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Entwurf

**Elektronische Betriebsmittel für Bahnen –
Zug-Kommunikations-Netzwerk –
Teil 3-1: MVB – Multipurpose Vehicle Bus
(IEC 9/1276/CDV:2009);
Englische Fassung FprEN 61375-3-1:2009**

Electronic Railway Equipment –
Train Communication Network –
Part 3-1: MVB – Multipurpose Vehicle Bus
(IEC 9/1276/CDV:2009);
English version FprEN 61375-3-1:2009

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2009-09-21 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfes besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise als Datei per E-Mail an dke@din.de in Form einer Tabelle. Die Vorlage dieser Tabelle kann im Internet unter www.dke.de/stellungnahme abgerufen werden;
- oder in Papierform an die DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE (Hausanschrift: Stresemannallee 15, 60596 Frankfurt am Main).

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevante Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 130 Seiten

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE

Nationales Vorwort

Die englische Originalfassung des internationalen Dokuments IEC 9/1276/CDV:2009 „Electronic Railway Equipment – Train Communication Network – Part 3-1: MVB – Multipurpose Vehicle Bus“ (Entwurf in der Umfrage) ist unverändert in diesen Norm-Entwurf übernommen worden.

Die Internationale Elektrotechnische Kommission (IEC) und das Europäische Komitee für Elektrotechnische Normung (CENELEC) haben vereinbart, dass ein auf IEC-Ebene erarbeiteter Entwurf für eine Internationale Norm zeitgleich (parallel) bei IEC und CENELEC zur Umfrage (CDV-Stadium) und Abstimmung als FDIS (en: Final Draft International Standard) bzw. Schluss-Entwurf für eine Europäische Norm gestellt wird, um eine Beschleunigung und Straffung der Normungsarbeit zu erreichen. Dem entsprechend ist das internationale Dokument IEC 9/1276/CDV:2009 „Electronic Railway Equipment – Train Communication Network – Part 3-1: MVB – Multipurpose Vehicle Bus“ unverändert in den Entwurf FprEN 61375-3-1:2009 übernommen worden.

Das internationale Dokument wurde vom TC 9 „Electrical equipment and systems for railways“ der Internationalen Elektrotechnischen Kommission (IEC) erarbeitet.

Es ist vorgesehen, auch bei der entsprechenden zukünftigen Deutschen Norm auf die deutsche Sprachfassung zu verzichten und diese in der englischsprachigen Fassung zu veröffentlichen.

Das Präsidium des DIN hat mit Präsidiumsbeschluss 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 den vorliegenden Normentwurf erfüllt.

Bei der Abstimmung zu dem Europäischen Schluss-Entwurf bei CENELEC und dem Internationalen Schluss-Entwurf bei IEC [Final Draft International Standard (FDIS)] sind jeweils nur „JA/NEIN“-Entscheidungen möglich, wobei „NEIN“-Entscheidungen fundiert begründet werden müssen. Dokumente, die bei CENELEC als Europäische Norm angenommen und ratifiziert werden, sind unverändert als Deutsche Normen zu übernehmen.

Für diesen Norm-Entwurf ist das nationale Arbeitsgremium UK 351.1 „Fahrzeuge“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE (www.dke.de) zuständig.

Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf eine Norm ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnichtsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils neueste gültige Ausgabe der in Bezug genommenen Norm.

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

Der Zusammenhang der zitierten Normen mit den entsprechenden Deutschen Normen 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.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRIC RAILWAY EQUIPMENT –
TRAIN BUS –**

Part 3-1: MVB : Multifunction Vehicle Bus

FOREWORD

This Committee Draft for Vote was prepared by the IEC TC9 WG43 according to the following resolution that was taken by TC9 during the Plenary Meeting in Kista (Sweden) on November 2008.

Resolution 48/13

Noting the comments received on documents 9/1162/CD to 9/1167/CD, TC9 instructs WG43 Convenor to prepare the CDV texts for 61375 series (except 61375-3-4) by May 2009 at the latest.

INTRODUCTION

This part of the IEC61375 specifies one component of the Train Communication Network, the Multifunction Vehicle Bus (MVB), a serial data communication bus designed primarily, but not exclusively, for interconnecting equipment where interoperability and interchangeability are needed.

This part specifies:

- a) the physical media in single-line and double-line configurations;
- b) the signalling and the redundancy handling;
- c) the format and timing of the transmitted frame and telegrams;
- d) the organisation of the bus traffic;
- e) the allocation of Mastership;
- f) the management of the bus;
- g) the Link Layer interface and the layer management interface.

This part is structured following the OSI layers of a reference MVB device as shown in Figure 1:

Clause 2 Physical Layer

- Electrical medium for short distance (RS-485, 20,0 m)
- Electrical medium for middle distance (transformer-coupled, 200,0 m)
- Optical fibre for long distances (glass fibres, 2,0 km)

Clause 3 Medium-dependent signalling

- Frame encoding and decoding
- Line Unit interface
- Physical redundancy handling

Clause 4 Frames and telegrams

- Master Frame and Slave Frame encoding, Telegram timing

Clause 5 Link Layer Control

- Addressing
- Master Frame and Slave Frame format

Clause 6 Medium allocation

- Periodic Polling
- Event Polling
- Devices Scan

Clause 7 Mastership transfer

- Regular and exceptional mastership transfer

Clause 8 Link Layer Interface

- Link Process Data Interface (LPI),
- Link Message Data Interface (LMI),
- Link Supervision Interface (LSI).

