INTERNATIONAL STANDARD

ISO 17458-2

First edition
2013-02-01

Road vehicles— FlexRay communications system —

Part 2:
Data link layer specification

Véhicules routiers — Système de communications FlexRay —

Partie 2: Spécification de la couche de liaison de données

Reference number
ISO 17458-2:2013(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword ... v
Introduction ... vi
1 Scope ... 1
2 Normative references ... 1
3 Terms, definitions, symbols and abbreviated terms ... 1
3.1 Terms and definitions ... 1
3.2 Symbols ... 7
3.3 Abbreviated terms ... 7
4 Document overview ... 10
5 Conventions ... 11
5.1 General ... 11
5.2 Notational conventions ... 11
5.3 SDL conventions ... 12
5.4 Bit rates ... 15
5.5 Roles of a node in a FlexRay cluster ... 15
5.6 Synchronisation methods ... 15
5.7 Network topology considerations ... 19
5.8 Example node architecture ... 24
6 Protocol operation control ... 29
6.1 Principles ... 29
6.2 Description ... 31
6.3 The protocol operation control process ... 37
7 Coding and Decoding ... 59
7.1 Principles ... 59
7.2 Description ... 59
7.3 Coding and decoding process ... 77
7.4 Bit strobing process ... 96
7.5 Wakeup pattern decoding process ... 99
8 Frame Format ... 103
8.1 Overview ... 103
8.2 FlexRay header segment (5 bytes) ... 103
8.3 FlexRay payload segment (0 – 254 bytes) ... 108
8.4 FlexRay trailer segment ... 111
8.5 CRC calculation details ... 111
9 Media Access Control ... 113
9.1 Principles ... 113
9.2 Description ... 123
9.3 Media access control process ... 126
10 Frame and Symbol processing ... 143
10.1 Principles ... 143
10.2 Description ... 143
10.3 Frame and symbol processing process ... 149
11 Wakeup and Startup ... 161
11.1 General ... 161
11.2 Cluster wakeup ... 162
11.3 Communication startup and reintegration ... 167

12 Clock synchronisation 190
12.1 Introduction 190
12.2 Time representation 191
12.3 Synchronisation process 193
12.4 Startup of the clock synchronisation 200
12.5 Time measurement 204
12.6 Correction term calculation 208
12.7 Clock correction 220
12.8 Sync frame configuration 223
12.9 Time gateway interface 225

13 Controller Host Interface 226
13.1 Principles 226
13.2 Description 227
13.3 Interfaces 228

Annex A (normative) System parameters 268
A.1 Protocol constants 268
A.2 Performance constants 270

Annex B (normative) Configuration constraints 271
B.1 General 271
B.2 Bit rates 271
B.3 Parameters 272
B.4 Calculation of configuration parameters for nodes in a TT-D cluster 281
B.5 Configuration of cluster synchronisation method and node synchronisation role 334
B.6 Calculation of configuration parameters for nodes in a TT-L cluster 335
B.7 Calculation of configuration parameters for nodes in a TT-E cluster 336

Annex C (normative) Wakeup application notes 345
C.1 Scope 345
C.2 Wakeup initiation by the host 345
C.3 Host reactions to status flags signalled by the communication controller 348
C.4 Retransmission of wakeup patterns 349
C.5 Transition to startup 349
C.6 Wakeup during operation 350

Bibliography 352

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 17458-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

ISO 17458 consists of the following parts, under the general title *Road vehicles — FlexRay communications system*:

— *Part 1: General information and use case definition*

— *Part 2: Data link layer specification*

— *Part 3: Data link layer conformance test specification*

— *Part 4: Electrical physical layer specification*

— *Part 5: Electrical physical layer conformance test specification*

Introduction

The FlexRay communications system is an automotive focused high speed network and was developed with several main objectives which were defined beyond the capabilities of established standardized bus systems like CAN and some other proprietary bus systems. Some of the basic characteristics of the FlexRay protocol are synchronous and asynchronous frame transfer, guaranteed frame latency and jitter during synchronous transfer, prioritization of frames during asynchronous transfer, single or multi-master clock synchronisation, time synchronisation across multiple networks, error detection and signalling, and scalable fault tolerance.

