

DIN EN 61375-2-5

ICS 35.240.60

**Elektronische Betriebsmittel für Bahnen –
Zug-Kommunikations-Netzwerk (TCN) –
Teil 2-5: Ethernet Train Backbone
(IEC 61375-2-5:2014);
Englische Fassung EN 61375-2-5:2015**

Electronic railway equipment –
Train communication network (TCN) –
Part 2-5: Ethernet train backbone
(IEC 61375-2-5:2014);
English version EN 61375-2-5:2015

Matériel électronique ferroviaire –
Réseau embarqué de train (TCN) –
Partie 2-5: Réseau central de train Ethernet
(IEC 61375-2-5:2014);
Version anglaise EN 61375-2-5:2015

Gesamtumfang 132 Seiten

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE

Anwendungsbeginn

Anwendungsbeginn für die von CENELEC am 2014-09-29 angenommene Europäische Norm als DIN-Norm ist 2016-06-01.

Nationales Vorwort

Vorausgegangener Norm-Entwurf: E DIN EN 61375-2-5:2012-12.

Für dieses Dokument ist das nationale Arbeitsgremium UK 351.1 „Fahrzeuge“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (www.dke.de) zuständig.

Die enthaltene IEC-Publikation wurde vom TC 9 „Electrical equipment and systems for railways“ erarbeitet.

Das IEC-Komitee hat entschieden, dass der Inhalt dieser Publikation bis zu dem Datum (stability date) unverändert bleiben soll, das auf der IEC-Website unter „<http://webstore.iec.ch>“ zu dieser Publikation angegeben ist. Zu diesem Zeitpunkt wird entsprechend der Entscheidung des Komitees die Publikation

- bestätigt,
- zurückgezogen,
- durch eine Folgeausgabe ersetzt oder
- geändert.

Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf ein Dokument ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils aktuellste Ausgabe des in Bezug genommenen Dokuments.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe des Dokuments.

Der Zusammenhang der zitierten Dokumente mit den entsprechenden Deutschen Dokumenten ergibt sich, soweit ein Zusammenhang besteht, grundsätzlich über die Nummer der entsprechenden IEC-Publikation. Beispiel: IEC 60068 ist als EN 60068 als Europäische Norm durch CENELEC übernommen und als DIN EN 60068 ins Deutsche Normenwerk aufgenommen.

Das Präsidium des DIN hat mit Präsidialbeschluss 1/2004 festgelegt, dass DIN-Normen, deren Inhalt sich auf internationale Arbeitsergebnisse der Informationsverarbeitung gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für die vorliegende Norm erfüllt.

Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird die Englische Fassung der EN 61375-2-5 veröffentlicht. Zu deren Einleitung, deren Abschnitt 1, der den Anwendungsbereich festlegt, und deren Abschnitt 3, der die Begriffe festlegt, wurde eine Übersetzung angefertigt und als Nationaler Anhang NA der vorliegenden Norm hinzugefügt. Für viele der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Diese Norm steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

Nationaler Anhang NA (informativ)

Einleitung^{N1)}

DIN EN 61375-2-5 definiert den Ethernet Train Backbone zur Gewährleistung der Interoperabilität zwischen verschiedenartigen, innerhalb eines Zugverbands gekuppelten Consists.

^{N1)} Die Gliederung(s)-Nummerierung) der IEC 61375-2-5 wurde beibehalten.

Die Norm folgt dem ISO-OSI-Modell und spezifiziert alle Protokollschichten von der Bitübertragungs- bis zur Anwendungsschicht.

Ein Konformitätserklärungsformular zur Protokollimplementierung (PICS) gestattet es Zulieferern, ihre Konformität zu dieser Norm zu erklären. Die Spezifikation des PICS-Formulars und der zugehörige Konformitätstest sind nicht Gegenstand dieser Norm.

1 Anwendungsbereich

Dieser Teil der Reihe DIN EN 61375 definiert die Anforderungen des Ethernet Train Backbone (ETB) für ein auf der Ethernet-Technologie basierendes Kommunikationssystem in freigebildeten Zügen.

Die Beachtung dieser Norm gewährleistet die Interoperabilität zwischen lokalen Consist-Subnetzen unabhängig von der Technologie dieser Consist-Subnetze (siehe DIN EN 61375-1 für weitere Details).

Zur Wahrung der Interoperabilität sollten alle Definitionen von Consist-Netzwerken diese Norm berücksichtigen.

Diese Norm kann zusätzlich auch für Triebzüge und Mehrfachtraktionen gelten, wenn dies zwischen Käufer und Lieferant vereinbart wurde.

2 Normative Verweisungen

Die folgenden zitierten Dokumente, die in diesem Dokument teilweise oder als Ganzes zitiert werden, sind für die Anwendung dieses Dokuments erforderlich. Bei datierten Verweisungen gilt nur die in Bezug genommene Ausgabe. Bei undatierten Verweisungen gilt die letzte Ausgabe des in Bezug genommenen Dokuments (einschließlich aller Änderungen).

IEC 61076-2-101:2012, *Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors – Detail specification for M12 connectors with screw-locking*

IEC 61156 (alle Teile), *Multicore and symmetrical pair/quad cables for digital communications*

IEC 61156-1:2007, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61156-5, *Multicore and symmetrical pair/quad cables for digital communications – Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring – Sectional specification*

IEC 61375-1:2012, *Electronic railway equipment – Train communication network (TCN) – Part 1: General architecture*

IEC 61375-2-3, *Electronic railway equipment – Train communication network (TCN) – Part 2-3: TCN communication profile (to be published)*

IEC 61375-3-4, *Electronic railway equipment – Train communication network (TCN) – Part 3-4: Ethernet Consist Network (ECN)*

IEC 62236-3-2, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

ISO/IEC 7498 (alle Teile), *Information technology – Open System Interconnection – Basic Reference Model*

ISO/IEC 8824 (alle Teile), *Information technology – Abstract Syntax Notation One (ASN.1)*

ISO/IEC 9646 (alle Teile), *Information technology – Open Systems Interconnection – Conformance testing methodology and framework*

ISO/IEC 11801:2002, *Information technology – Generic cabling for customer premises*

IEEE 802.1AB, *IEEE Standard for Local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*

IEEE 802.1AX:2008, *IEEE Standard for Local and metropolitan area networks – Link Aggregation*

IEEE 802.1D:2012, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges*

IEEE 802.1Q, *IEEE Standard for Local and metropolitan area networks – Virtual Bridged Local Area Networks*

IEEE 802.2, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical Link Control*

IEEE 802.3:2012, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

3 Begriffe, Symbole, Abkürzungen und Konventionen

3.1 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

3.1.1

Anwendungsebene

(en: application layer)

oberste Ebene im OSI-Modell mit direkter Verbindung zur Anwendung

3.1.2

Anwendungsprozess

(en: application process)

Element in einem realen offenen System, welches die Informationsverarbeitung für eine bestimmte Anwendung ausführt

3.1.3

Bridge

(en: bridge)

Gerät, welches Frames zwischenspeichert und auf der Grundlage der Link-Layer-Adressen von einem Bus zum anderen weiterleitet

3.1.4

Broadcast

(en: broadcast)

nahezu zeitgleiche Übertragung derselben Information an mehrere Ziele

Anmerkung 1 zum Begriff: Übertragung wird im TCN als nicht zuverlässig angesehen, d. h. einige Ziele können die Informationen empfangen und andere nicht.

3.1.5

Bus

(en: bus)

Kommunikationsmedium, welches dieselben Informationen nahezu zeitgleich an alle angeschlossenen Teilnehmer sendet und damit allen Geräten, zumindest zur Steuerung des Buszugriffs, eine gleiche Sicht des Buszustandes ermöglicht

3.1.6

Triebzug

(en: closed train)

aus einem oder mehreren Consists zusammengestellter Zug, wobei sich die Zusammenstellung während des Normalbetriebs nicht ändert, zum Beispiel U-Bahn, Nahverkehrszüge oder Hochgeschwindigkeitszugeinheiten

3.1.7

Kommunikationsgeräte

(en: communication devices)

mit dem Consist-Netzwerk oder dem Zug-Backbone verbundene Geräte mit der Fähigkeit, Daten zu übertragen oder als Datenquelle oder Datensenke zu arbeiten

3.1.8

Komposition

(en: composition)

Anzahl und Eigenschaften der Fahrzeuge, die einen Zug bilden

3.1.9

Konfiguration

(en: configuration)

Bestimmung der Topologie eines Netzwerks, der damit verbundenen Geräte, ihrer Fähigkeiten und des von ihnen verursachten Datenverkehrs; im erweiterten Sinne das Laden der Geräte mit Konfigurationsinformationen vor Aufnahme des regulären Betriebs

3.1.10

Consist

Trainset

Fahrzeugverband

(en: consist

train set

rake of coaches)

einzelnes Fahrzeug oder Gruppe von Fahrzeugen, welche im Normalbetrieb nicht getrennt werden und kein, ein oder mehrere Consist-Netzwerke enthält

3.1.11

Consist-Netzwerk

CN

(en: consist network)

Kommunikationsnetzwerk, welches die Kommunikationsgeräte innerhalb eines Consists verbindet

3.1.12

Endgerät

ED

(en: end device)

mit einem Consist-Netzwerk verbundene oder aus Redundanzgründen mit einer Gruppe von Consist-Netzwerken verbundene Einheit

3.1.13

Endknoten

(en: end node)

Knoten, der den Zug-Backbone abschließt

3.1.14

Funktion

(en: function)

Anwendungsprozess, welcher Nachrichten mit einem anderen Anwendungsprozess austauscht

3.1.15

Gateway

(en: gateway)

Verbindung zwischen unterschiedlichen Kommunikationstechnologien

3.1.16

Gruppenadresse

(en: group address)

Adresse einer Multicast-Gruppe, zu der ein Gerät gehört

3.1.17**Host**

(en: host)

jegliche mit den Netzwerk verbundene adressierbare Einheit: Endgeräte, Netzwerkgeräte usw.