Clause 9 Real-Time Protocols

Clause 10 Gateway Function

Clause 11 Network Management

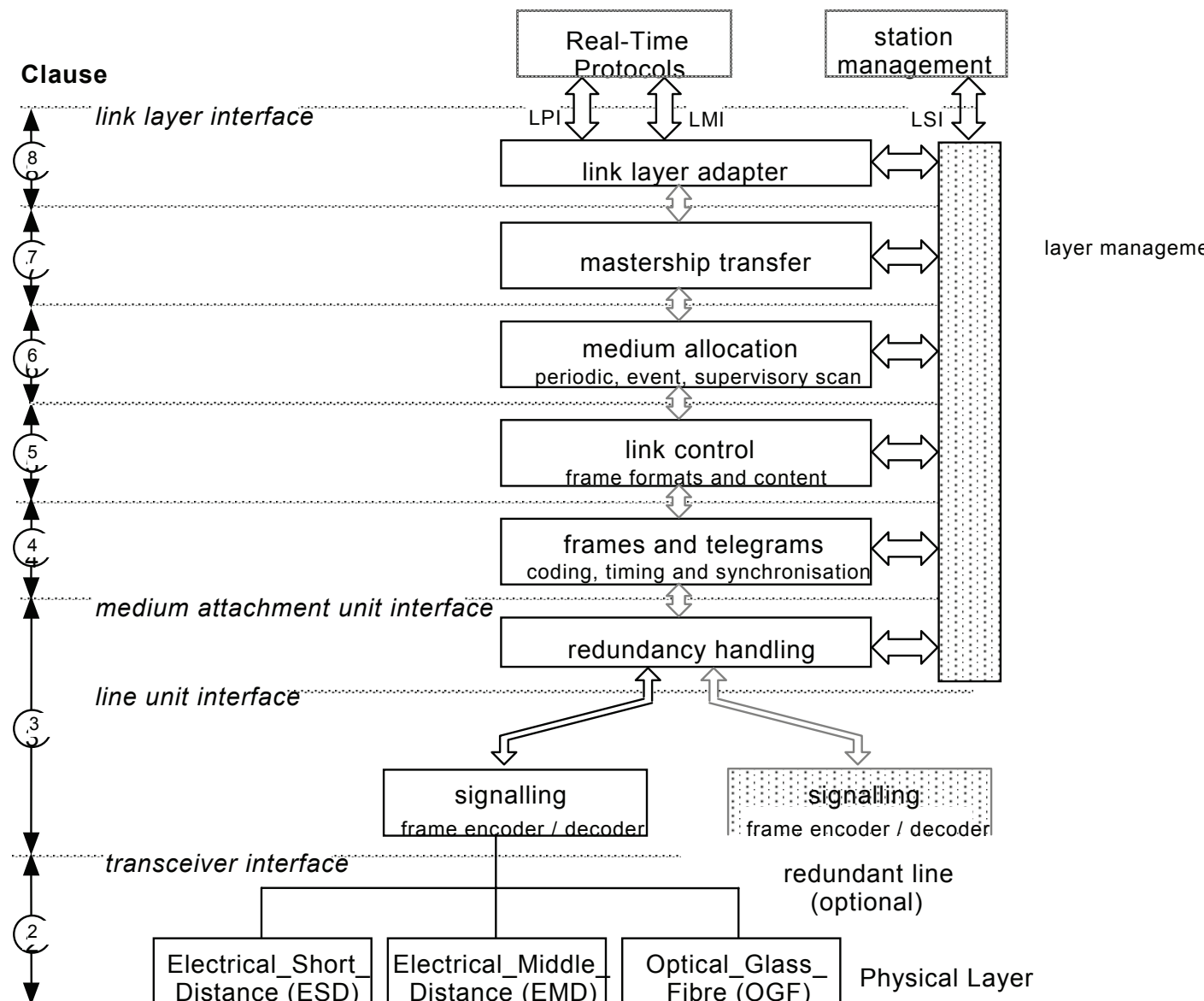


Figure 1 – Reference device and structure of the document

ELECTRIC RAILWAY EQUIPMENT – TRAIN BUS –

Part 3-1: MVB : Multifunction Vehicle Bus

1 General

1.1 Scope

This part of IEC 61375 applies where MVB is required.

1.2 Normative references

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

IEC 60096-1: *Radio-frequency cables – Part 1: General requirements and measuring methods*

IEC 60245-1, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60304, *Standard colours for insulation for low-frequency cables and wires*

IEC 60332-1-1, *Tests on electric and optical fibre cables under fire conditions – Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus*

IEC 60571, *Electronic equipment used on rail vehicles*

IEC 60794-1-1, *Optical fibre cables – Part 1-1: Generic specification – General*

IEC 60807 (all parts), *Rectangular connectors for frequencies below 3 MHz*

IEC 60870-5-1, *Telecontrol equipment and systems. Part 5: Transmission protocols - Section One: Transmission frame formats*

IEC 60874-10-1, *Connectors for optical fibres and cables – Part 10-1: Detail specification for fibre optic connector type BFOC/2,5 terminated to multimode fibre type A1*

IEC 60874-10-2, *Connectors for optical fibre and cables – Part 10-2: Detail specification for fibre optic connector BFOC/2,5 terminated to single-mode fibre type B1*

IEC 60874-10-3, *Connectors for optical fibre and cables – Part 10-3: Detail specification for fibre optic connector BFOC/2,5 terminated to single and multimode fibre*

ISO/IEC 8482, *Information technology – Telecommunications and information exchange between systems – Twisted pair multipoint interconnections*

ISO/IEC 8802-2, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control*

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

ISO/IEC 8825 (all parts), *Information technology – ASN.1 encoding rules*

ISO/IEC 8859-1, *Information technology – 8-bit single-byte coded graphic character sets – Part 1: Latin alphabet No. 1*

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

ISO/IEC 10646, *Information Technology – Universal Multiple Octet Coded Character Set (UCS)*

ISO/IEC 13239, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures*

ITU-T Recommendation V24, *List of definitions for interchange circuits between data terminal equipment (DTE) and data-circuit terminating equipment (DCE)*

ITU-T Recommendation Z.100, *Specification and Description Language (SDL)*

UIC 556 ORE B 108.3 Fiche No. 556, *Information transmission in the train (train-bus)*

UIC 557, *Diagnostics on passenger rolling stock*

IEEE 754, *Standard for Binary Floating-Point Arithmetic*

1.3 Terms and definitions

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

NOTE Keywords in this standard are written with the first letter of each word in upper case and, when they are composed of two or several words, these are joined by an underscore. This convention allows keywords to be tracked in the documents.

1.3.1

address

identifier of a communication partner, of which several types exist, depending on the layer.

1.3.2

agent

application process in a Station which accesses the local managed objects on behalf of the Manager

1.3.3

Aperiodic Data

transmission of Process Data on a demand basis. This service is not used

1.3.4

Application Layer

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

1.3.5

Application Layer Interface

definition of the services offered by the Application Layer

1.3.6

Application Messages Adapter

code directly called by the application implementing the Messages services

1.3.7**Application Messages Interface**

definition of the Messages services

1.3.8**Application Process**

communicating entity, implemented for instance by a task

1.3.9**Application Processor**

processor which runs a communicating Application Process

1.3.10**Application Supervision Interface**

definition of the Supervision services available in particular to the Agent

1.3.11**Application Variables Adapter**

code directly called by the application implementing the Variables services

1.3.12**Application Variables Interface**

definition of the Variables services

1.3.13**arbiter**

device, or common protocol followed by several devices, which selects one of several devices competing for mastership

1.3.14**Auxiliary Channel**

channel used for detecting additional Nodes

1.3.15**Basic Period**

bus activity is divided into periods. The shortest is the Basic Period, which consists of a Periodic Phase (for Periodic Data) and of a Sporadic Phase (for Message Data and Supervisory Data)

1.3.16**big-endian**

ordering scheme for storing or transmitting data in which the most significant part of a multiple-octet data is stored at the lowest octet address, and transmitted first

1.3.17**bit-stuffing**

method specified by ISO/IEC 13239 to prevent Frame Data from being misinterpreted as a Flag, consisting of inserting an additional "0" symbol after each string of five "1" symbols and removing this "0" at reception

1.3.18**bridge**

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

1.3.19

broadcast

nearly simultaneous transmission of the same information to several destinations. Broadcast in the TCN is not considered reliable, i.e. some destinations may receive the information and others not