The FlexRay communications system is defined for advanced automotive control applications. It serves as a communication infrastructure for future generation high-speed control applications in vehicles by providing:

— A message exchange service that provides deterministic cycle based message transport;

— Synchronisation service that provides a common time base to all nodes;

— Start-up service that provides an autonomous start-up procedure;

— Error management service that provides error handling and error signalling;

— Wakeup service that addresses the power management needs;

Since start of development the automotive industry world wide supported the specification development. The FlexRay communications system has been successfully implemented in production vehicles today.

The ISO 17458 series specifies the use cases, the communication protocol and physical layer requirements of an in-vehicle communication network called "FlexRay communications system".

This part of ISO 17458 has been established in order to define the protocol requirements for vehicle communication systems implemented on a FlexRay data link.

To achieve this, it is based on the Open Systems Interconnection (OSI) Basic Reference Model specified in ISO/IEC 7498-1 and ISO/IEC 10731, which structures communication systems into seven layers. When mapped on this model, the protocol and physical layer requirements specified by ISO 17458 are broken into:

— Diagnostic services (layer 7), specified in ISO 14229-1 [7], ISO 14229-4 [9];

— Presentation layer (layer 6), vehicle manufacturer specific;

— Session layer services (layer 5), specified in ISO°14229-2 [8];

— Transport layer services (layer 4), specified in ISO 10681-2 [5];

— Network layer services (layer 3), specified in ISO 10681-2 [5];

— Data link layer (layer 2), specified in ISO 17458-2, ISO 17458-3;

— Physical layer (layer 1), specified in ISO 17458-4, ISO 17458-5;

in accordance with Table 1.

Table 1 — FlexRay communications system specifications applicable to the OSI layers

Applicability	OSI 7 layers	FlexRay communications system	Vehicle manufacturer enhanced diagnostics
Seven layer according to ISO 7498-1 and ISO/IEC 10731	Application (layer 7)	vehicle manufacturer specific	ISO 14229-1, ISO 14229-4
	Presentation (layer 6)	vehicle manufacturer specific	vehicle manufacturer specific
	Session (layer 5)	vehicle manufacturer specific	ISO 14229-2
	Transport (layer 4)	vehicle manufacturer specific	ISO 10681-2
	Network (layer 3)	vehicle manufacturer specific	
	Data link (layer 2)	ISO 17458-2, ISO 17458-3	
	Physical (layer 1)	ISO 17458-4, ISO 17458-5	

Table 1 shows ISO 17458 Parts 2 – 5 being the common standards for the OSI layers 1 and 2 for the FlexRay communications system and the vehicle manufacturer enhanced diagnostics.

The FlexRay communications system column shows vehicle manufacturer specific definitions for OSI layers 3 – 7.

The vehicle manufacturer enhanced diagnostics column shows application layer services covered by ISO 14229-4 which have been defined in compliance with diagnostic services established in ISO 14229-1, but are not limited to use only with them. ISO 14229-4 is also compatible with most diagnostic services defined in national standards or vehicle manufacturer's specifications. The presentation layer is defined vehicle manufacturer specific. The session layer services are covered by ISO 14229-2. The transport protocol and network layer services are specified in ISO 10681.

Road vehicles — FlexRay communications system — Part 2: Data link layer specification

1 Scope

This part of ISO 17458 specifies the FlexRay communication protocol which is specified for a dependable automotive network. Some of the basic characteristics of the FlexRay protocol are synchronous and asynchronous frame transfer, guaranteed frame latency and jitter during synchronous transfer, prioritization of frames during asynchronous transfer, single or multi-master clock synchronisation[1)] time synchronisation across multiple networks, error detection and signalling, and scalable fault tolerance[2)].