3.1.18**Zugtaufe**

(en: inauguration)

Vorgang, der im Fall einer Kompositionsänderung ausgeführt wird und allen Knoten des Zug-Backbones ihre Zug-Backbone Adresse, ihre Orientierung und Informationen bezüglich aller getauften Knoten am selben Backbone zuweist

3.1.19**Integrität**

(en: integrity)

Fähigkeit eines Systems, im Fall von Fehlfunktionen seiner Teile falsche Daten erkennen und abweisen zu können

3.1.20**Zwischenknoten**

(en: intermediate node)

Knoten, welcher die Kontinuität zwischen zwei mit ihm verbundenen Busabschnitten gewährleistet, diese jedoch nicht abschließt

3.1.21**Linientopologie**

(en: linear topology)

Topologie mit in Reihe verbundenen Knoten, wobei zwei Knoten mit jeweils nur einem anderen Knoten verbunden sind und alle anderen Knoten jeweils mit zwei anderen Knoten verbunden sind (d. h. verbunden in Form einer Linie)

3.1.22**lokales Netzwerk**

(en: local area network)

durch einen gemeinsamen Medienzugriffssteuerung und einen gemeinsamen Adressraum gekennzeichnete Teil eines Netzwerkes

3.1.23**Mediumzugriffssteuerung**

(en: medium access control)

Teil der Sicherungsschicht, welcher den Zugriff auf das Medium steuert (Arbitrierung, Busverwaltertransfer, Sendeaufforderung)

3.1.24**Medium**

(en: medium)

physischer Träger des Signals: elektrischer Draht, Lichtwellenleiter, usw.

3.1.25**Nachricht**

(en: message)

in einem oder mehreren Paketen übertragenes Datenelement

3.1.26**mobile adressierbare Zugeinheit**

(en: Mobile Train Unit)

Teil eines Zuges, welcher eindeutig vom Boden aus adressierbar sein muss. Eine mobile adressierbare Zugeinheit stellt ein aktives Kommunikations-Gateway für die Kommunikation vom Zug zum Boden bereit

3.1.27

Multicast

(en: multicast)

Übertragung der gleichen Nachricht an eine Gruppe von Empfängern, die durch ihre Gruppenadresse identifiziert sind

Anmerkung 1 zum Begriff: Der Begriff „Multicast“ wird auch verwendet, wenn die Gruppe alle Empfänger umfasst.

3.1.28

Netzwerk

(en: network)

Gruppe möglicherweise unterschiedlicher Kommunikationssysteme, welche Informationen in einer gemeinsam vereinbarten Weise austauschen

3.1.29

Netzwerkadresse

(en: network address)

Adresse zur Identifizierung eines Kommunikationsgerätes in der Vermittlungsschicht

3.1.30

Netzwerkgerät

ND

(en: network device)

Komponente zum Aufbau eines Consist-Netzwerks und eines Zugnetzwerks

Anmerkung 1 zum Begriff: Diese können passive Komponenten wie z. B. Kabel oder Verbinder sein, aktive nicht gesteuerte Komponenten, wie z. B. Repeater, Medienwandler oder (nicht gesteuerte) Switches, oder gesteuerte aktive Komponenten wie z. B. Gateways, Router und (nicht gesteuerte) Switches.

3.1.31

Vermittlungsschicht

(en: network layer)

für die Datenvermittlung zwischen unterschiedlichen Bussen verantwortliche Schicht des OSI-Modells

3.1.32

Netzwerk-Management

(en: network management)

notwendige Vorgänge zur ferngesteuerten Konfiguration, Überwachung, Diagnose und Wartung des Netzwerks

3.1.33

Knoten

(en: node)

Gerät am Zug-Backbone, welches als Gateway zwischen Zug-Backbone und Consist-Netzwerk arbeiten kann

3.1.34

freigebildeter Zug

(en: open train)

aus einem oder mehreren Consists zusammengestellter Zug, wobei sich die Konfiguration während des Bahnbetriebs ändern kann, z. B. internationale Züge

3.1.35

Betreiber

(en: operator)

Unternehmen oder Organisation, welche/s Züge betreibt

3.1.36**Paket**

(en: packet)

Einheit einer Nachricht (Information, Bestätigung oder Steuerung), die durch Protokolle auf der Vermittlungsschicht oder der Transportschicht übertragen wird

3.1.37**Empfänger**

(en: receiver)

elektronisches Gerät, welches Signale vom physikalischen Medium empfangen kann

3.1.38**Repeater**

(en: repeater)

Verbindungselement in der Bitübertragungsschicht zwischen den Busabschnitten, welches eine Verlängerung des Busses über die durch passive Elemente gesetzten Grenzen hinweg ermöglicht

Anmerkung 1 zum Begriff: Die verbundenen Abschnitte arbeiten mit gleicher Geschwindigkeit und mit gleichem Protokoll. Die durch den Repeater eingebrachte Verzögerung liegt im Bereich der Dauer eines Bits.

3.1.39**Router**

(en: router)

Verbindung von zwei Bussen in der Vermittlungsschicht, welche Datenpakete von einem Bus zu einem anderen auf der Grundlage ihrer Netzwerkadressen weiterleitet

3.1.40**Dienst**

(en: service)

einem Anwender bereitgestellte Fähigkeiten und Eigenschaften eines Teilsystems (z. B. eine Kommunikationsschicht)

3.1.41**Switch**

(en: switch)

in IEEE 802.1D definierte MAC-Bridge

3.1.42**Topologie**

(en: topology)

mögliche Kabelverbindungen und Geräteanzahl in einem gegebenen Netzwerk

3.1.43**Topographiezähler**

(en: topology counter)

Zähleinrichtung im Knoten, welche bei jeder Zugtaufe den CRC-Wert des Train Network Directory speichert

3.1.44**Zug-Kommunikations-Netzwerk**

(en: train communication network)

Daten-Kommunikations-Netzwerk zur Verbindung programmierbarer elektronischer Betriebsmittel an Bord von Bahnfahrzeugen

3.1.45**Zug-Backbone**

(en: train backbone)

Bus zur Verbindung der Fahrzeuge eines Zuges entsprechend den TCN-Protokollen

3.1.46

Zug-Backbone-Knoten

(en: train backbone node)

mit dem Zug-Backbone verbundenes Gerät, welches während der Zugtaufe eine Knotennummer erhält. Ein Zug-Backbone-Knoten kann zur Verbindung eines Endgerätes oder eines Consist-Netzwerkes mit dem Zug-Backbone verwendet werden.

3.1.47

Zug-Backbone-Knotennummer

Knotenadresse

Knotennummer

(en: train backbone node number

node address

node number)

jedem aktiven Zug-Backbone Knoten wird während der Zugtaufe eine Nummer zugewiesen, welche die Position des Zug-Backbone-Knotens am Zug-Backbone anzeigt

3.1.48

Transportschicht

(en: transport layer)

für die Steuerung des Ende-zu-Ende-Flusses und für die Behandlung von Fehlern zuständige Schicht des OSI-Modells

3.2 Symbole und Abkürzungen

CAN	Controller Area Network
CCTV	Videoüberwachungsanlage
CIDR	Classless Inter Domain Routing
CN	Consist-Netzwerk
CRC	zyklische Redundanzprüfung
CSTINFO	Consist Information
CstUUID	universeller und eindeutiger Consist Identifier
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
ECN	Ethernet-Consist-Netzwerk
ED	Endgerät
EMC	elektromagnetische Kompatibilität
ETB	Ethernet-Zug-Backbone
ETBN	Ethernet-Zug-Backbone-Knoten
FLR	Frame-Verlustrate
FQDN	vollständiger Domänenname (en: Fully Qualified Domain Name)
IEEE	Institut für Elektrotechnik- und Elektronik-Ingenieure
IETF	Arbeitsgruppe für Internettechnik (en: Internet Engineering Task Force)
IP	Internetprotokoll
LACP	Link-Aggregationssteuerungsprotokoll
LAG	Link-Aggregationsgruppe
LLDP	Link Layer Discovery-Protokoll
LLDPDU	LLDP Datenpaket
MAC	Medienzugriffssteuerung
MCG	mobiles Kommunikationsgateway

MDI	medienabhängige Schnittstelle
MTU	maximale Übertragungseinheit
MVB	Multifunktions-Fahrzeugbus
NAT	Netzwerkadressübersetzung
ND	Netzwerkgerät
NTP	Netzwerk-Zeitprotokoll
OSI	offenes Kommunikationssystem
PCS	Unterschicht zur Bitübertragungskodierung
PD	spannungsversorgtes Gerät (bei PoE)
PD/MD	Prozessdaten/Nachrichtendaten
PICS	Konformitätserklärung zur Protokollimplementierung
PMA	physikalischer Medienzugang
PMD	abhängig vom physikalischen Medium
PoE	Power over Ethernet
PSE	spannungsversorgendes Gerät (bei PoE)
RFC	Request For Comments
TBN	Zug-Backbone-Knoten
TCMS	Zug-Steuer- und Überwachungssystem
TCN	Zug-Kommunikations-Netzwerk
TCP	Übertragungssteuerungsprotokoll
TLV	Typ/Länge/Wert
TNDir	Zugnetzwerkverzeichnis
TTDP	Train Topology Discovery-Protokoll
UDP	User Datagram-Protokoll
UML	vereinheitlichte Modellierungssprache
VLAN	virtuelles lokales Netzwerk
WTB	drahtgebundener Zugbus
XML	Extensible Markup Language

3.3 Konventionen

3.3.1 Basis numerischer Werte

Diese Norm verwendet eine Dezimaldarstellung für alle numerischen Werte, falls nicht anderweitig angegeben.