1.3.20

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

1.3.21

Bus Administrator

device capable of becoming Master of the MVB

1.3.22

Bus Controller

processor or integrated circuit in charge of the Link Layer of communication

1.3.23

Bus Switch

switch or relay within a WTB Node which connects electrically the cable sections of the two directions

1.3.24

Caller

Application Process which initialises a message exchange

1.3.25

Check Sequence

method of error detection based on appending to the transmitted useful data a checksum or a cyclic redundancy check (CRC) calculated on the useful data

1.3.26

Check Variable

Process Variable of type antivalent boolean protecting another Process Variable

1.3.27

Check Offset

bit offset of a Check Variable within a Dataset

1.3.28

Closed Train

train consisting of a set of vehicles, where the composition does not change during normal operation, for instance metro, suburban train, or high-speed train units

1.3.29

composition

number and characteristics of the vehicles forming a train

1.3.30

configuration

definition of the topology of a bus, 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

1.3.31**Connect Confirm**

response of the Consumer to the Connect Request of the Producer

1.3.32**Connect Request**

first packet of a message sent from Producer to Consumer

1.3.33**Consist**

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

1.3.34**Consist network**

bus connecting equipment within a consist, e.g. the MVB, and which conforms or adapts to the TCN Real-Time protocols as described in this document

1.3.35**consistency**

Dataset consisting of several elements is consistent if all elements are read or written in one indivisible operation

1.3.36**Consumer**

receiver of a message at the Transport Layer (see: Producer)

1.3.37**continuity vehicle**

vehicle without an operational Train Bus Node, but carrying a section of the bus to connect passively the Train Bus of its adjacent vehicles.

1.3.38**conversation**

data exchange at the Application Layer, consisting of a Call Message and a Reply Message (the latter is missing in the multicast protocol). A conversation starts with the first Connect Request frame and ceases when the last acknowledgement for the Reply Message has been received or is no longer expected

1.3.39**datagram**

frame containing all information necessary to forward it to its final destination, without knowledge of previous frame's contents. Datagrams do not use a previous connection establishment and they are not acknowledged at the Link Layer

1.3.40**Dataset**

all Process Variables transmitted in one Process Data frame

1.3.41**delimiter**

sequence of signals which includes code violation symbols (neither "1" nor "0") which is used to delimit the start (Start Delimiter) and the end (End Delimiter) of a frame, as defined for instance in IEC 61158-2

1.3.42

Destination Device

receiver of a frame at the Link Layer (see: Source Device)

1.3.43

device

unit connected to one or more busses

1.3.44

Device Address

Device Address identifies a device within a bus; On the MVB, the Device Address has 12 bits; On the WTB, the Device Address has 8 bits, the least significant 6 bits being the Node Address;

A device connected to several busses may have a different Device Address for each bus. Special devices such as repeaters only participate at the Physical Layer and have no Device Address

1.3.45

Device Status

16-bit word expressing the capabilities and status of an MVB device connection

1.3.46

Direction 1

one direction of a WTB Node

1.3.47

Direction 2

other direction of a WTB Node

1.3.48

Electrical Middle Distance

one of the media of the MVB

1.3.49

Electrical Short Distance

one of the media of the MVB

1.3.50

End Delimiter

sequence which ends a frame before the medium returns to idle

1.3.51

End Node

Node which terminates the two bus segments connected to it but does not establish continuity between them

1.3.52

Event Round

sequence of polls in which all events pending at the start are read

1.3.53

extension box

wiring box where the trunk cable is interrupted and passively extended by an extension cable to connect a device

1.3.54**extension cable**

cable inserting a Node in a trunk cable, consisting of two separate twisted wire pairs per line, possibly of smaller cross-section than the trunk cable itself

1.3.55**field device**

device attaching simple sensors and actuators to the bus, outside a rack

1.3.56**final**

receiver of a packet (data or acknowledgement) at the Network Layer. When two devices communicate within the same bus, the final is located in the destination device (see: origin)

1.3.57**Flag**

sequence of "1" and "0" symbols which serves to delimit the beginning or the end of a frame. Flags which would appear in the transmitted data are modified by bit-stuffing, as defined for instance in ISO/IEC 13239

1.3.58**frame**

sequence of consecutive symbols sent in one time slot by a transmitter, between two slots where the line is idle.

1.3.59**Frame Check Sequence**

16-bit FCS specified in ISO/IEC 13239

1.3.60**Frame Data**

data transmitted between the Start Delimiter and the End Delimiter (on the MVB) or between the Preamble and the End Delimiter (on the WTB)

1.3.61**fritting**

electrical cleaning of oxidised contacts by applying a breakdown voltage over the contact

1.3.62**Function**

Application Process which exchanges messages with another Application Process

1.3.63**Function Directory**

directory which maps a Function Identifier to a Station Identifier and vice-versa

1.3.64**Function Identifier**

8-bit identifier of a Function

1.3.65**F code**

in a Master Frame, indicates the request and the expected response Slave Frame size

1.3.66

gateway

connection between different busses at the Application Layer requiring application-dependent data analysis and protocol conversion

1.3.67

Group Address

address of a multicast group to which a Node belongs

1.3.68

Group Directory

directory which indicates to a Node to which multicast group it pertains

1.3.69

hamming distance

minimum number of bits of a given correct bit sequence, which, if inverted, create a false bit sequence indistinguishable from a correct one

1.3.70

HDLC

High-level Data Link Control, a set of standardised protocols, including ISO/IEC 13239 for data transmission

1.3.71

HDLC Data

data transmitted in an HDLC frame

1.3.72

Inauguration

operation executed in case of composition change, which gives all Nodes of the WTB their address relative to the Master, their orientation and the descriptor of all named Nodes on the same bus

1.3.73

Individual Period

interval between two successive transmissions of the same Process Data from the same source. The Individual Period is a power-of-2 multiple of the Basic Period

1.3.74

instance

a) one of several objects which share the same definition (object instance)

b) one of several (simultaneous or not) executions of the same program (process instance)

1.3.75

integrity

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

1.3.76

Intermediate Node

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

1.3.77

jumper cable

cable connecting the trunk cables of two consecutive vehicles, possibly of a larger cross-section than the trunk cable, and which is plugged by hand in the case of the UIC-cable. There are generally two jumper cables between vehicles

1.3.78**Line**

non-redundant bus. A dual-thread bus consists of two lines

1.3.79**Line Unit**

all circuits providing the electrical attachment to a line

1.3.80**Link Address**

address supplied to the Link Layer to identify to which Bus and to which Device Address a packet is sent or received

1.3.81**Link Control**

field in the HDLC frame which indicates the type of frame

1.3.82**Link Data**

data transported by the Link Layer, but not relevant to it

1.3.83**Link Header**

part of a Message Data frame relevant to the Link Layer

1.3.84**Link Layer**

layer in the OSI model establishing point-to-point and broadcast connections between devices attached to the same bus

1.3.85**Link Layer Interface**

interface between Link Layer and higher communication layers

1.3.86**Link Layer Management**

interface controlling the Link Layer for management purposes

1.3.87**little-endian**

ordering scheme for storing or transmitting data in which the least significant part of a multiple-octet data is stored at the lowest octet address, and transmitted first

1.3.88**local area network**

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

1.3.89**logical link control**

protocols and associated frame formats which serve to control the Link Layer

1.3.90**Logical Address**

address which is not bound to a specific device (e.g. the Process Data address)

1.3.91

Logical Port

ports of a device used for the Process Data traffic and addressed by the Logical Address

1.3.92

Macro Cycle

number of Basic Periods corresponding to a Macro Period

1.3.93

Macro Period

longest Individual Period, after which the periodic traffic returns to the same pattern, counted in milliseconds

1.3.94

Main Channel

channel over which the main bus traffic is received

1.3.95

Management Message

message exchanged between a Manager and an Agent for Network Management.

