INTERNATIONAL STANDARD

ISO 11898-1

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Road vehicles — Controller area network (CAN) —

Part 1: Data link layer and physical signalling

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

Partie 1: Couche liaison et signalisation physique

Reference number
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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.

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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.

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ISO 11898-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This first edition of ISO 11898-1, together with ISO 11898-2, replaces ISO 11898:1993, which has been technically revised. Whereas the replaced International Standard covered both the CAN DLL and the high-speed PL, ISO 11898-1 specifies the DLL, including LLC and MAC sublayers, as well as the PLS sublayer, while ISO 11898-2 specifies the high-speed MAU.

ISO 11898 consists of the following parts, under the general title *Road vehicles — Controller area network (CAN)*:

— *Part 1: Data link layer and physical signalling*

— *Part 2: High-speed medium access unit*

— *Part 3: Low-speed, fault-tolerant, medium dependent interface*

— *Part 4: Time-triggered communication*

Road vehicles — Controller area network (CAN) —

Part 1: Data link layer and physical signalling

1 Scope

This part of ISO 11898 specifies the data link layer (DLL) and physical signalling of the controller area network (CAN): a serial communication protocol that supports distributed real-time control and multiplexing for use within road vehicles. While describing the general architecture of CAN in terms of hierarchical layers according to the ISO reference model for open systems interconnection (OSI) established in ISO/IEC 7498-1, it provides the characteristics for setting up an interchange of digital information between modules implementing the CAN DLL — itself specified according to ISO/IEC 8802-2 and ISO/IEC 8802-3 — with detailed specification of the logical link control (LLC) sublayer and medium access control (MAC) sublayer.

2 Conformance

The conformance of the DLL shall be tested according to ISO 16845.

3 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/IEC 7498-1, *Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model*

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 8802-3, *Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO 16845, *Road vehicles — Controller area network (CAN) — Conformance test plan*

4 Terms and definitions

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

4.1
bit rate
number of bits per time during transmission, independent of bit representation

4.2
bit stuffing
filling using bits to provide bus state changes required for periodic resynchronization when using an NRZ bit representation

NOTE Whenever the transmitting logic encounters a certain number (stuff width) of consecutive bits of equal value in the data, it automatically stuffs a bit of complementary value — a stuff bit — into the outgoing bit stream. Receivers destuff the frame, i.e. the inverse procedure is carried out.

4.3
bit time
t_B
duration of one bit

4.4
bus
topology of a communication network, where all nodes are reached by passive links which allow transmission in both directions

4.5
bus comparator
device converting physical signals used for transfer across the communication medium back into logical information or data signals

4.6
bus driver
device converting information or data signals into physical signals so that these signals can be transferred across the communication medium

4.7
bus state
one of two complementary logical states: dominant or recessive

NOTE The dominant state represents the logical 0, and the recessive state represents the logical 1. During simultaneous transmission of dominant and recessive bits, the resulting bus state is dominant. When no transmission is in progress, the bus is idle. During that time it is in the recessive state.

4.8
contention-based arbitration
CSMA arbitration procedure where simultaneous access of multiple nodes results in a contention

4.9
frame
data link PDU specifying the arrangement and meaning of bits or bit fields in the sequence of transfer across the transmission medium

4.10
multicast
addressing where a single frame is addressed to a group of nodes simultaneously

NOTE *Broadcast* is a special case of multicast, whereby a single frame is addressed to all nodes simultaneously.

4.11
multimaster
system partitioned into several nodes where every node may temporarily control the action of other nodes

4.12
node
assembly, linked to a communication network, capable of communicating across the network according to a communication protocol specification

NOTE A CAN node is a node communicating across a CAN network.

4.13
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

4.14
priority
attribute to a frame controlling its ranking during arbitration, a high priority increases the probability that a frame wins the arbitration process

4.15
protocol
formal set of conventions or rules for the exchange of information between nodes, including the specification of frame administration, frame transfer and PL

4.16
receiver
node when if it is not a transmitter and the bus is not idle

4.17
time-triggered communication
option where a frame can be transmitted at a specific time slot, also providing a global synchronization of clocks and allowing the disabling of the automatic retransmission of frames

4.18
transmitter
node originating a data frame or remote frame, which stays transmitter until the bus is idle again or until the node loses arbitration

5 Symbols and abbreviated terms

ACK	acknowledgement
BCH	Bose-Chaudhuri-Hocquenghem
BR	bit rate
t_B	bit time
CAN	controller area network
CRC	cyclic redundancy check
CSMA	carrier sense multiple access
DLC	data length code
DLL	data link layer

