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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

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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.

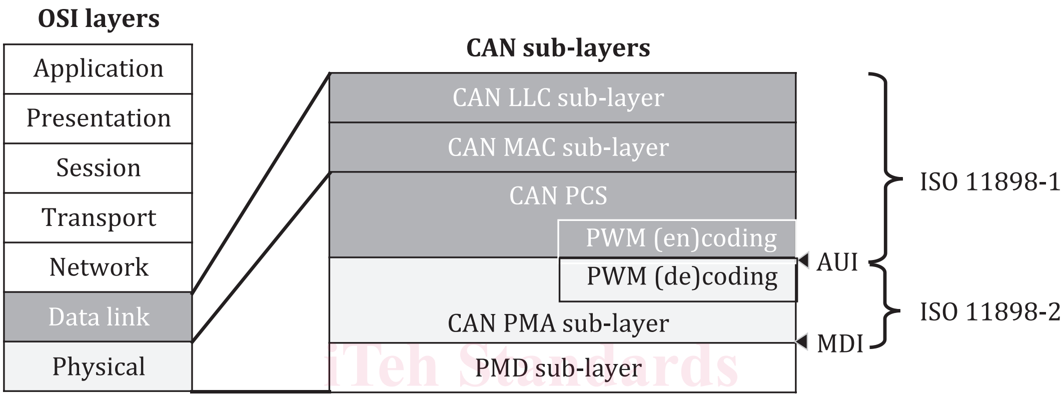
Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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-with 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 will generate 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 coding 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
CBFF
classic base frame format
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
CEFF
classic extended frame format
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 coding 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 coding 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 coding 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 coding 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 coding 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
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
FEFF	flexible data rate extended frame format
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