1.3.96

Manager

Function in a Station which is dedicated to Network Management and which send management Call Messages through System Addresses

1.3.97

marshalling

allocation of application addresses or names to the Process Variables of a dataset, that, on the WTB, depends on the Node Type and Version

1.3.98

Master

device which spontaneously sends information on a bus to a number of slave devices. It may give a Slave the right to transmit for one Slave Frame only within a limited time

1.3.99

Master Frame

frame sent by a Master

1.3.100

Master Start Delimiter

Start Delimiter of a Master Frame

1.3.101

medium access control

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

1.3.102

medium dependent interface

mechanical and electrical interface between the transmission medium and a Medium Attachment Unit

1.3.103

medium

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

1.3.104**Medium Attachment Unit**

device used as a coupler to the transmission medium

1.3.105**message**

data item transmitted in one or several packets

1.3.106**Messages**

transmission service of the TCN

1.3.107**Message Data**

data transmitted sporadically by the Link Layer in relation to message transmission; the corresponding Link Layer service

1.3.108**messenger**

communication stack caring for end-to-end message communication and interfacing to the application

1.3.109**multicast**

transmission of the same message to a group of Repliers, identified by their Group Address. The word "multicast" is used even if the group includes all Repliers

1.3.110**Multifunction Vehicle Bus****MVB**

Vehicle Bus to be used for connecting programmable stations and simple sensors/actors.

1.3.111**Multiple Unit Train**

train consisting of a set of closed trains, where the composition of the set may change during normal operation

1.3.112**network**

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

1.3.113**Network Address**

address which identifies a Function or a Station within the network. It can be either a User Address or a System Address

1.3.114**Network Header**

part of a Message Data frame relevant to the Network Layer

1.3.115**Network Layer**

layer in the OSI model responsible for routing between different busses

1.3.116

Network Management

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

1.3.117

Node

device on the Wire Train Bus, which may act as a gateway between Train Bus and Vehicle Bus

1.3.118

Node Address

address of a Node on the Train Bus (6 bits). It is equal to the least significant 6 bits of the 8-bit Device Address on the WTB

1.3.119

Node Descriptor

24-bit data structure which indicates for a Node its Node Period and its Node Key

1.3.120

Node Directory

directory which maps the Node Address to the Device Address (one-to-one mapping in WTB)

1.3.121

Node Key

16-bit identifier selected by the application to identify a Node's type and version. The Master distributes it to all other Nodes after each composition change and before exchanging data

1.3.122

Node Period

on the WTB, desired Individual Period of a Node (identical to Individual Period except if overload occurs)

1.3.123

octet

8-bit word stored in memory or transmitted as a unit *

1.3.124

Open Train

train consisting of a set of vehicles where the configuration may change during normal operation, for instance international UIC trains

1.3.125

Optical Glass Fibre

one of the media of the MVB

1.3.126

origin

sender of a packet (data or acknowledgement) at the Network Layer. When two devices communicate within the same bus, the Origin is located on the source device (see: final)

1.3.127

packet

unit of a message (information, acknowledgement or control) transmitted in exactly one Message Data frame

* IEC prescribes 'octet ' instead of 'byte'

1.3.128**period**

time unit after which a periodic pattern repeats itself

1.3.129**Periodic Data**

Process Data transmitted periodically, at an interval which is the Individual Period

1.3.130**Periodic List**

list of Nodes, addresses or devices to be polled in each period of a Macro Cycle

1.3.131**Periodic Phase**

phase during which the Master polls for Periodic Data according to its Periodic List

1.3.132**Physical Address**

Device Address on the MVB and the Node Address on the WTB which identify communicating devices on the same bus

1.3.133**Physical Port**

Port used for the Message Data or the Supervisory Data traffic and addressed by the Device Address

1.3.134**pitch**

distance between adjacent devices on the same electrical bus required to avoid clustering of bus loads

1.3.135**polling**

sending of a Master Frame in order to receive a Slave Frame

1.3.136**Port**

memory structure which contains data for transmission or reception, and in which a new value overwrites the former value (buffer, not queue). A Port provides means for simultaneous access by the bus and the application(s)

1.3.137**Port Index Table**

look-up table which deduces the memory address of a port from the Logical Address of the Process Data

1.3.138**Preamble**

sequence of signals heading a frame for the purpose of synchronising the receiver, used on the WTB

1.3.139**Presentation Layer**

layer in the OSI model responsible for data representation and conversion

1.3.140

Process Data

source-addressed data broadcast periodically by the link layer in relation with Process Variables transmission; the corresponding Link Layer service

1.3.141

Process Variable

variable expressing the state of a process (e.g. speed, brake command)

1.3.142

Producer

sender of a message at the Transport Layer (see: Consumer)

1.3.143

Publisher

source of a Dataset for broadcasting (see: Subscriber)

1.3.144

PV Name

identifier of a Process Variable

1.3.145

PV Set

set of Process Variables belonging to the same Dataset

1.3.146

queue

memory storing an ordered set of frames in a first-in, first-out fashion

1.3.147

rack

equipment containing one or more devices, attached to the same segment

1.3.148

reassembly

act of regenerating a long message from several packets generated by segmentation

1.3.149

receiver

electronic device which may receive signals from the physical medium

1.3.150

Receive Queue

queue for receiving Message Data in a device

1.3.151

regular operation

normal bus activity as opposed to Inauguration (WTB) or configuration (MVB)

1.3.152

repeater

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

1.3.153**Replier**

Application Process which has been requested by the Caller to receive a Call Message and to reply with a Reply Message

1.3.154**residual error rate**

probability of integrity breach (unrecognised wrong bit) per transmitted bit

1.3.155**router**

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

1.3.156**scan**

polling of devices in a certain sequence for supervisory purposes

1.3.157**section**

part of a segment, which is passively connected to another section without terminator in between

1.3.158**segment**

piece of cable to which devices are attached, terminated at both ends by its characteristic impedance. Segments may consist of several sections (non-terminated) connected by connectors