Analoge Werte und Teilwerte enthalten ein Komma.

BEISPIEL: Die Spannung ist 20,0 V.

Binäre und hexadezimale Werte werden unter Verwendung der Konvention ASN.1 (ISO/IEC 8824-1) dargestellt.

BEISPIEL: Dezimal 20 kodiert auf 8 Bits = '0001 0100'B = '14'H.

3.3.2 Konventionen für Benennungen

Schlüsselworte beginnen mit einem Großbuchstaben.

Ist der Name des Schlüsselworts zusammengesetzt, werden die unterschiedlichen Teile des Namens durch ein Leerzeichen getrennt.

BEISPIEL „Zug Backbone“, „Consist“, „Consist Netzwerk“

Parameter werden mit einem Großbuchstaben am Anfang angegeben.

Ist der Name des Parameters zusammengesetzt, werden die unterschiedlichen Teile ohne Leerzeichen zusammengefügt und alle Teile beginnen mit einem Großbuchstaben.

BEISPIEL „NumberOfConsists“

3.3.3 Konventionen für Zustandsdiagramme

Die Darstellung von Zustandsdiagrammen folgt der Darstellungsart von UML-Zustandsmaschinen.

3.3.4 Darstellung von Datenstrukturen

Datenstrukturen werden entsprechend der ISO ASN.1-Syntax definiert. Eine in DIN EN 61375-2-1:2012, 6.4 „Presentation and encoding of transmitted and stored data“ definierte Erweiterung zu ASN.1 wird ebenfalls verwendet.

Alle Daten innerhalb einer Datenstruktur sind im Big-Endian-Format angeordnet (höchstwertigstes Oktett einen Datums zuerst).

English Version

**Electronic railway equipment - Train communication network
(TCN) - Part 2-5: Ethernet train backbone
(IEC 61375-2-5:2014)**

Matériel électronique ferroviaire - Réseau embarqué de
train (TCN) - Partie 2-5: Réseau central de train Ethernet
(IEC 61375-2-5:2014)

Elektronische Betriebsmittel für Bahnen - Zug-
Kommunikations-Netzwerk (TCN) - Teil 2-5: Ethernet Train
Backbone
(IEC 61375-2-5:2014)

This European Standard was approved by CENELEC on 2014-09-29. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

The text of document 9/1933/FDIS, future edition 1 of IEC 61375-2-5, prepared by IEC/TC 9 "Electrical equipment and systems for railways" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61375-2-5:2015.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2015-08-27
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2017-09-29

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61375-2-5:2014 was approved by CENELEC as a European Standard without any modification.

IEC 61375-2-1:2012	NOTE	Harmonized as EN 61375-2-1:2012.
IEC 61784-2	NOTE	Harmonized as EN 61784-2.
IEC 61918	NOTE	Harmonized as EN 61918.

CONTENTS

INTRODUCTION.....	8
1 Scope.....	9
2 Normative references	9
3 Terms, definitions, symbols, abbreviations and conventions	10
3.1 Terms and definitions	10
3.2 Symbols and abbreviations.....	14
3.3 Conventions.....	16
3.3.1 Base of numeric values	16
3.3.2 Naming conventions.....	16
3.3.3 State diagram conventions	16
3.3.4 Annotation of data structures.....	16
4 ETB physical layer	16
4.1 Train regions.....	16
4.2 Physical characteristics	17
4.2.1 General	17
4.2.2 Intra car physical layer	17
4.2.3 Inter car physical layer	19
4.2.4 Inter Consist physical layer	22
4.3 Power over Ethernet (PoE).....	25
4.4 ETB physical architecture and redundancy	27
4.4.1 General	27
4.4.2 Link aggregation architecture	27
4.4.3 Functions.....	29
5 ETB data link layer	30
6 ETB network layer: IPv4 subnets definition.....	31
6.1 General.....	31
6.2 IP mapping introduction.....	32
6.3 Topology.....	32
6.3.1 General	32
6.3.2 Closed train	33
6.4 Network IP address map	33
6.4.1 Global IPv4 address space.....	33
6.4.2 Train subnet definition.....	34
6.4.3 Train IP address map summary	38
6.4.4 Train IP group addresses (multicast)	38
6.5 Particular hosts IP addresses	39
6.5.1 ETBN (Ethernet Train Backbone Node).....	39
6.5.2 Hosts on train subnet	40
6.5.3 Host inside a closed train	41
6.6 Some use cases.....	43
6.7 Dynamic IP routing management	46
6.7.1 Unicast routes.....	46
6.7.2 Multicast routes	46
7 ETB Transport layer.....	48
8 ETB Train Inauguration: TTDP	48

8.1	Contents of this clause.....	48
8.2	Objectives and assumptions	48
8.2.1	Goals	48
8.2.2	Out of scope	49
8.2.3	Assumptions	49
8.3	ETBN settings.....	50
8.3.1	ETB switch port states	50
8.3.2	Node settings	51
8.4	General behaviour	52
8.5	ETBN Inauguration state diagram.....	52
8.5.1	General	52
8.5.2	Actions	53
8.5.3	Transitions.....	55
8.6	ETBN peers discovery.....	56
8.6.1	Internal peers detection	56
8.6.2	External peers detection	56
8.6.3	Switch port states handling	57
8.6.4	ETB lines statuses	57
8.7	TTDP messages description.....	59
8.7.1	General	59
8.7.2	Convention	59
8.7.3	TTDP frame tagging.....	59
8.7.4	Transport and addressing	59
8.7.5	TTDP HELLO frame	60
8.7.6	TTDP TOPOLOGY frame	65
8.8	TTDP data structures	71
8.8.1	Connectivity Vector.....	71
8.8.2	ETBN Vector.....	71
8.8.3	Connectivity Table	72
8.8.4	Connectivity Table CRC	73
8.8.5	Train network directory	73
8.8.6	Train network directory CRC (Topology Counter).....	75
8.8.7	Corrected topology	75
8.9	TTDP frames timing	76
8.9.1	TTDP HELLO.....	76
8.9.2	TTDP TOPOLOGY	79
8.10	Inauguration Train Application interface.....	80
8.11	Degraded modes.....	80
8.11.1	Late insertion ETBN.....	80
8.11.2	Losing ETBN	81
8.11.3	End ETBN failure and partial topology counter.....	81
8.12	Some discovery timing	82
8.12.1	ETBN wakeup.....	82
8.12.2	ETBN failure	83
8.12.3	Consist coupling	84
9	ETB ETBN redundancy.....	84
10	ETB physical train naming convention (optional)	86
10.1	General	86

10.2	ETB Train domain	86
10.3	Hostname	87
11	ETB Quality of Service.....	87
11.1	Contents of this clause	87
11.2	Frame forwarding	87
11.2.1	ETBN switching rate.....	87
11.2.2	No Head-of-Line blocking	87
11.2.3	Switching priorities.....	87
11.2.4	Switching queuing scheme	88
11.3	Priority of Inauguration frames.....	88
11.4	ETB ingress rate limiting	89
11.5	ETB egress rate shaping	89
11.6	ETB data classes	89
12	ETB Management and monitoring	89
13	ETB Application interface.....	90
13.1	Contents of this clause	90
13.2	Abstract communication model	90
13.3	ETB Process Data and Message Data protocols	90
13.4	ETB protocol transparency	90
13.5	ETBN interfaces.....	91
13.5.1	Application.....	91
13.5.2	Maintenance and monitoring.....	91
14	ETB conformity statement.....	92
	Annex A (normative) Summary of ETB sizing parameters	93
	Annex B (normative) Physical topology building algorithm.....	94
	Annex C (normative) TTDP MIB definition	97
	Bibliography	117
	Annex ZA (normative) Normative references to international publications with their corresponding European publications.....	118
	Annex ZZ (informative) Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC	120
	Figure 1 – ETB train regions	17
	Figure 2 – ETB Inter car at same potential.....	21
	Figure 3 – ETB Inter car not at the same potential	22
	Figure 4 – ETB Consist reversing	24
	Figure 5 – ETB Inter Consist segment	25
	Figure 6 – ETBN PSE PoE use case	25
	Figure 7 – ETBN PD PoE use case	26
	Figure 8 – PoE in inter-Consist	26
	Figure 9 – PoE PSE alternative A.....	27
	Figure 10 – Redundant train backbone architecture	27
	Figure 11 – Link aggregation model	28
	Figure 12 – Link aggregation group	29
	Figure 13 – Conversations over LAG.....	29
	Figure 14 – Hierarchical Consist topology.....	32