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.

ISO 17458-1, *Road vehicles — FlexRay communications system — Part 1: General information and use case definition*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17458-1 and the following apply.

3.1.1
application data
data produced and / or used by application tasks

NOTE In the automotive context the term 'signal' is often used for application data exchanged among tasks.

3.1.2
bus
communication system topology in which nodes are directly connected to a single, common communication media (as opposed to connection through stars, gateways, etc.)

NOTE The term bus is also used to refer to the media itself.

1) Multi-master clock synchronisation refers to a synchronisation that is based on the clocks of several (three or more) synchronisation masters or sync nodes.
2) Scalable fault tolerance refers to the ability of the FlexRay protocol to operate in configurations that provide various degrees of fault tolerance (i.e., single or dual channel clusters, clusters with many or few sync nodes, etc.).

3.1.3
channel idle
condition on the physical transmission medium when no node is transmitting, as perceived by each individual node in the network

NOTE The detection of channel idle occurs some time after all nodes have actually stopped transmitting (due to idle detection times, channel effects, ringing, etc.).

3.1.4
clique
set of communication controllers having the same view of certain systems properties

EXAMPLE The global time value or the activity state of communication controllers.

3.1.5
cluster
communication system of multiple nodes connected via at least one communication channel directly (bus topology), by active stars (star topology) or by a combination of bus and star connections (hybrid topologies)

NOTE Clusters can be coupled by gateways.

3.1.6
coldstart node
node capable of initiating the communication startup procedure on the cluster by sending startup frames

NOTE TT-D coldstart nodes, TT-L coldstart nodes, and TT-E coldstart nodes are all considered to be coldstart nodes. By definition, all coldstart nodes are also sync nodes.

3.1.7
communication slot
interval of time during which access to a communication channel is granted exclusively to a specific node for the transmission of a frame with a frame ID corresponding to the slot

NOTE FlexRay distinguishes between static communication slots and dynamic communication slots.

3.1.8
cycle-dependent slot assignment
method of assigning, for a given channel, an individual slot (identified by a specific slot number and a specific cycle counter number) or a set of slots (identified by a specific slot number and a set of communication cycle numbers) to a node

3.1.9
cycle-independent slot assignment
method of assigning, for a given channel, the set of all communication slots having a specific slot number to a node (i.e., on the given channel, slots with the specific slot number are assigned to the node in all communication cycles)

3.1.10
cycle number
positive integer used to identify a communication cycle

NOTE The cycle number of each communication cycle is one greater than the cycle number of the previous cycle, except in cases where the previous cycle had the maximum cycle number value, in which case the cycle number has the value of zero. The cycle number of the first cycle is, by definition, zero.

3.1.11
cycle time
time within the current communication cycle, expressed in units of macroticks

NOTE Cycle time is reset to zero at the beginning of each communication cycle.

3.1.12
dynamic segment
portion of the communication cycle where the media access is controlled via a mini-slotting scheme

NOTE 1 During this segment access to the media is dynamically granted on a priority basis to nodes with data to transmit.

NOTE 2 Also known as Flexible Time Division Multiple Access (FTDMA).

3.1.13
dynamic slot / dynamic communication slot
interval of time within the dynamic segment of the communication cycle consisting of one or more minislots during which access to a communication channel is granted exclusively to a specific node for transmission of a frame with a frame ID corresponding to the slot

NOTE In contrast to a static communication slot, the duration of a dynamic communication slot may vary depending on the length of the frame. If no frame is sent, the duration of a dynamic communication slot equals that of one minislot.

3.1.14
frame
structure used by the communication system to exchange information within the system

NOTE A frame consists of a header segment, a payload segment and a trailer segment. The payload segment is used to convey application data.

