



International  
Standard

**ISO 11898-1**

**Road vehicles — Controller area  
network (CAN) —**

Part 1:  
**Data link layer and physical coding  
sublayer**

*Véhicules routiers — Gestionnaire de réseau de  
communication (CAN) —*

*Partie 1: Couche liaison de données et sous-couche de codage  
physique*

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## 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Data communication*.

This third edition cancels and replaces the second edition (ISO 11898-1:2015), which has been technically revised.

The main changes are as follows:

- CAN XL requirements added;
- CAN FD light protocol ([Annex A](#)) requirements added;
- editorial corrections.

A list of all parts in the ISO 11898 series can be found on the ISO website.

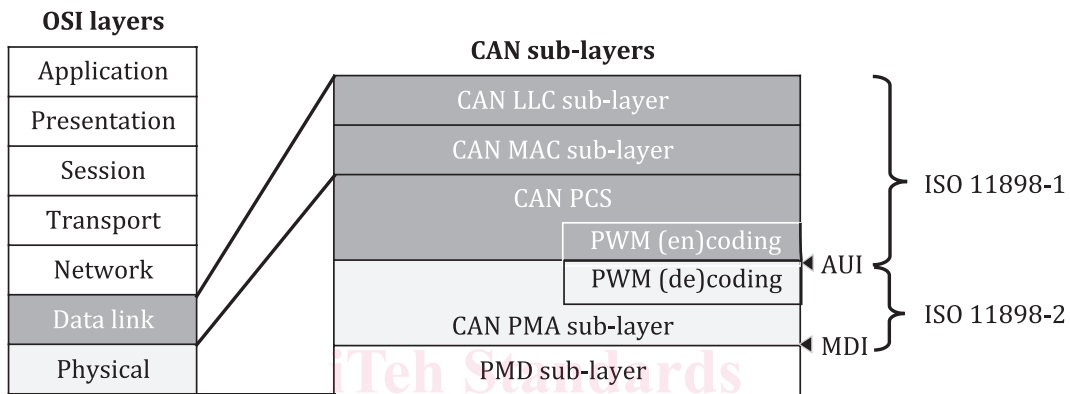
Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

The ISO 11898 series provides requirement specifications for the controller area network (CAN) data link layer and physical layer. It is intended for chip implementers, e.g. this document can be used for CAN protocol controllers and ISO 11898-2 for CAN transceivers. The CAN data link layer models the open systems interconnection (OSI) data link layer; it is internally subdivided into logic link control (LLC) and medium access control (MAC). This document also specifies the physical coding sub-layer (PCS) by means of the attachment unit interface (AUI). The PCS also provides the pulse-width modulation (PWM) encoding to be linked to a CAN SIC XL transceiver, which provides the PWM decoding.

The OSI layers above the data link layer (e.g. the network layer) are not specified in the ISO 11898 series of specifications.

Figure 1 shows the relationship between the OSI layers and the CAN sub-layers.



### Key

AUI attachment unit interface

LLC logic link control

MAC medium access control

MDI medium dependent interface

PCS physical coding sub-layer

PMA physical medium attachment

PMD physical medium dependent

PWM pulse-width modulation

Figure 1 — CAN data link and physical sub-layers in relation to the OSI model

# Road vehicles — Controller area network (CAN) —

## Part 1: Data link layer and physical coding sublayer

### 1 Scope

This document specifies the controller area network (CAN) data link layer (DLL) and the physical coding sub-layer (PCS). The CAN DLL features data fields of up to 2048 byte when the CAN extended data field length (XL) frame format is used.

This document divides the CAN DLL into the logical link control (LLC) and the medium access control (MAC) sub-layers. The DLL's service data unit (SDU), which interfaces the LLC and the MAC, is implemented by means of the LLC frame. The LLC frame also features the service data unit type (SDT) and the virtual CAN channel identifier (VCID), which provide higher-layer protocol configuration and identification information. How the higher-layer functions are handled is not specified in this document. There are five implementation options:

- 1 support of the CAN classic frame format only, not tolerating the CAN flexible data rate (FD) frame format;
- 2 support of the CAN classic frame format and tolerating the CAN FD frame format;
- 3 support of the CAN classic frame format and the CAN FD frame format;
- 4 support of the CAN classic frame format, the CAN FD frame format and the CAN XL frame format;
- 5 support of the CAN FD frame format for CAN FD light responders ([Annex A](#)).