1.3.159**segmentation**

division of a long message into several shorter frames for transmission

1.3.160**Send Queue**

queue for sending Message Data in a device

1.3.161**service**

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

1.3.162**Session Header**

part of a Message Data frame relevant to the Session Layer

1.3.163**Session Layer**

OSI layer in charge of establishing and closing communication

1.3.164**Side A**

one side of a vehicle with respect to a WTB Node

1.3.165**Side B**

other side of a vehicle with respect to a WTB Node

1.3.166

Slave

device which receives information from the bus or sends information on the bus in response to a request (also called a poll) from the Master

1.3.167

Slave Frame

frame sent by a Slave

1.3.168

Slave Start Delimiter

Start Delimiter of a Slave Frame on the MVB

1.3.169

Source Device

sender of a frame at the Link Layer (see: destination device)

1.3.170

sporadic transmission

transmission which is made upon demand, when an event external to the network requires it (also called aperiodic, event-driven, demand-driven transmission)

1.3.171

Sporadic Data

data frames transmitted on demand to carry Message Data or Supervisory Data

1.3.172

Sporadic Phase

second half of a Basic Period, dedicated to the demand-driven transmission of messages and bus management data

1.3.173

star coupler

device which takes the light of an optical fibre and redistributes it to several other fibres

1.3.174

Start Delimiter

delimiter which announces the beginning of a frame on the MVB

1.3.175

Station

device capable of message communication, by contrast to simple devices, and which supports an Agent Function

1.3.176

Station Directory

directory which maps a Station Identifier to a Link Address and vice-versa

1.3.177

Station Identifier

8-bit identifier of a Station

1.3.178

Station Status Word

16-bit descriptor of the status and capabilities of a Station

1.3.179**Strong Master**

Strong Node is currently Master and will not relinquish mastership until demoted to Weak Node status

1.3.180**Strong Node**

Node selected by the application to become Strong Master. There may be only one Strong Master on a bus segment

1.3.181**stub**

T-connection branching from an electrical bus line (at the tap), connecting a device to the line

1.3.182**Subscriber**

one of the sinks of a broadcast Dataset (see: Publisher)

1.3.183**Supervisory Data**

data transmitted within one bus only for the purpose of Link Layer supervision (e.g. arbitration on the MVB or Inauguration on the WTB)

1.3.184**System Address**

Network Address of a Management Message exchanged between Manager and Agent, consisting of Node Address and Station Identifier

1.3.185**tap**

place where a segment is tapped. A tap is a three-way electrical fork

1.3.186**Telegram**

Master Frame and the corresponding Slave Frame, treated as a whole

1.3.187**terminator**

circuit which closes an electrical transmission line, ideally by its characteristic impedance

1.3.188**Terminator Switch**

switch which inserts the Terminator at the end of a segment on the WTB

1.3.189**Topography**

data structure describing the Nodes attached to the Train Bus, including their address, orientation, position and Node Descriptor

1.3.190**topology**

possible cable interconnection and number of devices a given network supports

1.3.191**Topography Counter**

counter in a Node which is incremented at each new Inauguration

1.3.192

Traffic Store

shared memory accessed both by the network and the user, which contains the Process Data Port

1.3.193

Train Communication Network

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

1.3.194

Train Bus

bus connecting the vehicles of a train, in particular, the WTB, and which conforms to the TCN protocols

1.3.195

Train Network Management

services of the Network Management for TCN

1.3.196

transceiver

combination of a transmitter and of a receiver

1.3.197

transmitter

electronic device which can transmit a signal on the physical medium

1.3.198

Transport Data

data carried by the Transport Layer, but not relevant to it

1.3.199

Transport Header

part of a Message Data frame relevant to the Transport Layer

1.3.200

Transport Layer

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

1.3.201

trunk cable

cable which runs along the vehicles, as opposed to extension cable or jumper cable

1.3.202

User Address

Network Address of a User Message exchanged between Functions, consisting of Node Address (or Group Address) and Function Identifier

1.3.203

User Message

messages exchanged between user Functions

1.3.204

Variables

transmission service of the TCN

1.3.205**Var_Offset**

bit offset of a Process Variable within a Dataset

1.3.206**Vehicle Descriptor**

application-dependent information about a particular vehicle, such as length and weight

1.3.207**Weak Master**

Weak Node is currently Master and which will relinquish mastership if it finds another, stronger Master

1.3.208**Weak Node**

Node which may take over the bus mastership spontaneously, but which releases it if it detects a stronger Node

1.3.209**Wire Train Bus (WTB)**

Train Bus for frequently coupled and uncoupled vehicles, such as international UIC trains

1.4 Abbreviations

ALI	Application Layer Interface, the definition of the semantics of all network services used by the application (a set of primitives, expressed as procedures, constants and data types)
AMA	Application Messages Adapter, the code directly called by the application which implements the Messages service
AMI	Application Messages Interface, the definition of the message services
ANSI	American National Standard Institute, a standardisation body in the United States
ASI	Application Supervision Interface, the definition of the Management services
ASN.1	Abstract Syntax Notation Number 1 on data presentation (ISO/IEC 8824)
AVA	Application Variables Adapter, the code directly called by the application implementing the Process Variable services
AVI	Application Variables Interface, the definition of the Process Variable services
BER	Basic Encoding Rules, a transfer syntax for ASN.1 data types (ISO/IEC 8825)
BR	Bit Rate, the rate of data throughput on the medium expressed in bits per second (bit/s) or in hertz (Hz), whichever is appropriate
BT	Bit Time, the duration of the transmission of one bit, expressed in μ s
ITU	International Telecommunication Union, the international standardisation body for telecommunications based in Geneva
CRC	Cyclic Redundancy Check, a data integrity check based on polynomial division
DIN	Deutsches Institut für Normung, the German national standardisation body
EIA	Electronics Industries Association, a standardisation body in the United States
EMD	Electrical Middle Distance, one of the media of the MVB

ESD	Electrical Short Distance, one of the media of the MVB
EP	Electro-Pneumatic brake cable as described in UIC leaflet 648
ERRI	European Railways Research Institute, laboratory based in Utrecht, Netherlands
FCS	Frame Check Sequence, an error detection code appended to the transmitted data, as specified in ISO/IEC 13239
GCT	Guidelines for Conformance Test, the conformance testing specified in Annex B of this Standard
HDLC	High-level Data Link Control, a Link Layer protocol whose frame format is defined in ISO/IEC 13239
IEC	International Electrotechnical Commission, Geneva
IEEE	Institute of Electrical and Electronics Engineers, New York
ISO	International Standard Organisation, Geneva
LLC	Logical Link Control, a sub-layer within the Link Layer ruling the data exchange
LME	Layer Management Entity, the entity in charge of supervising a layer on behalf of Network Management
LMI	Layer Management Interface, the services provided by the LME
MAC	Medium Access Control, a sub-layer within the Link Layer ruling which device is entitled to send on the bus
MAU	Medium Attachment Unit, the part of a Node which interfaces electrically to the bus and which provides/accepts binary logic signals
MIB	Management Information Base, the set of all objects accessed by Network Management
MVB	Multifunction Vehicle Bus, a Consist Network.
NRZ	Non-Return to Zero, the simplest encoding scheme in which one bit is represented by one level for a "1" and the other level for a "0", or vice-versa, with a separate clocking
OGF	Optical Glass Fibre, one of the media of the MVB
ORE	Office de Recherches et d'Essais, a UIC laboratory based in Utrecht, Netherlands
OSI	Open System Interconnection, a universal communication model defined in the ISO/IEC 7498
PCTR	Protocol Conformance Test Report, defined in ISO/IEC 9646
PICS	Protocol Implementation Conformance Statement, defined in ISO/IEC 9646
PTA	Process Data to Traffic Store Adapter, the component which accesses one of the Traffic Stores
RIC	Regulation for the reciprocal use of coaches and vans in international traffic, edited by UIC.
RTP	Real-Time Protocols, the common communication protocols given in Clause 2 of this standard
SDL	Specification and Description Language, a specification language defined by ITU-T Z100 Annex D for communication protocols