3.1.15
frame identifier

slot position in the static segment and priority in the dynamic segment

NOTE A lower identifier indicates a higher priority.

3.1.16
global time
combination of cycle counter and cycle time

3.1.17
Hamming distance
minimum distance (i.e., the number of bits which differ) between any two valid code words in a binary code

3.1.18
implementation dependent
behaviour that, subject to restrictions in the specification, may be chosen by an implementation designer. Implementation dependent behaviour shall be described in detail in the documentation of an implementation

3.1.19
key slot
static slot that is used by a node to transmit sync and startup frames or the slot that is used to transmit when the node is operating in key slot only mode.

3.1.20
macrotick
interval of time derived from the cluster-wide clock synchronisation algorithm

NOTE A macrotick consists of an integral number of microticks. The actual number of microticks in a given macrotick is adjusted by the clock synchronisation algorithm. The macrotick represents the smallest granularity unit of the global time.

3.1.21
microtick
interval of time derived directly from the CC's oscillator (possibly through the use of a prescaler)

NOTE The microtick is not affected by the clock synchronisation mechanisms, and is thus a node-local concept. Different nodes can have microticks of different duration.

3.1.22
minislot
interval of time within the dynamic segment of the communication cycle that is of constant duration (in terms of macroticks) and that is used by the synchronized FTDMA media access scheme to manage media arbitration

3.1.23
non-coldstart node
node that is not capable of initiating the communication startup procedure (i.e., does not transmit startup frames)

3.1.24
non-sync node
node that is not configured to transmit sync frames.

3.1.25
non-synchronized operation
operation of a node when the node does not have a notion of FlexRay time, i.e., has no knowledge of slot identifier, slot boundaries, cycle counter, or segment boundaries

3.1.26
network
combination of the communication channels that connect the nodes of a cluster

3.1.27
node
logical entity connected to the network that is capable of sending and / or receiving frames

3.1.28
null frame
frame that contains no usable data in the payload segment

NOTE A null frame is indicated by a bit in the header segment, and all data bytes in the payload segment are set to zero.

3.1.29
physical communication link
inter-node connection through which signals are conveyed for the purpose of communication

NOTE All nodes connected to a given physical communication link share the same electrical or optical signals (i.e., they are not connected through repeaters, stars, gateways, etc.). Examples of a physical communication link include a bus network or a point-to-point connection between a node and a star. A communication channel may be constructed by combining one or more physical communication links together using stars.

3.1.30
precision
worst-case deviation between the corresponding macroticks of any two synchronized nodes in the cluster

3.1.31
slot
see communication slot

3.1.32
slot ID (identifier)
see slot number

3.1.33
slot multiplexing
technique of assigning, for a given channel, slots having the same slot identifier to different nodes in different communication cycles

3.1.34
slot number
number used to identify a specific slot within a communication cycle

3.1.35
star
device that allows information to be transferred from one physical communication link to one or more other physical communication links

NOTE A star duplicates information present on one of its links to the other links connected to the star. A star can be either passive or active. For the purposes of this specification, all usages of the term "star" are references to an active star as described in ISO 17458-4.

3.1.36
startup frame
FlexRay frame whose header segment contains an indicator that integrating nodes may use timerelated information from this frame for initialisation during the startup process

NOTE Startup frames are always also sync frames.

3.1.37
static slot / static communication slot
interval of time within the static segment of the communication cycle that is constant in terms of macroticks and during which access to a communication channel is granted exclusively to a specific node for transmission of a frame with a frame ID corresponding to the slot

NOTE Unlike a dynamic communication slot, each static communication slot contains a constant number of macroticks regardless of whether or not a frame is sent in the slot.

3.1.38
static segment
portion of the communication cycle where the media access is controlled via a static Time Division Multiple Access (TDMA) scheme

NOTE During this segment access to the media is determined solely by the progression of time.