**NOTE** Nodes of the first option can communicate with nodes of the third and fourth option when only the CAN classic frame format is used. Nodes of the first option cannot communicate with nodes of the fifth option: any attempt at communication generates error frames. Therefore, new designs implementing the fourth option can communicate with all other nodes.

### 2 Normative references

There are no normative references in this document.

### 3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.1

##### **arbitration mode**

operating mode of the physical coding sub-layer (PCS) in which it is allowed that dominant bits can overwrite recessive bits

### 3.2

#### **arbitration phase**

phase in which the *nominal bit time* (3.42) is used

### 3.3

#### **attachment unit interface**

##### **AUI**

interface between the physical coding sub-layer (PCS) and the physical medium attachment (PMA) sub-layer

### 3.4

#### **bit stuffing**

frame coding method providing *bus state* (3.8) changes required for periodic resynchronization when using a *non-return-to-zero* (NRZ) (3.43) bit representation

Note 1 to entry: Two types of bit stuffing exist: dynamic bit stuffing and fixed bit stuffing. The *transmitter* (3.54) adds stuff bits into the outgoing bit stream and *receivers* (3.48) de-stuff the *data frames* (3.16) and the *remote frames* (3.49) i.e. the inverse procedure is carried out.

### 3.5

#### **bus**

shared medium of any topology

### 3.6

#### **bus comparator**

physical coding attachment comparator

electronic circuit converting analogue signals used for transfer across the communication medium back into digital signals

### 3.7

#### **bus driver**

electronic circuit converting digital signals into analogue signals so that these signals can be transferred across the communication medium, i.e. the *bus* (3.5)

### 3.8

#### **bus state**

one of two complementary logical states: dominant or recessive

Note 1 to entry: The dominant state represents the logical 0, and the recessive state represents the logical 1. This document uses the terms "dominant" and "recessive" for the bit values of the medium access control (MAC) frame, independent of the *transceiver mode* (3.53). When no transmission is in progress, the *bus* (3.5) is *idle* (3.33). During idle time, it is in recessive state.

### 3.9

#### **bus-off**

state of a *node* (3.39) in which it does not influence the *bus* (3.5)

### 3.10

#### **classic base frame format**

##### **CBFF**

format for *data frames* (3.16) or *remote frames* (3.49) using an 11-bit *identifier* (3.31) and which are transmitted with one single bit rate and up to and including eight data bytes

### 3.11

#### **classic extended frame format**

##### **CEFF**

format for *data frames* (3.16) or *remote frames* (3.49) using a 29-bit *identifier* (3.31) and which are transmitted with one single bit rate and up to and including eight data bytes

### 3.12

#### **classic frame**

*data frame* (3.16) or *remote frame* (3.49) using the *CC base frame format* (3.10) or the *classic extended frame format* (3.11)



**3.13**

**commander node**

*node* (3.39) that sends data frames to *responder nodes* (3.50) to initiate a controller area network (CAN) *FD light* (3.26) communication

**3.14**

**data bit rate**

number of bits per time during *data phase* (3.17), independent of bit encoding/decoding

**3.15**

**data bit time**

duration of one bit in *data phase* (3.17), defined by a number of data time quanta in the bit

**3.16**

**data frame**

**DF**

*frame* (3.28) containing application content

**3.17**

**data phase**

phase in which the *data bit time* (3.15) is used

**3.18**

**data RX mode**

operating mode of the physical medium attachment (PMA) sub-layer in which the *bus states* (3.8) can be different from the bus states in the *arbitration mode* (3.1)

**3.19**

**data TX mode**

operating mode of the physical medium attachment (PMA) sub-layer in which it can drive the *bus states* (3.8) differently than it drives them in the *arbitration mode* (3.1)