Figure 15 – Closed train	33
Figure 16 – "Subnet Id" with single Consist Network.....	35
Figure 17 – "Subnet Id" with two single Consist Networks	36
Figure 18 – Multiple Consist Networks, without fault tolerance	36
Figure 19 – "Subnet Id" with ETBN redundancy	37
Figure 20 – "Subnet Id" in multiple units with ETBN redundancy	37
Figure 21 – IP train address space summary	38
Figure 22 – Relative addressing example	43
Figure 23 – Train composed of a single Consist Network	44
Figure 24 – Train composed of two single Consist Networks	44
Figure 25 – Train composed of single Consist Network with ETBN redundancy	45
Figure 26 – Train composed of two Consist Networks with ETBN redundancy	45
Figure 27 – Train with two Consist Networks in single Consist	46
Figure 28 – ETBN top node reference	49
Figure 29 – ETBN orientation capability	50
Figure 30 – ETB switch in passive bypass setting.....	51
Figure 31 – ETB switch in intermediate setting	51
Figure 32 – ETB switch in End Node Setting	52
Figure 33 – ETBN Inauguration state diagram	53
Figure 34 – Switch port state diagram	57
Figure 35 – ETBN physical line state machine.....	58
Figure 36 – TTDP HELLO frame LLDPDU structure.....	60
Figure 37 – LLDP organizationally TLV structure	60
Figure 38 – TTDP HELLO frame structure	64
Figure 39 – TTDP specific HELLO TLV structure	64
Figure 40 – TTDP TOPOLOGY frame structure	69
Figure 41 – TTDP TOPOLOGY specific ETB TLV structure	70
Figure 42 – TTDP TOPOLOGY specific CN TLV structure.....	70
Figure 43 – Train composition for TNDiir example	74
Figure 44 – TTDP HELLO normal mode and recovery timing.....	77
Figure 45 – TTDP HELLO failure timing.....	78
Figure 46 – TTDP TOPOLOGY frames handling	79
Figure 47 – TTDP ETBNs wake up timing.....	82
Figure 48 – TTDP ETBN failure timing.....	83
Figure 49 – TTDP Consist coupling timing.....	84
Figure 50 – Example of ETBN IP routing table without redundancy	85
Figure 51 – Example of ETBN IP routing table with redundancy.....	85
Figure 52 – ETB train domain definition	86
Figure 53 – Abstract communication model for ETB communication	90
Figure B.1 – Physical topology building.....	94
Figure C.1 – TTDP MIB tree view.....	99

Table 1 – ETB Intra car physical layer interface	17
Table 2 – ETB Inter car physical layer interface	19
Table 3 – ETB Inter consist physical layer interface	23
Table 4 – ETB Switch data link layer interface	30
Table 5 – ETB OSI Network layer	31
Table 6 – Train subnet definition	34
Table 7 – Train subnet decomposition	34
Table 8 – Train IP group addresses reserved range	39
Table 9 – ETBN ETB IP address	40
Table 10 – Hosts IP on train subnet	41
Table 11 – Application ED common interface	48
Table 12 – ETB switch port states	50
Table 13 – TTDP destination MAC addresses	60
Table 14 – Connectivity Vector	71
Table 15 – Connectivity Vector Fields	71
Table 16 – ETBN Vector	71
Table 17 – ETBN Vector Fields	71
Table 18 – Connectivity Table	72
Table 19 – Connectivity Table fields	72
Table 20 – Train network directory	73
Table 21 – Train network directory fields	73
Table 22 – Train network directory (example)	75
Table 23 – DSCP field mapping	88
Table 24 – ETB Switching Priorities	88
Table 25 – Train Topology Discovery Object	91
Table A.1 – ETB sizing parameters	93

INTRODUCTION

IEC 61375-2-5 defines the Ethernet Train Backbone so as to achieve interoperability between Consists of different types when coupled in the same train composition.

The standard follows the ISO-OSI model and specifies the whole protocols stack from the physical layer up to the application layer.

A Protocol Implementation Conformance Statement (PICS) pro-forma allows suppliers to state their conformity to this standard. The PICS pro-forma specification and the related conformity test are not in the scope of this standard.

ELECTRONIC RAILWAY EQUIPMENT – TRAIN COMMUNICATION NETWORK (TCN) –

Part 2-5: Ethernet train backbone

1 Scope

This part of IEC 61375 defines Ethernet Train Backbone (ETB) requirements to fulfil open train data communication system based on Ethernet technology.

Respect of this standard ensures interoperability between local Consist subnets whatever Consist network technology (see IEC 61375-1 for more details).

All Consist network definitions should take into account this standard to preserve interoperability.

This standard may be additionally applicable to closed trains and multiple-unit trains when so agreed between purchaser and supplier.

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.

IEC 61076-2-101:2012, *Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors – Detail specification for M12 connectors with screw-locking*

IEC 61156 (all parts), *Multicore and symmetrical pair/quad cables for digital communications*

IEC 61156-1:2007, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61156-5, *Multicore and symmetrical pair/quad cables for digital communications – Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring – Sectional specification*

IEC 61375-1:2012, *Electronic railway equipment – Train communication network (TCN) – Part 1: General architecture*

IEC 61375-2-3, *Electronic railway equipment – Train communication network (TCN) – Part 2-3: TCN communication profile (to be published)*

IEC 61375-3-4, *Electronic railway equipment – Train communication network (TCN) – Part 3-4: Ethernet Consist Network (ECN)*

IEC 62236-3-2, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

ISO/IEC 7498 (all parts), *Information technology – Open System Interconnection – Basic Reference Model*

ISO/IEC 8824 (all parts), *Information technology – Abstract Syntax Notation One (ASN.1)*

ISO/IEC 9646 (all parts), *Information technology – Open Systems Interconnection – Conformance testing methodology and framework*

ISO/IEC 11801:2002, *Information technology – Generic cabling for customer premises*

IEEE 802.1AB, *IEEE Standard for Local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*

IEEE 802.1AX:2008, *IEEE Standard for Local and metropolitan area networks – Link Aggregation*

IEEE 802.1D:2012, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges*

IEEE 802.1Q, *IEEE Standard for Local and metropolitan area networks – Virtual Bridged Local Area Networks*

IEEE 802.2, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical Link Control*

IEEE 802.3:2012, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

3 Terms, definitions, symbols, abbreviations and conventions

3.1 Terms and definitions

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

3.1.1

application layer

upper layer in the OSI model, interfacing directly to the Application

3.1.2

application process

element within a real open system which performs the information processing for a particular application

3.1.3

bridge

device which stores and forwards frames from one bus to another on the base of their Link Layer addresses

3.1.4

broadcast

nearly simultaneous transmission of the same information to several destinations

Note 1 to entry: Broadcast in the TCN is not considered reliable, i.e. some destinations may receive the information and others not.

3.1.5

bus

communication medium which broadcasts the same information to all attached participants at nearly the same time, allowing all devices to obtain the same sight of its state, at least for the purpose of arbitration

3.1.6

closed train

train composed of one or a set of Consists, where the configuration does not change during normal operation, for instance metro, sub-urban train, or high speed train units

3.1.7

communication devices

devices connected to Consist Network or Train Backbone with the ability to source and sink data

3.1.8

composition

number and characteristics of the vehicles forming a train

3.1.9

configuration

definition of the topology of a network, the devices connected to it, their capabilities and the traffic they produce; by extension, the operation of loading the devices with the configuration information before going to regular operation

3.1.10

consist

train set

rake of coaches

single vehicle or a group of vehicles which are not separated during normal operation. A Consist contains no, one or several Consist networks.

3.1.11

Consist Network

CN

communication network interconnecting communication devices in one Consist

3.1.12

End Device

ED

unit connected to one Consist Network or to one set of Consist Networks prepared for redundancy reasons

3.1.13

end node

node which terminates the Train Backbone

3.1.14

function

Application Process which exchanges messages with another Application Process

3.1.15

gateway

connection between different communication technologies

3.1.16

group address

address of a multicast group to which a device belongs

3.1.17

host

any addressable unit connected to the network: End Devices, Network Devices, etc.

3.1.18

inauguration

operation executed in case of composition change, which gives all Nodes of the Train Backbone their Train Backbone address, their orientation and information about all named Nodes on the same backbone

3.1.19

integrity

property of a system to recognize and to reject wrong data in case of malfunction of its parts

3.1.20

intermediate node

node which establishes continuity between two bus sections connected to it, but does not terminate them

3.1.21

linear topology

topology where the nodes are connected in series, with two nodes each connected to only one other node and all others each connected to two other nodes (that is, connected in the shape of a line)

3.1.22

Local Area Network

part of a network characterized by a common medium access and address space

3.1.23

Medium Access Control

sublayer of the Link Layer, which controls the access to the medium (arbitration, mastership transfer, polling)

3.1.24

medium

physical carrier of the signal: electrical wires, optical fibers, etc.

3.1.25

message

data item transmitted in one or several packets

3.1.26

Mobile Train Unit

part of a train which shall be uniquely addressable from ground. A mobile train unit provides one active mobile communication gateway for train to ground communication.

3.1.27

multicast

transmission of the same message to a group of receivers, identified by their Group Address

Note 1 to entry: The word "multicast" is used even if the group includes all receivers.