TCN	Train Communication Network, a set of communicating consist networks and Train Backbones.
TNM	Train Network Management
UIC	International Union of Railways , the international railways operators association
WTB	Wire Train Bus

1.5 Conventions

1.5.1 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

1.5.2 Naming conventions

Keywords in the TCN specifications are written with a capital letter at the beginning.

If the name is composed, the different parts of the name are united with a space.

When a data structure is associated with a keyword, its type consists of the same basic names separated by an underscore.

When the value corresponding to the keyword is transmitted in a message, the corresponding field has the same name as the type, but in lower case.

When the value is passed as parameter, the parameter name has the same name as the field in a message.

In the SDL diagrams, the corresponding variable has the same name as the type, but without underscores.

EXAMPLES

Topo Counter is a counter of the link layer;

It is of the type Topo_Counter, which is an UNSIGNED6.

When its value is transmitted in a message, the corresponding field is called 'topo_counter'.

When its value is transmitted across a procedural interface, the parameter is called 'topo_counter', its C-type is Type_Topo_Counter.

In the SDL diagrams, the variable representing the counter is called TopoCounter.

1.5.3 Time naming conventions

Time values beginning with a lower case (e.g. t mm) are measurable time intervals.

Time values beginning with an uppercase (e.g. T reply) are parameters or time-out values.

1.5.4 Procedural interface conventions

A procedural interface is defined by a set of service primitives, which represent an abstract, implementation-independent interaction between the service user and the service provider.

These primitives are expressed in this standard as procedures in the ANSI C syntax with typed parameters.

This ought to be considered as a semantic description only, which does not imply a particular implementation or language. Any interface which provides the same semantics is allowed.

Conformance to the syntax of this interface cannot be claimed. Implementations are free to change the procedure or parameters names, to add parameters or to split procedures, as long as the specified service is provided.

Interface procedures are defined in the ANSI C syntax using the Courier font.

Procedure names, variables and parameters appear in all lower case.

EXAMPLE `Im_send_request`

Constants and type definitions appear in all upper case.

EXAMPLE `UNSIGNED32`

The name of a procedure or of a type is prefixed:

for the Variables service by

- `lp_` or `LP_` Link Layer
`ap_` or `AP_` Application Layer

for the Messages service by

- `MD_` messages in general
`lm_` or `LM_` Link Layer
`nm_` or `NM_` Network Layer
`tm_` or `TM_` Transport Layer
`sm_` or `SM_` Session Layer
`am_` or `AM_` Application Layer

Table 1 shows a template used for procedures and types.

Table 1 – Template for the specification of an interface procedure

Definition	<i>The service or data type is expressed here.</i> <i>In case of an indication procedure, the event which triggers the call is indicated here, beginning with "When"</i> <i>The name and parameters of the service procedure are defined here.</i> <i>In case of an indication procedure, the type of the procedure is specified.</i> <i>Input parameters, output parameters and return parameters are distinguished</i>	
Syntax	<pre>MD_RESULT lm_send_request (/* example */ unsigned, destination, UNSIGNED8 link_control, MD_PACKET * p_packet ENUM8 * status)</pre>	
Input	<i>Input parameters are supplied to the procedure, which is not allowed to modify them</i>	
	destination	The data type "unsigned" is compiler-dependent
	link_control	parameter passed by reference, not modified by the procedure. The data type is an 8-bit word
	p_packet	The "*" denotes a pointer to the p_packet data structure, which is of type MD_PACKET, defined elsewhere in this standard
Output	<i>Output parameters are expected to be modified by the call</i>	
	status	The type ENUM8 is an 8-bit enumeration type
Result	<i>The Result parameter is an optional output parameter which expresses success or failure of the call, but not necessarily of the service</i>	
	MD_RESULT	The Result parameter is of the type: AM_RESULT for the AMI, MD_RESULT for the LMI, LP_RESULT for the LPI, AP_RESULT for the AVI, The template specifies the error codes expected for each procedure individually. The Result parameter is not explicitly described if the only two values expected are: xx_OK = 0 successful completion; xx_FAILURE <> 0 some problem. The result can also be returned as an output parameter in the parameter list, depending on the implementation
Usage	The rules listed after the procedure template indicate how the procedure should be used. Although usage rules are not mandatory, not following them produces unpredictable results	
NOTE Data structures represented in this table are interface specifications which should not be confused with formats of the same data structures when transmitted over a bus, see 1.5.5.		

1.5.5 Specification of transmitted data

The format of transmitted data, single frames as well as whole messages, is specified in two forms:

- a graphical form, which is not normative, but shows the message structure at a glance.
- a textual form based on ASN.1, with encoding rules specified in 2.3.

EXAMPLE A graphical form of a message is shown in Table 2, the corresponding textual form is shown in Table 3.

Table 2 – Example of message structure

first transmitted octet									next transmitted octet							
bit->	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	snu	gni	node_id						station_id							
2	next_station_id								rsv1	Tvd	topo_counter					
4	tnm_key								sif_code (= 3)							
6	parameter 1															
8	parameter 2								parameter 3						par4	
	parameter 5: ARRAY [n] OF (repeat following field (n) times)															
	parameter 5.1															
	parameter 5.2															
	parameter5.3: STRING32															
	(CHARACTER8)								last character or 0							
^octet																

In the graphical form, one line is used for each word of 16 bits, but in Clause 4 (WTB), lines are 8-bit oriented.

Arrays of parameters are preceded by a repetition frame on the top and to its left.

Repetitions can be nested (see parameter 5.3 in Table 4).

If the size of a parameter may be longer than three words, three lines are allocated for it and the middle one has a shaded border.