**3.20**

**edge**

difference in *bus states* (3.8) between two consecutive time quanta

**3.21**

**error frame**

**EF**

*frame* (3.28) indicating the detection of an error condition

**3.22**

**FD base frame format**

**FBFF**

format for *data frames* (3.16) using an 11-bit *identifier* (3.31), which can be transmitted with a flexible bit rate

**3.23**

**FD enabled**

able to receive and to transmit *FD frames* (3.25) as well as *CC frames* (3.12)

**3.24**

**FD extended frame format**

**FEFF**

format for *data frames* (3.16) using a 29-bit *identifier* (3.31), which can be transmitted with a flexible bit rate

**3.25**

**FD frame**

*data frame* (3.16) using the *FD base frame format* (3.22) or *FD extended frame format* (3.24)

**3.26**

**FD light**

implementation option for a *responder node* (3.50) that is based on a subset of the controller area network (CAN) functionality.

**3.27**

**FD tolerant**

not able to receive or to transmit *FD frames* (3.25), but not disturbing them

**3.28**

**frame**

protocol data unit of the data link layer specifying the arrangement and meaning of bits or bit fields in the sequence of transfer across the transmission medium

**3.29**

**handle**

label of one or multiple logical link control (LLC) frames, or data link layer service data units (LSDU), the data link layer (DLL)'s interface data coming from the higher open systems interconnection (OSI) layers (network layer or transport layer)

**3.30**

**higher-layer protocol**

**HLP**

*protocol* (3.46) above the data link layer protocol, e.g. transport layer protocol or network layer protocol according to the open system interconnection model

**3.31**

**identifier**

**ID**

unique label reflecting the *priority* (3.45) of a particular *frame* (3.28)

**3.32**

**identifier-based arbitration**

carrier sense multiple access/collision resolution arbitration procedure resolving *bus* (3.5) contention when multiple *nodes* (3.39) simultaneously access the bus

**3.33**

**idle**

operating condition of the *bus* (3.5) after the completion of a *frame* (3.28) until the next frame starts

**3.34**

**idle condition**

detection of a consecutive sequence of 11 sampled recessive bits

**3.35**

**integrating**

status of a *node* (3.39) waiting on an *idle condition* (3.34) after starting the protocol operation during *bus-off* (3.9) recovery or after a *protocol exception event* (3.47)

**3.36**

**minimum time quantum**

smallest time quantum that can be configured for the specific *node* (3.39)

**3.37**

**multi master**

network with several nodes where every *node* (3.39) is allowed to start sending a *frame* (3.28) when the controller area network (CAN) *bus* (3.5) is *idle* (3.33)

**3.38**

**multicast**

address method transmitting a single *frame* (3.28) to a group of *nodes* (3.39)

Note 1 to entry: A broadcast is a special case of multicast, whereby a single frame is addressed to all nodes simultaneously.

**3.39**

**node**

assembly, linked to a communication network, capable of communicating across the network according to a communication protocol specification (a node can be in one of four states: *integrating* (3.35), *idle* (3.33), *receiver* (3.48), or *transmitter* (3.54))

Note 1 to entry: A node operating in a controller area network (CAN) is called a CAN node.

**3.40**

**node clock**

time base to coordinate the bit-time-related state machines in controller area network (CAN) *nodes* (3.39)

**3.41**

**nominal bit rate**

number of bits per time during an *arbitration phase* (3.2), independent of the bit-encoding/decoding

**3.42**

**nominal bit time**

duration of one bit in an *arbitration phase* (3.2), defined by a number of nominal time quanta in the bit

**3.43**

**non-return-to-zero**

**NRZ**

method of representing binary signals, i.e. within one and the same bit time, the signal level does not change, where a stream of bits having the same logical value provides no *edges* (3.20)

**3.44**

**overload frame**

**OF**

*frame* (3.28) indicating an overload condition

**3.45**

**priority**

attribute to a *data frame* (3.16) and to a *remote frame* (3.49) controlling its ranking during the arbitration

Note 1 to entry: A high priority increases the probability that a data frame or a remote frame wins the arbitration process. Further details are given in 6.6.17.5.