3.1.28

network

set of possibly different communication systems which interchange information in a commonly agreed way

3.1.29

network address

address which identifies a communication device on network layer

3.1.30
network device
ND

components used to set up Consist Networks and Train Networks

Note 1 to entry: These may be passive components such as cables or connectors, active unmanaged components such as repeaters, media converters or (unmanaged) switches, or active managed components such as gateways, routers and (managed) switches.

3.1.31
network layer

layer in the OSI model responsible for routing between different busses

3.1.32
network management

operations necessary to remotely configure, monitor, diagnose and maintain the network

3.1.33
node

device on the Train Backbone, which may act as a gateway between Train Backbone and Consist Network

3.1.34
open train

train composed of a set of Consists, where the configuration may change during operation, for instance international trains

3.1.35
operator

enterprise or organization which operates trains

3.1.36
packet

unit of a message (information, acknowledgement or control) transmitted by protocols on network or transport layer

3.1.37
receiver

electronic device which may receive signals from the physical medium

3.1.38
repeater

connection at the Physical Layer between bus segments, providing an extension of the bus beyond the limits permitted by passive means

Note 1 to entry: The connected segments operate at the same speed and with the same protocol. The delay introduced by a repeater is in the order of one bit duration.

3.1.39
router

connection between two busses at the Network Layer, which forwards datagrams from one bus to another on the base of their Network Address

3.1.40
service

capabilities and features of a sub-system (e.g. a communication layer) provided to a user

3.1.41

switch

MAC bridge as defined in IEEE 802.1D

3.1.42

topology

possible cable interconnection and number of devices a given network supports

3.1.43

topology counter

counter in a node which at each Inauguration memorises CRC of Train Network Directory

3.1.44

train communication network

data communication network for connecting programmable electronic equipment on-board rail vehicles

3.1.45

train backbone

bus connecting the vehicles of a train and which conforms to the TCN protocols

3.1.46

train backbone node

node device on the Train Backbone which receives a train backbone node number during Inauguration. A train backbone node can be used to connect an End Device or a Consist Network to the Train Backbone.

3.1.47

train backbone node number

node address

node number

each active train backbone node is assigned a number during Inauguration, which indicates the position of the train backbone node on the Train Backbone

3.1.48

transport layer

layer of the OSI model responsible for end-to-end flow control and error recovery

3.2 Symbols and abbreviations

CAN	Controller Area Network
CCTV	Closed Circuit Television
CIDR	Classless Inter Domain Routing
CN	Consist Network
CRC	Cyclic Redundancy Check
CSTINFO	ConSisT INfOrmation
CstUUID	Consist Universally Unique IDentifier
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
ECN	Ethernet Consist Network
ED	End Device
EMC	Electro Magnetic Compatibility
ETB	Ethernet Train Backbone

ETBN	Ethernet Train Backbone Node
FLR	Frame Loss Rate
FQDN	Fully Qualified Domain Name
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
LACP	Link Aggregation Control Protocol
LAG	Link Aggregation Group
LLDP	Link Layer Discovery Protocol
LLDPDU	LLDP Data Unit
MAC	Medium Access Control
MCG	Mobile Communication Gateway
MDI	Media Dependent Interface
MTU	Maximum Transmission Unit
MVB	Multifunction Vehicle Bus
NAT	Network Address Translation
ND	Network Device
NTP	Network Time Protocol
OSI	Open System Interconnection
PCS	Physical Coding Sublayer
PD	Powered Device (about PoE)
PD/MD	Process Data/Message Data
PICS	Protocol Implementation Conformance Statement
PMA	Physical Medium Attachment
PMD	Physical Medium Dependent
PoE	Power Over Ethernet
PSE	Power Source Equipment (about PoE)
RFC	Request For Comments
TBN	Train Backbone Node
TCMS	Train Control and Monitoring System
TCN	Train Communication Network
TCP	Transport Control Protocol
TLV	Type/Length/Value
TNDir	Train Network Directory
TTDP	Train Topology Discovery Protocol
UDP	User Data protocol
UML	Unified Modeling Language
VLAN	Virtual Local Area Network
WTB	Wire Train Bus
XML	eXtensible Markup Language

3.3 Conventions

3.3.1 Base of numeric values

This standard uses a decimal representation for all numeric values unless otherwise noted.

Analog and fractional values include a comma.

EXAMPLE The voltage is 20,0 V.

Binary and hexadecimal values are represented using the ASN.1 (ISO/IEC 8824) convention.

EXAMPLE Decimal 20 coded on 8 bits = '0001 0100'B = '14'H.

3.3.2 Naming conventions

Keywords are written with a capital letter at the beginning.

If the keyword name is composed, the different parts of the name are united with a space, and all parts begin with a capital letter.

EXAMPLES "Train Backbone", "Consist", "Consist Network".

Parameters are written with a capital letter at the beginning.

If the parameter name is composed, the different parts of the name are united without a space, and all parts begin with a capital letter.

EXAMPLE "NumberOfConsists".

3.3.3 State diagram conventions

State diagrams are defined following the notation of UML state machines.

3.3.4 Annotation of data structures

Data structures are defined following ISO ASN.1 syntax. A superset of ASN.1 defined in IEC 61375-2-1:2012, 6.4 "Presentation and encoding of transmitted and stored data" is also used.

All data within a data structure are organized in big-endian format (most significant octet of a data item first).

4 ETB physical layer

4.1 Train regions

ETB use physical lines along the train to connect the active network devices together (ETBN, Repeater, etc.). These lines are also called physical segments, and shall use passive components such as cables and connectors, dedicated to Ethernet.

Along the train, three regions shall be distinguished for the ETB network (see Figure 1 below):

- **Intra Car:** Passive components (cabling) and active network devices inside a car (or locomotive, etc.).
- **Inter Car:** Passive components (cabling) at the interface between 2 cars. This category refers also to optional active network devices outside the car (such as under body, etc.).
- **Inter Consist:** Passive components (cabling) at the interface between 2 Consists using a manual coupler, or auto coupler. This category refers also to optional active network devices outside the car.

These regions are characterized by different train contexts and environments (mechanical, thermal, EMC, etc.). As a consequence, cabling (cables and connectors) are different on these 3 regions.

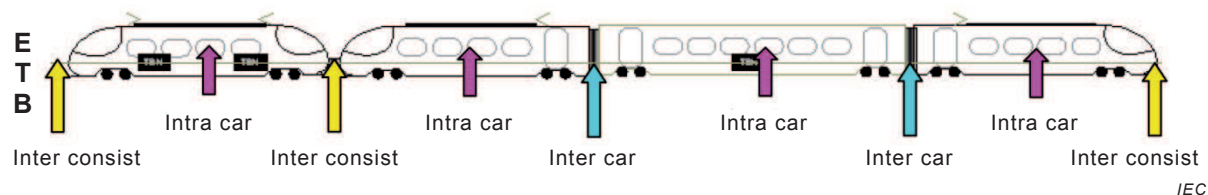


Figure 1 – ETB train regions

4.2 Physical characteristics

4.2.1 General

The following tables summarize network physical layer requirements for passive components (cables and connectors) and active network devices (ETBN, Repeater, etc.) depending on the 3 regions defined.

4.2.2 Intra car physical layer

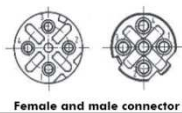
Table 1 below defines the physical layer requirements.

(M: Mandatory, O: Optional, C: Conditional, X: Prohibited)

Table 1 – ETB Intra car physical layer interface (1 of 2)

ETB Intra car physical layer interface			
OSI Layers	Requirements	Type	Description
Application	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clauses 24 and 25
Presentation			
Session			
Transport			
Network			
Data			
Physical	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28 Prohibited on the ETB backbone.
	Physical Layer crossover	M	Conformance to IEEE 802.3:2012, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN, etc.)
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	By-pass relay on ETBN ports	M	If ETB switch is out of order (e.g. powerless) train backbone ports are bypassed
	Power over Ethernet (PoE)	O	Conformance to IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported See 4.3 for more details

Table 1 (2 of 2)

ETB Intra car physical layer interface																							
OSI Layers	Requirements	Type	Description																				
	Connector for active Network Devices M12 D coded	M	Crimped contacts recommended Female connector on active network device, male connector on train cable Conformance to IEC 61076-2-101, which defines the pin out: <table><tr><th>Signal</th><th>Function</th><th>Cable wire colour</th><th>M12 D-coding contact number</th></tr><tr><td>TD+</td><td>Transmission Data +</td><td>Yellow</td><td>1</td></tr><tr><td>TD-</td><td>Transmission Data -</td><td>Orange</td><td>3</td></tr><tr><td>RD+</td><td>Receiver Data +</td><td>White</td><td>2</td></tr><tr><td>RD-</td><td>Receiver Data -</td><td>Blue</td><td>4</td></tr></table>  Female and male connector	Signal	Function	Cable wire colour	M12 D-coding contact number	TD+	Transmission Data +	Yellow	1	TD-	Transmission Data -	Orange	3	RD+	Receiver Data +	White	2	RD-	Receiver Data -	Blue	4
	Signal	Function	Cable wire colour	M12 D-coding contact number																			
	TD+	Transmission Data +	Yellow	1																			
TD-	Transmission Data -	Orange	3																				
RD+	Receiver Data +	White	2																				
RD-	Receiver Data -	Blue	4																				
Connector for interior cabling (between walls, cabinets, container, etc.)	O	Ethernet circular cell arranged in a quartet distribution. Pin out distribution identical to M12: TD+: Contact 1,TD-: Contact 3 RD+: Contact 2, RD-: Contact 4																					
Cables CAT5e	M	Conformance to ISO/IEC 11801 and IEC 61156-5 Two pairs shielded or unshielded: See screening practices ISO/IEC 11801:2002,Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible to connecting hardware																					
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002 • ;The Telecommunication outlet (TO) is the M12 instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.																				