3.1.39
sync frame
FlexRay frame whose header segment contains an indicator that the deviation measured between the frame's arrival time and its expected arrival time should be used by the clock synchronisation algorithm

3.1.40
sync node
node configured to transmit sync frames

NOTE Coldstart nodes and TT-D non-coldstart sync nodes are considered to be sync nodes.

3.1.41
synchronized operation
operation of a node when the node has a notion of FlexRay time, i.e., has knowledge of slot identifier, slot boundaries, cycle counter, and segment boundaries

3.1.42
time gateway
pair of nodes attached to different clusters connected by a time gateway interface

3.1.43
time gateway interface
interface used by a time gateway source node to provide timing information for a time gateway sink node

3.1.44
time gateway sink node
node configured as TT-E coldstart node, which is connected via a time gateway interface to a time gateway source node

NOTE The time gateway sink node receives timing information from the time gateway source node.

3.1.45
time gateway source node
node connected via a time gateway interface to a time gateway sink node

NOTE The time gateway source node provides timing information for the time gateway sink node.

3.1.46
time sink cluster
cluster using the TT-E synchronisation method

NOTE The term emphasizes that the TT-E coldstart nodes of this cluster receive their timing from another cluster.

3.1.47
time source cluster
cluster that provides the timing information for a time sink cluster

3.1.48
transmission slot assignment list
structure identifying the set of all slots assigned to a node for transmission

3.1.49
TT-D cluster
cluster in which the clock synchronisation uses the TT-D synchronisation method

NOTE A TT-D cluster consists of two or more TT-D coldstart nodes, zero or more TT-D non-coldstart sync nodes and, zero or more non-sync nodes.

3.1.50
TT-D coldstart node
coldstart node operating in a TT-D cluster

NOTE This node has only a single key slot and sends a startup / sync frame in the configured key slot in each cycle on each configured channel.

3.1.51
TT-D non-coldstart sync node
node that is configured to transmit sync frames but is not capable of initiating the communication startup procedure (i.e., does not send startup frames)

3.1.52
TT-D synchronisation method
method of clock synchronisation in which the clock synchronisation is derived in a distributed manner from two or more sync nodes

NOTE Two or more coldstart nodes are required to start up a cluster using this synchronisation method.

3.1.53
TT-E cluster
cluster in which the clock synchronisation uses the TT-E synchronisation method

NOTE A TT-E cluster consists of one or more TT-E Coldstart nodes and zero or more non-sync nodes.

3.1.54
TT-E coldstart node
coldstart node operating in a TT-E cluster

NOTE This node has two key slots and sends startup / sync frames in both configured key slots in each cycle on each configured channel. A TT-E coldstart node is a time gateway sink (i.e., is configured for external synchronisation) and bases its timebase on the clock sync information derived from the time source cluster as delivered by the time gateway interface.

3.1.55
TT-E synchronisation method
method of clock synchronisation in which the clock synchronisation is derived directly from the clock synchronisation of another FlexRay cluster

NOTE In this method a single coldstart node is capable of starting up the cluster.

3.1.56
TT-L cluster
cluster in which the clock synchronisation uses the TT-L synchronisation method

NOTE A TT-L cluster consists of one TT-L Coldstart node and one or more non-sync nodes.

3.1.57
TT-L coldstart node
coldstart node operating in a TT-L cluster

NOTE This node has two key slots and sends startup / sync frames in both configured key slots in each cycle on each configured channel.

3.1.58
TT-L synchronisation method
method of clock synchronisation in which the clock synchronisation is derived from the local clock of a single sync node, and in which a single coldstart node starts up the cluster

3.2 Symbols

Σ Summation symbol, a large upright capital Sigma

$\in$ Element, lower-case epsilon

$\forall$ For all (given any), universal quantifier symbol, a turned "A"

3.3 Abbreviated terms

µs	Microsecond
µT	Microtick
AP	Action Point
BD	Bus Driver
BIST	Built-In Self Test
BITSTRB	Bit Strobing Process