicles — Test methods for electrical disturbances from electrostatic discharge*

[5] ISO/IEC 11801, *Information technology — Generic cabling for customer premises*

[6] EN 55022, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement (CISPR 22)*

[7] EN 50238, *Railway applications – Compatibility between rolling stock and train detection systems*

[8] EN 50121-3-2, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

[9] EN 50265-2, *Common test methods for cables under fire conditions – Test for resistance to vertical flame propagation for a single insulated conductor or cable*

[10] EN 61375 (all parts), *Electronic railway equipment – Train communication network (TCN) (IEC 61375, all parts)*

[11] TIA/EIA 568, *Commercial Building Telecommunications Cabling Standard*

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