It has to be noted that the number of connectors on an Ethernet physical segment and the length of the cable are not indicated in the table. Instead, a minimum requirement of electric performance and compliance to ISO/IEC 11801 is defined. It means that the electric parameters of a cabling depend not only on the number of connectors and the cable length, but also on some more complex parameters like shield, type of connectors, quality of cabling, installation, etc. As a consequence, it is proposed a global concept of verification in being compliant to the electric Ethernet parameters ISO/IEC 11801.

Inside a car, all shields of cables and connectors shall be connected to the mechanical earth of the car. To prevent EMC influences, a cable shield shall be connected on a 360° circular basis in the connector.

4.2.3 Inter car physical layer

4.2.3.1 General

Table 2 below defines the physical layer requirements.

(M: Mandatory, O: Optional, C: Conditional, X: Prohibited)

Table 2 – ETB Inter car physical layer interface (1 of 2)

ETB Inter car physical layer interface			
OSI Layers	Requirements	Type	Description
Application	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clauses 24 and 25
Presentation			
Session			
Transport			
Network			
Data			
Physical	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28. Prohibited on the ETB backbone
	Physical Layer crossover	M	Conformance to IEEE 802.3:2012, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN,etc.)
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	Power over Ethernet (PoE)	O	IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported. See 4.3 for more details.
	Connector for inter car	O	Specific connector different from M12 connector. Ethernet circular cell arranged in a quartet. Pin out distribution identical to M12: TD+: Contact 1,TD-: Contact 3 RD+: Contact 2, RD-: Contact 4
	Cables CAT5e	M	ISO/IEC 11801, IEC 61156 Shielded or unshielded: See screening practices ISO/IEC 11801:2002, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible to connecting hardware.

Table 2 (2 of 2)

ETB Inter car physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) includes cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002; The Telecommunication outlet (TO) is the inter-car connector instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002 Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

It has to be noted that the number of connectors on an Ethernet physical segment and the length of the cable are not indicated in the table. Instead, a minimum requirement of electric performance and compliance to ISO/IEC 11801 is defined. It means that the electric parameters of a cabling depend not only on the number of connectors and the cable length, but also on some more complex parameters like shield, type of connectors, quality of cabling, installation, etc. As a consequence, it is proposed a global concept of verification in being compliant to the electric Ethernet parameters ISO/IEC 11801.

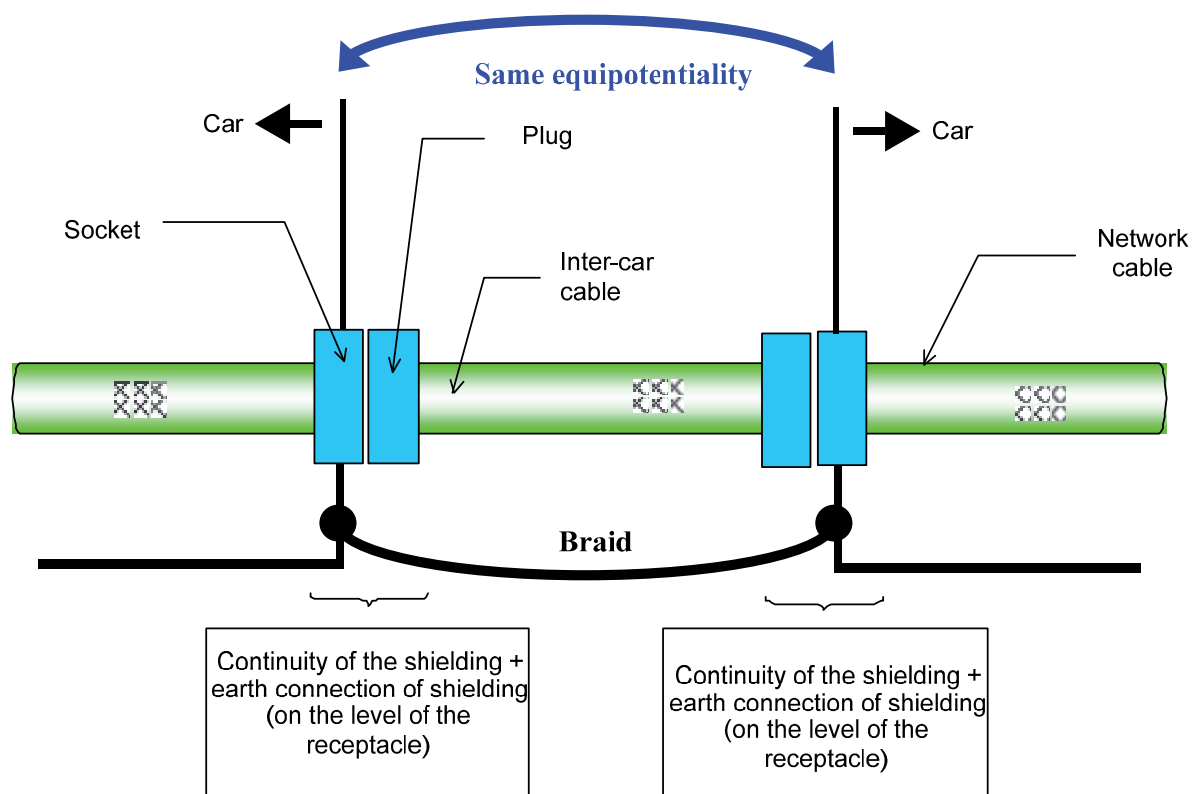
Two use cases have to be considered:

- The two adjacent cars are at the same potential.
- The two adjacent cars are at a different potential.

4.2.3.2 Inter Car at same potential

For information only:

A braid connects two adjacent cars which therefore are at the same potential. The Ethernet shield could have the continuity from car N to car N+1; in this case, no interruption of shielding is necessary (see Figure 2).



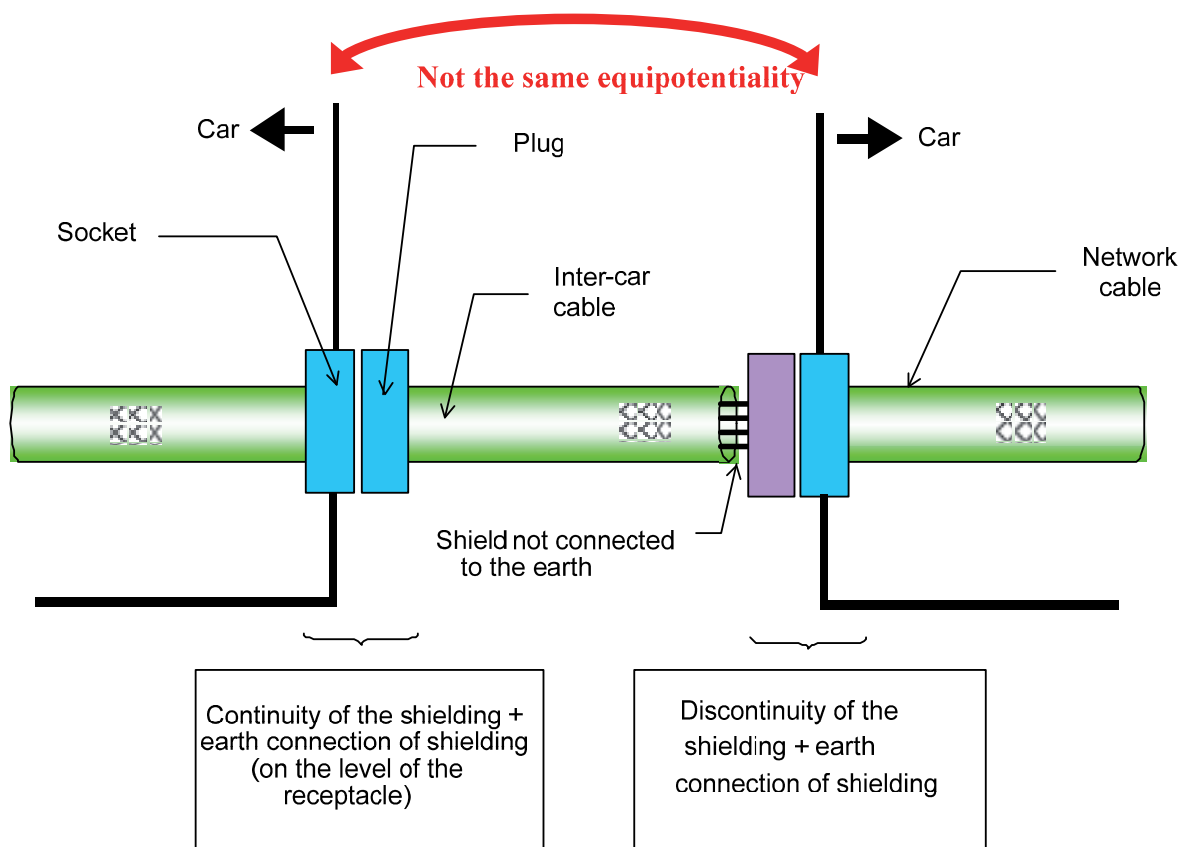
IEC

Figure 2 – ETB Inter car at same potential

4.2.3.3 Inter Car not at the same potential

For information only:

In some cases, the inter car cannot be at the same potential: Refurbishment, etc. Therefore, the Ethernet cable shield could be interrupted to avoid ground current flowing between cars (see Figure 3).