Table 3 – Example of textual message form (corresponding to Table 2)

```

Call_Mgt_Message ::= RECORD
{
  snu                BOOLEAN1 (=1)      -- this '1' means that message
                                         uses system addressing
  gni                BOOLEAN1 (=0)      -- this '0' means that final
                                         is an individual device
  node_id            UNSIGNED6          -- 6-bit node address of final
  station_id         UNSIGNED8          -- 8-bit identifier of the
                                         station
  next_station_id    UNSIGNED8          -- 8-bit identifier of next
                                         station
  rsv1              BOOLEAN1 (=0)      -- this bit is always 0
  tvd               BOOLEAN1           -- this bit indicates if
                                         topography counter is valid
  topo_counter       UNSIGNED6          -- 6-bit topography counter
  tnm_key            UNSIGNED8,         -- announces a network
                                         management call message.
  sif_code           UNSIGNED8,         -- there is a different
                                         SIF_code for each
                                         Management Message
  parameter1         INTEGER16,        -- a 16-bit value. If the
                                         parameter has less than 16
                                         bits, the value is right-
                                         justified and sign-extended
                                         (e.g. one single octet is
                                         transmitted as the second
                                         octet).
  parameter2         INTEGER8,         -- this value is transmitted
                                         in the most significant
                                         part of a word.
  parameter3         UNSIGNED6         -- this value is transmitted
                                         in the least significant
                                         octet, but the lower two
                                         bits of that octet are
                                         reserved for parameter4.
  par4              ANTIVALENT2        -- parameter4 has two bits
  parameter5         ARRAY [n] OF     -- parameter5 represents a
                                         structured data to be
                                         {
                                         -- repeated n times,
                                         containing:
                                         parameter5.1      INTEGER16      -- first parameter of the
                                         repeated field
                                         parameter5.2      UNIPOLAR4.16    -- second parameter of the
                                         repeated field
                                         parameter5.3      STRING32      -- third parameter is a string
                                         (array of up to 32 8-bit
                                         characters);
                                         - a string is closed by a
                                         '0' character, or by two
                                         such '0' characters to
                                         align on a 16-bit word
                                         boundary;
                                         - a void string consists of
                                         32 '0' characters;
                                         - the actual size of a
                                         string is deduced from the
                                         number of significant
                                         characters before the zero.
                                         },
}

```

Fields names begin with a lower case letter, their type begins with an upper case. Sometimes, the same type is used as a transmission format, in which case only the first letter is upper case, and as a C-type, in which case the whole type is in upper case.

EXAMPLE Am_Result (transmission format) and AM_RESULT (C-type of an interface procedure).

1.5.6 State diagram conventions

The transport protocol state machine is described as in ISO/IEC 8802-2 (Logical Link Layer) in the form of a table, which specifies the transitions between the possible states in which a state machine may be.

Transitions between states are governed by events, coming from the Network Layer (inbound packets), from the Session Layer (commands) or from time-outs.

An action depending on the event is executed before leaving the state. This action defines the next state.

Figure 2 shows an example of a state transition diagram.

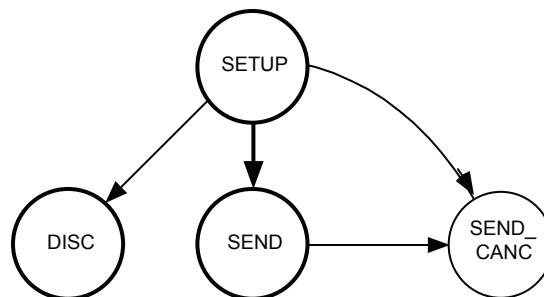


Figure 2 – State transition example

From “SETUP”, the machine may go to three different states, DISC, SEND or SEND_CANC.

The transition between these states are governed as Table 4 shows.

Table 4 – State transitions table

Current state	Event	Action(s)	Next state (if <> current)
SETUP	rcv_DR	close_send (DR_reason);	DISC
	rcv_CC AND (conn_ref = CC_conn_ref)	IF (eot) THEN close_send (AM_OK); ELSE credit:= CC_credit; send_not_yet:= credit; send_data_or_cancel; END;	DISC SEND or SEND_CANC
	TMO AND (rep_cnt = MAX_REP_CNT)	close_send (AM_CONN_TMO_ERR);	DISC

According to Table 4, there are three events which cause a transition from SETUP to the DISC state:

- 1) rcv_DR (received Disconnect_Request, a network event). The corresponding action consists in closing the connection (close_send) before going to state DISC;
- 2) another network event (received Connect_Confirm with correct reference), leading either to state DISC, SEND or SEND_CANC, depending on the outcome of the send_data or cancel procedure;
- 3) A time-out conditioned by the predicate (rep_cnt = MAX_REP_CNT), which also causes the closing of the connection.

2 Physical Layer

2.1 Topology

2.1.1 Segments

An MVB shall consist of one or several bus segments of the following media:

- a) ESD: an Electrical Short Distance medium using a pair of wires with differential transmission according to the RS-485 standard, supporting up to 32 devices over a distance of 20,0 m without need for galvanic separation, and over longer distances when using galvanic isolation, as specified in 2.4;
- b) EMD: an Electrical Middle Distance medium, using a shielded, twisted wire pair, supporting up to 32 devices over a distance of 200,0 m and allowing transformers for galvanic isolation, as specified in 2.5;
- c) OGF: an Optical Glass Fibre medium, using optical fibres bussed through a star coupler, over a distance up to 2,0 km, intended for critical environments such as locomotives, as specified in 2.6.

2.1.2 Couplers

MVB segments shall be interconnected by couplers of one of the following types:

- a) repeater for connecting different media;
- b) star couplers for forming optical fibres into a bus.

EXAMPLE An MVB configuration, shown in Figure 3, consists of an ESD segment supporting a bus administrator, several devices within and outside of a rack and a gateway, an EMD segment supporting several devices and a bus administrator, and an OGF segment supporting a number of devices. Segments are interconnected by repeaters. The star coupler consists of an ESD segment which, in this example, supports no devices. Each segment in Figure 3 could be duplicated to increase availability.