**3.46**

**protocol**

formal set of conventions or rules for the exchange of information between *nodes* (3.39), including the specification of frame administration, frame transfer and physical medium attachment (PMA)

**3.47**

**protocol exception event**

either exception from the formal set of conventions or rules to be able to tolerate future new frame formats, or reaction to errors when controller area network (CAN) XL is used with error signalling disabled

**3.48**

**receiver**

*node* (3.39) that, while the *bus* (3.5) is not *idle* (3.33), is neither transmitting nor *integrating* (3.35)

**3.49**

**remote frame**

**RF**

*frame* (3.28) that requests the transmission of a dedicated *data frame* (3.16)

**3.50**

**responder node**

*node* (3.39) that is controlled by a *commander node* (3.13) using controller area network (CAN) *FD light* (3.26) communication

**3.51**

**stuff bit count**

**SBC**

number of stuff bits in a *frame* (3.28) before the cyclic redundancy check (CRC) field, not including fixed stuff bits

**3.52**

**transceiver**

electronic circuit, implementing the physical medium attachment (PMA) sub-layer, that connects controller area network (CAN) *nodes* (3.39) to a *CAN bus* (3.5) consisting of a *bus comparator* (3.6) and a *bus driver* (3.7)

**3.53**

**transceiver mode**

operating mode of the physical medium attachment (PMA) sub-layer

**3.54**

**transmitter**

*node* (3.39) sending a *data frame* (3.16) or a *remote frame* (3.49)

Note 1 to entry: A node remains a transmitter until the *bus* (3.5) is *idle* (3.33) again or until the node loses arbitration.

**3.55**

**XL frame**

*data frame* (3.16) using the *XL frame format* (3.56)

**3.56**

**XL frame format**

**XLFF**

format for *data frames* (3.16) using an 11-bit *identifier* (3.31), including up to 2048 data bytes, where the bit rate is switched at the beginning and at the end of the *data phase* (3.17)

**4 Symbols and abbreviated terms**

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

ACK	acknowledgement
ADH	arbitration to data high
ADS	arbitration to data sequence
AF	acceptance field
AH1	arbitration high 1
AH2	arbitration high 2
AL1	arbitration low 1
BCH code	Bose-Chaudhuri-Hocquenghem code

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BRS	bit rate switch
CAN	controller area network
CC	classic
CRC	cyclic redundancy check
DAH	data arbitration high
DAS	data to arbitration sequence
DF	data frame
DH	data high bit
DL	data low bit
DLC	data length code
DLL	data link layer
EOF	end of frame
ESI	error state indicator
FCE	fault confinement entity
FCP	format check pattern
FCRC	frame CRC
FD	flexible data rate
FDF	flexible data rate format indicator
FTYP	frame type
IDE	identifier extension
IPT	information processing time
LLC	logical link control
LME	layer management entity
LPDU	logical link control protocol data unit
LSB	least significant bit
LSDU	logical link control service data unit
MAC	medium access control
MPDU	medium access control protocol data unit
MSB	most significant bit
nCRC	order of the generated polynomia
NRZ	non-return-to-zero

OF	overload frame
OSI	open systems interconnection
PCRC	preface cyclic redundancy check
PCS	physical coding sub-layer
PDU	protocol data unit
PL	physical layer
PMA	physical medium attachment
PMD	physical medium dependent
PWM	pulse width modulation
PWML	pulse width modulation long phase
PWMO	pulse width modulation offset time
PWMS	pulse width modulation short phase
resXL	reserved bit extended data field length format
RRS	remote request substitution
RTR	remote transmission request
SDT	service data unit type
SDU	service data unit
SEC	simple/extended content
SIC	signal improvement capability
SJW	synchronization jump width
SOF	start of frame
SSP	secondary sample point
$t_q$	time quantum/time quanta
$t_{q.min}$	minimum time quantum
VCID	virtual controller area network channel identifier
XL	extended data field length
XLF	extended data field length format indicator

## 5 Basic concepts of CAN

### 5.1 CAN properties

A CAN has the following properties:

- multi-master priority-based bus access;