IEC

Figure 3 – ETB Inter car not at the same potential

NOTE The implementation of the shielding solution is not in the scope of this standard.

4.2.4 Inter Consist physical layer

Table 3 below defines the physical layer requirements.

(M: Mandatory, O: Optional, C: Conditional, X: Prohibited)

Table 3 – ETB Inter consist physical layer interface (1 of 2)

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
Application	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3, Clauses 24 and 25
Presentation			
Session			
Transport			
Network			
Data			
Physical	Full Duplex Mode	M	Conformance to IEEE 802.3, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3, Clause 28. Prohibited on the ETB backbone
	Physical Layer crossover	M	Conformance to IEEE 802.3, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN, etc.) Straight (MDI) on the male connector auto coupler side, crossover (MDI-X) on the female connector auto coupler side
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	Power over Ethernet (PoE)	O	IEEE 802.3, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported. See 4.3 for more details.
	Connector for inter Consist	O	Specific connector different from M12 connector. Ethernet circular cell arranged in a quartet. Pin out distribution identical to M12: TD+: Contact 1, TD-: Contact 3 RD+: Contact 2, RD-: Contact 4
	Cables CAT5e	M	ISO/IEC 11801, IEC 61156 Shielded or unshielded: See screening practices ISO/IEC 11801, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible with connecting hardware

Table 3 (2 of 2)

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) includes cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 • Connectors shall be compliant with Clause 10; The Telecommunication outlet (TO) is the inter-Consist connector instead of the RJ45 • Channel shall be compliant with Clause 6 Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.
	Consist orientation Reversing	C	Refers to the change of orientation of a Consist In order to provide Consists reversing capability, physical connection between two Consists requires two lines (see Figure 4 below).

It has to be noted that the number of connectors on a physical Ethernet segment and the length of the cable are not indicated in the table. Instead, a minimum requirement of electric performance and compliance to ISO/IEC 11801 is defined. It means that the electric parameters of a cabling depend not only on the number of connectors and the cable length, but also on some more complex parameters like shield, type of connectors, quality of cabling, installation, etc. As a consequence, it is proposed a global concept of verification in being compliant to the electric Ethernet parameters ISO/IEC 11801.

Figure 4 below illustrates the Consist reversing connection constraint: connectors shall be placed on Consist extremities with a central symmetry. When using male/female connectors, they shall be placed in an alternate / inversed way and be an even number.

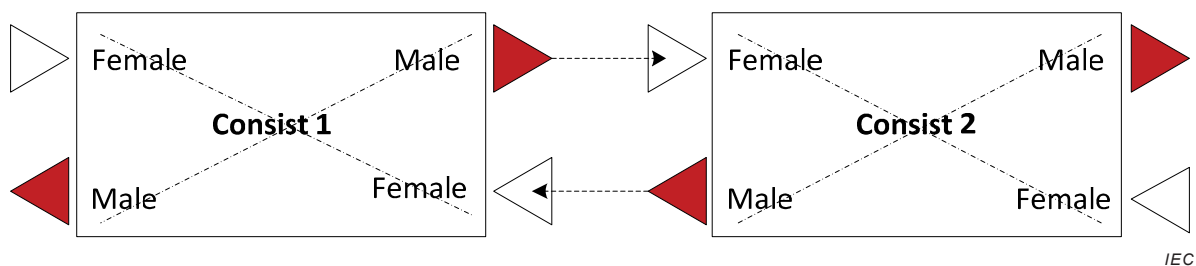
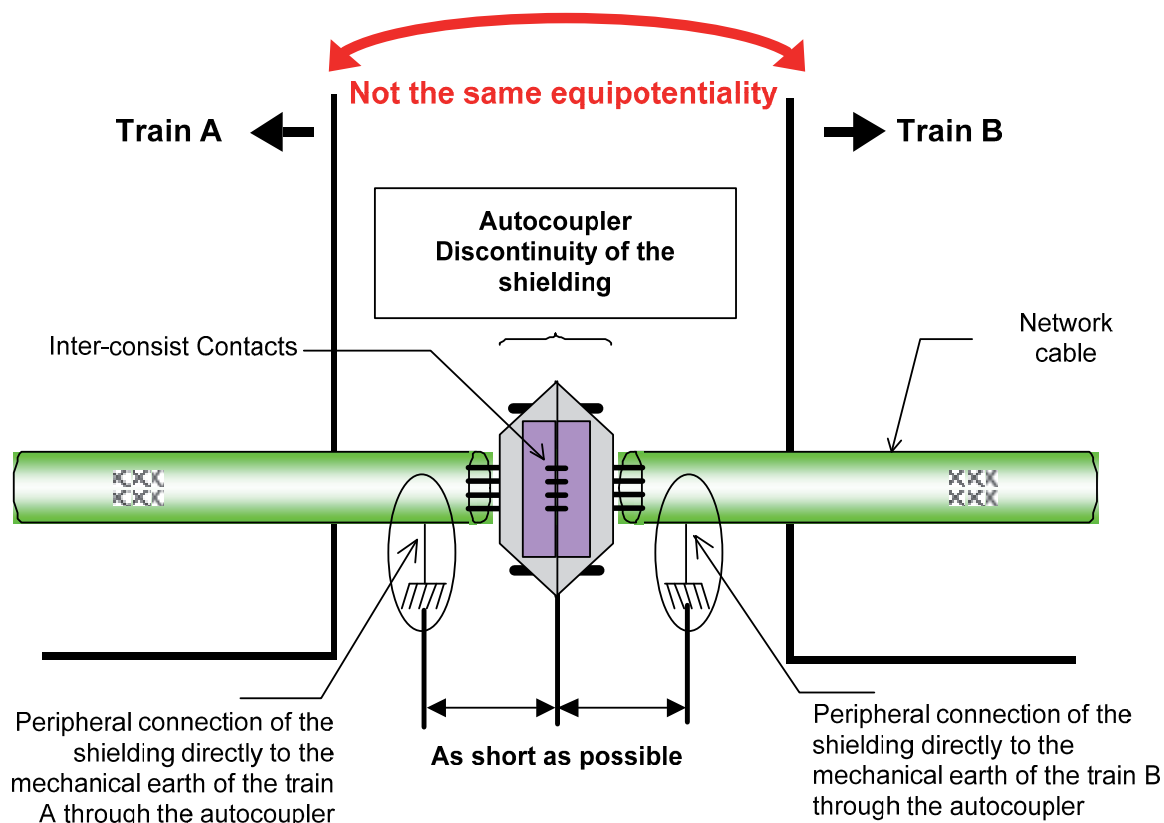


Figure 4 – ETB Consist reversing

For information only:

Typically, the same potential between 2 Consists cannot be ensured. In this case, the interruption of the Ethernet cable shield could be required (see Figure 5).



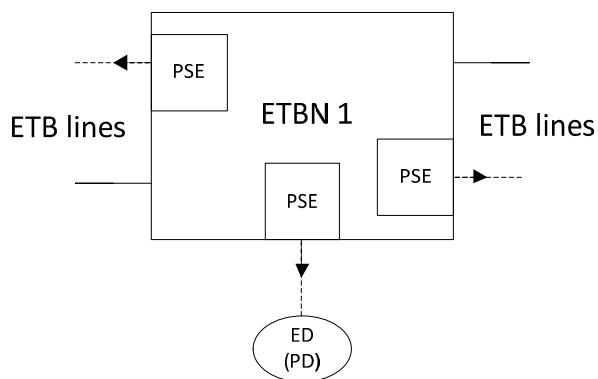
IEC

Figure 5 – ETB Inter Consist segment

NOTE The implementation of the shielding solution is not in the scope of this standard.

4.3 Power over Ethernet (PoE)

Figure 6 and Figure 7 give some use cases of PoE usage in ETBN:



IEC

Figure 6 – ETBN PSE PoE use case

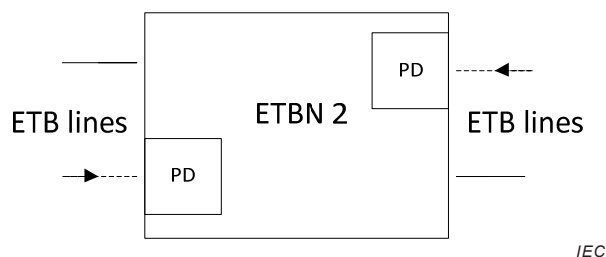


Figure 7 – ETBN PD PoE use case

In intra-car PoE could be used to power an ED (CCTV, etc.). The ND Ethernet port acts as a PSE (Power Source Equipment).

In inter-car and inter-Consist, PoE could be used to power a ND. A PSE interface shall be connected to a PD interface. In case of ETB link redundancy, PSE and PD interfaces shall be alternated in order to keep a symmetrical rotation of car (see Figure 8 below). PSE interfaces shall be associated with female connectors and PD interfaces shall be associated with male connectors if male/female connectors are used for inter-Consist interface (see Figure 4).