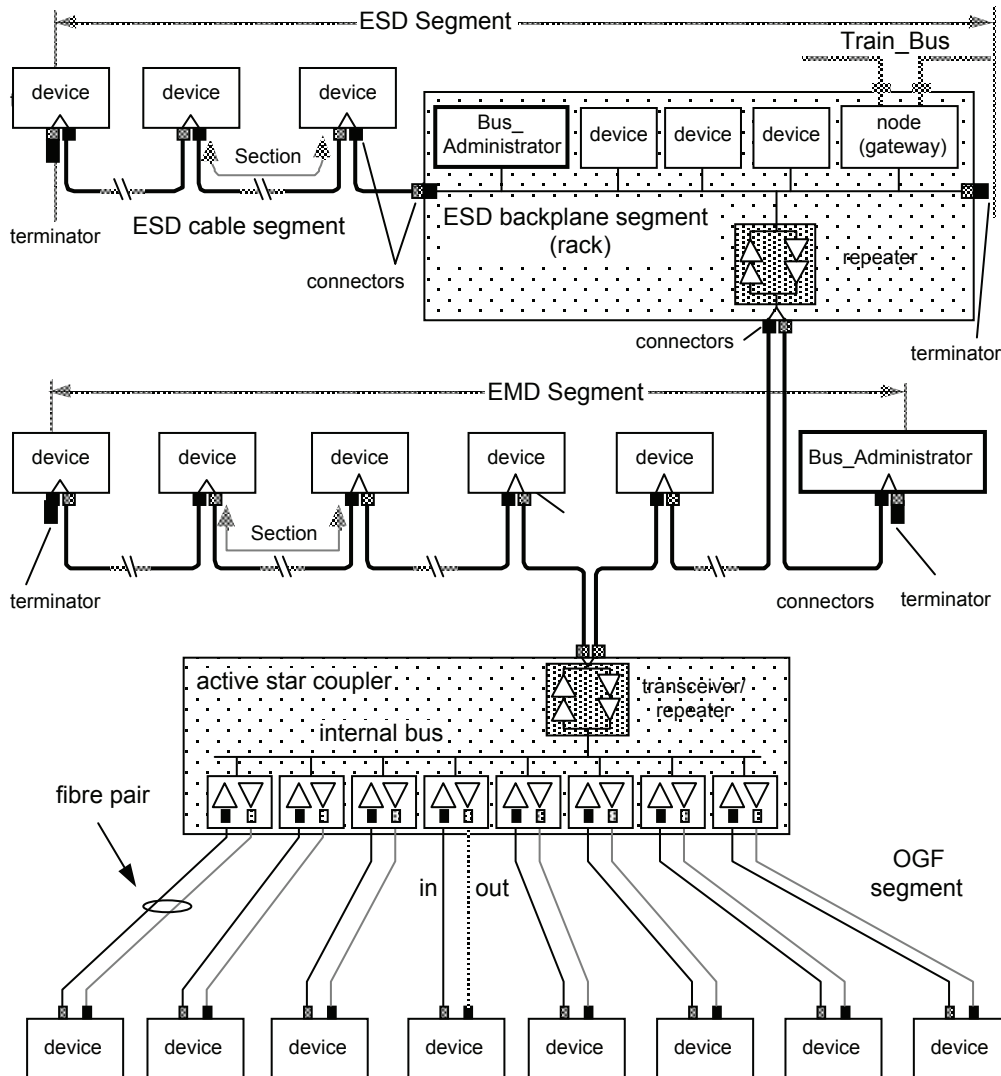


Figure 3 – MVB configuration

2.1.3 Double-line segments

As an option, a segment may be duplicated to increase availability (double-line segment).

An MVB may consist of a combination of double-line segments and single-line segments interconnected by bus couplers.

2.2 Device classes

2.2.1 Capabilities

There exist five classes of devices attached to the MVB, which differ in their capabilities.

MVB devices shall provide a subset of the following six capabilities listed in Table 5.

Table 5 – MVB devices capabilities

Capability	Description	Class
Device_Status	the device is able to send its Device_Status when polled	1, 2, 3, 4, 5
Process_Data	the device is able to send Process Data when polled and to receive Process Data from other devices	1, 2, 3, 4, 5
Message_Data	the device is able to send Message Data when polled and to receive Message Data from other devices. This capability implies that the devices are able to execute the Real-Time Protocols and have a Network Management Agent.	2, 3, 4, 5
User_Programmable	the device is able to be down-loaded with User Application programs. This capability implies the Message_Data capability.	3, 4, 5
Bus_Administrator	the device is able to act as a master. This capability implies the Message_Data, Process_Data and Device_Status capabilities and the ability to read the Device_Status of all other devices.	4, 5
TCN_Gateway	the device is able to access at least another bus (MVB or other). This capability implies the Device_Status, Process_Data and Message_Data capabilities, and the presence of a router if at least two of the busses obeys to the Real-Time Protocols.	5

2.2.2 Class 0 devices

Class 0 devices are not requested to support any capability.

NOTE Class 0 includes special devices, such as repeaters or star couplers, which do not participate in the application data exchange or participate in another way (for instance with another protocol).

2.2.3 Class 1 devices

Class 1 devices shall offer the capabilities: Device_Status and Process_Data.

NOTE In these devices, the Port_Address of the Process Data may be tied to their Device_Address, for instance, the Port_Address may be identical to the Device_Address.

2.2.4 Class 2 devices

Class 2 devices shall offer the capabilities: Device_Status, Process_Data and Message_Data.

NOTE Class 2 devices are intelligent field devices which can be configured over the bus, but not programmed.

2.2.5 Class 3 devices

Class 3 devices shall offer the capabilities: Device_Status, Process_Data, Message_Data and User_Programmable.

2.2.6 Class 4 devices

Class 4 devices shall offer the capabilities: Device_Status, Process_Data, Message_Data and Bus_Administrator.

NOTE The User_Programmable capability is optional.

2.2.7 Class 5 devices

Class 5 devices shall offer the capabilities: Device_Status, Process_Data, Message_Data and TCN_Gateway.

Class 5 devices may offer the Bus_Administrator capability.

NOTE Gateways with Bus_Administrator capability can synchronise the busses.

2.2.8 Device Attachment

Three different device attachments are considered:

- a) ESD: Devices equipped with the connectors carrying ESD signals according to 2.4;
- b) EMD: Devices equipped with the connectors carrying EMD signals according to 2.5;
- c) OGF: Devices equipped with the connectors carrying ESD signals according to 2.6.

NOTE A device may support more than one attachment.

2.3 Specifications common to all media

2.3.1 Signalling speed

The signalling speed shall be 1,5 Mbit/s $\pm$ 0,01 %, using Manchester encoding (BR = 1,5 MHz or 1,5 Mbit/s, BT = 666,7 ns).

2.3.2 Propagation delays

Between any two devices, the reply delay, including propagation delays and repeater delays and assuming a worst-case source delay of T_source_max (see 4.2.3), shall not be larger than T_reply_def = 42,7 μ s (see 4.2.2), except if the bus is operated in Extended Reply Mode.

If the worst case propagation delay is larger than T_reply_def, the bus may be operated in Extended Reply Delay mode, provided that the worst case round-trip delay T_reply_max is entered as a configuration parameter of all connected devices.

The difference between the maximum and the minimum propagation delay on two consecutive telegrams, considering overall propagation and repeater delays, shall at no place exceed 4,0 BT.

The sum of the interframe spacings from one master frame to another master frame shall be larger than 9,0 BT.

NOTE 1 The default value of T_reply_def of 42,7 μ s limits the number of repeaters to four, and the transmitted distance to 2,0 km. Using a value larger than T_reply_def is possible with certain precautions explained in the Extended Reply Delay mode (4.2.4.2).

NOTE 2 Fluctuations in propagation delay could reduce the interframe spacing and cause frame overlap. Repeaters may increase the interframe spacing, but overrun may occur if the above requirement is exceeded.

NOTE 3 Imposing a minimum sum of interframe spacings prevents a pair of fast master and slave from overrunning slower listeners.

2.3.3 Transceiver interface

The transceiver interface specifies for all types of media the interface between the Bus_Controller and the transceivers within a device.

This interface can remain internal to a device, but it is recommended to make it available for testing. This interface is not covered by conformance testing.

The transceiver interface is defined as an electrical interface operating with binary signals.