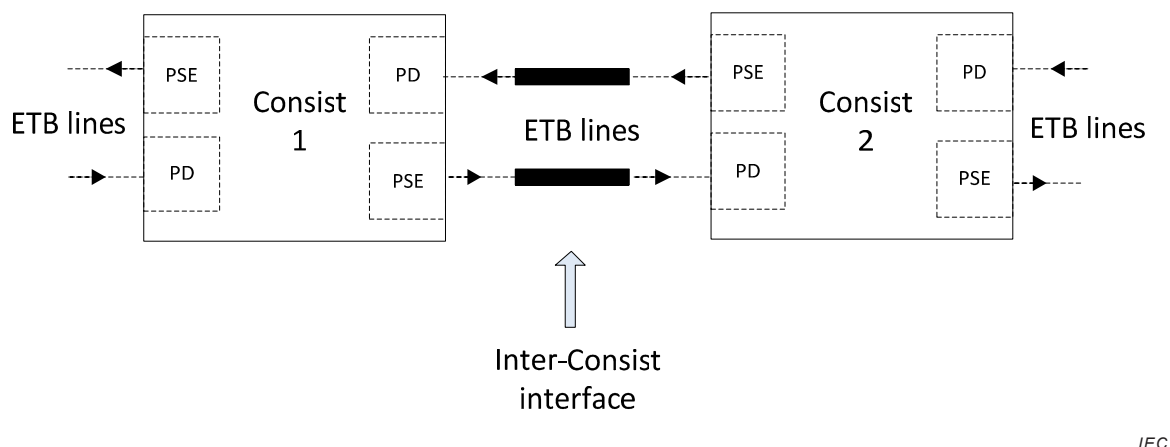


Figure 8 – PoE in inter-Consist

Figure 9 shows the connection between PSE and PD. The alternative A of PoE IEEE 802.3 Clause 33 shall be used because only two pairs are used (Tx/Rx).

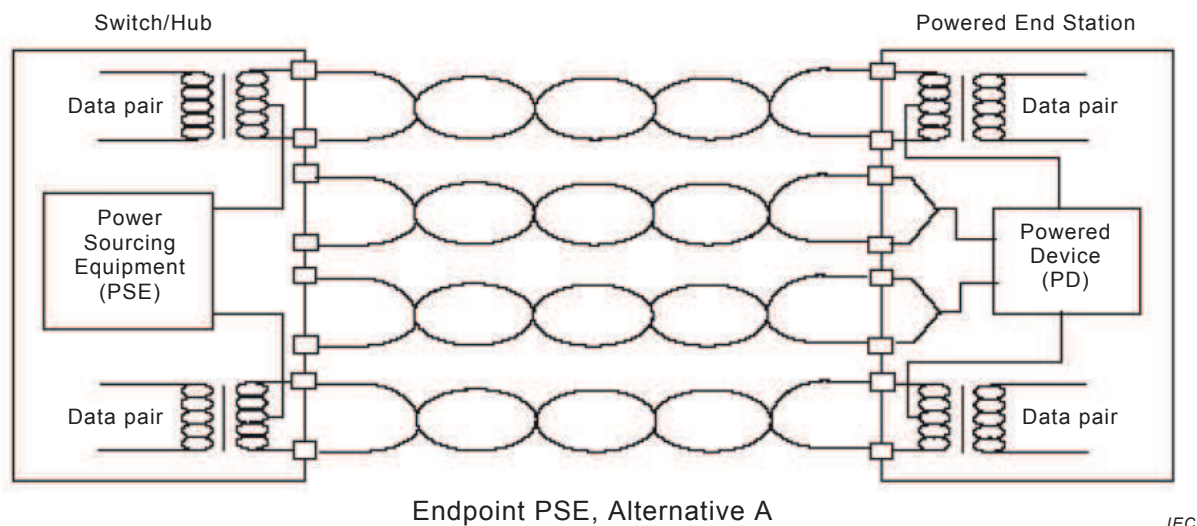


Figure 9 – PoE PSE alternative A

4.4 ETB physical architecture and redundancy

4.4.1 General

IEC 61375-1 describes the general architecture applicable to ETB, with an optional requirement of redundancy (see 5.2.3 “Train Backbone based on switched technology”). An illustration is shown on Figure 10 below:

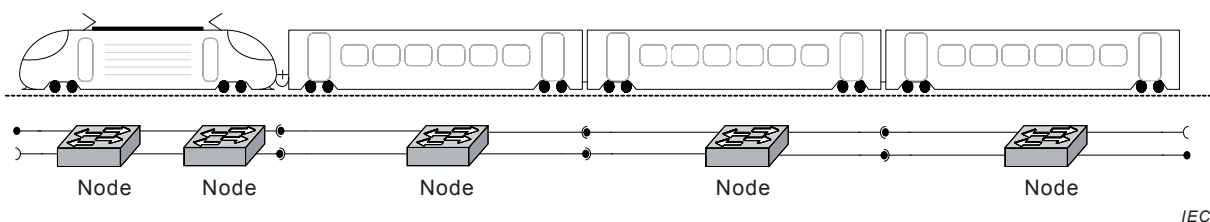


Figure 10 – Redundant train backbone architecture

The general requirements for the ETB physical layer architecture are the following:

- As a switched technology is used, nodes shall provide a data transmission medium to each of their direct neighbour nodes, if present. Each ETBN has at least one ETB forward port and one ETB backward port statically defined.
- When optional redundancy is required, data transmission medium shall be at least doubled.
- Even without redundancy requirement, the link between 2 ETBNs shall be doubled using normal switch ports when Consist reversing capability is required. Physical connection between two Consists needs two cables in this case (see 4.2.4).
- A bypass relay function shall bridge a node if the node is powerless or not operating.

4.4.2 Link aggregation architecture

When there are multiple lines between 2 ETBNs (e.g. when redundancy or Consist reversing is required), link aggregation layer from IEEE 802.1AX shall be used.

As having a single, non-redundant line for ETB communications can be considered as a degraded mode of link aggregation, it will be assumed (and so described) in the rest of the this standard that link aggregation is used.

Link aggregation described in IEEE 802.1AX is managed at OSI layer 2, and allows one or more lines to be aggregated together to form a logical group, able to manage the link redundancy (see Figure 11 below).

Link aggregation combines several individual lines, each having a physical and MAC layer. From the MAC client, a single MAC interface is provided.

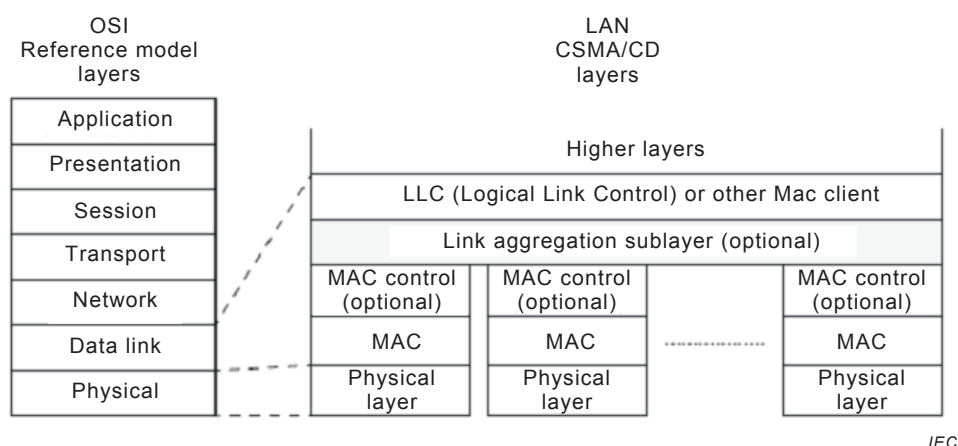


Figure 11 – Link aggregation model

On an ETB node, up to four physical ports are allowed to provide redundancy for a communication link, and will be defined as a link aggregation group (also called hereinafter logical link).

When Consist reversing is required, for symmetry reasons (see 4.2.4), 2 or 4 physical lines shall be used in each aggregation group. As stated before, the special case of a single line (no symmetry needed when Consist reversing not required) is considered as a degraded mode of link aggregation. So, a link aggregation group on ETB may contain 1, 2 or 4 physical lines.

Between 2 ETB nodes, there is only one link aggregation group which contains the redundant Ethernet segments. The link aggregation process is only defined as a relation between 2 ETB nodes.

In some cases, due to the specific railway context, some repeaters could be placed on lines between two ETBNs (e.g. to regenerate electric signal). This requires the use of a protocol that can take into account this architecture (see Figure 12 below and 4.4.3.2), because the only use of the "line status" becomes insufficient: only a frame exchange can solve this problem. According to IEEE 802.1AX, the usual way to perform this function is to implement LACP (Link Aggregation Control Protocol). For this ETB specification, and in order to limit network load, instead of using LACP, line port status are managed by Train Topology Discovery Protocol (TTDP) described below using LLDP frame with a specific organizational HELLO TLV (TTDP HELLO frame).

A logical link is usable as long as at least one of its physical lines is ok (as in standard link aggregation). The degraded state information of a link when it loses a physical line can be retrieved by SNMP.

An intermediate repeater Network Device shall transfer LLDP frames without any change between these two interfaces.