EOF	end of frame
FCE	fault confinement entity
IC	integrated circuit
IDE	identifier extension flag
LAN	local area network
LLC	logical link control
LME	layer management entity
LPDU	LLC protocol data unit
LSB	least significant bit
LSDU	LLC service data unit
MA	medium access
MAC	medium access control
MAU	medium access unit
MDI	medium dependent interface
MPDU	MAC protocol data unit
MSB	most significant bit
MSDU	MAC service data unit
NRZ	non-return-to-zero
OSI	open system interconnection
OVLD	overload
PCI	protocol control information
PDU	protocol data unit
PL	physical layer
PLS	physical signalling
PMA	physical medium attachment
REC	receive error counter
RTR	remote transmission request
SDU	service data unit
SJW	synchronization jump width
SOF	start of frame
SRR	substitute remote request
TEC	transmit error counter
TTC	time triggered communication

6 Basic concepts of CAN

6.1 CAN properties

CAN shall have the following properties:

— multi-master priority-based bus access;

— non-destructive contention-based arbitration;

— multicast frame transfer by acceptance filtering;

— remote data request;

— configuration flexibility;

— system-wide data consistency;

— error detection and error signalling;

— automatic retransmission of frames that have lost arbitration or have been destroyed by errors during transmission;

— distinction between temporary errors and permanent failures of nodes and autonomous switching-off of defective nodes.

6.2 Frames

Information on the bus shall be sent in fixed format frames of different but limited length. When the bus is idle, any connected node may start to transmit a new frame.

6.3 Bus access method

When the bus is idle, any node may start to transmit a frame. If two or more nodes start to transmit frames at the same time, the bus access conflict shall be resolved by contention-based arbitration using the identifier. The mechanism of arbitration shall ensure that neither information nor time is lost. The transmitter with the frame of highest priority shall gain the bus access.

6.4 Information routing

In CAN systems a node shall not make use of any information about the system configuration (e.g. node address). Instead, receivers accept or do not accept information based upon a process called frame acceptance filtering, which decides whether the received information is relevant or not. There is no need for receivers to know the transmitter of the information and vice versa.

6.5 System flexibility

Nodes may be added to the CAN network without requiring any change in the software or hardware of any node, if the added node is not the transmitter of any data frame and if the added node does not require any additional transmitted data.

6.6 Data consistency

Within CAN a frame shall simultaneously be accepted either by all nodes or by none. Thus data consistency shall be a property of the system achieved by the concepts of multicast and by error handling.

6.7 Remote data request

By sending a remote frame, a node requiring data may request another node to send the corresponding data frame. The data frame and the corresponding remote frame shall be named by the same identifier.

6.8 Error detection

For detecting errors, the following measures shall be provided:

— monitoring (transmitters compare the bit levels to be transmitted with the bit levels detected on the bus);

— 15-bit CRC;

— variable bit stuffing with a stuff width of 5;

— frame check;

— acknowledge check.

6.9 Error signalling and recovery time

Corrupted frames shall be flagged by any transmitting node and any normally operating (error-active) receiving node. Such frames shall be aborted and retransmitted according to the implemented recovery procedure (see 8.3.4). The recovery time from detecting an error until the possible start of the next frame shall be typically seventeen (17) to twenty-three (23) bit times [in the case of a heavily disturbed bus, up to thirty-one (31) bit times], if there are no further errors.

6.10 ACK

All receivers shall check the consistency of the received frame and shall acknowledge a consistent frame and shall flag an inconsistent frame. A frame that is not acknowledged is corrupted and shall be flagged by the transmitting node.

6.11 Automatic retransmission

Frames that have lost arbitration and frames that have been disturbed by errors during transmission shall be retransmitted automatically when the bus is idle again. A frame that will be retransmitted shall be handled as any other frame, i.e. it participates in the arbitration process to gain bus access. In case of TTC, the automatic retransmission shall be disabled (see 9.2.5).

6.12 Fault confinement

CAN nodes shall be able to distinguish short disturbances from permanent failures. Defective transmitting nodes shall be switched off. *Switched off* means a node is logically disconnected from the bus, so that it can neither send nor receive any frames (see 13.1.4.3).

6.13 Error-active

An error-active node shall normally take part in bus communication and send an active error flag when an error has been detected. The active error flag shall consist of six (6) consecutive dominant bits and shall violate the rule of bit stuffing and all fixed formats appearing in a regular frame (see 13.1.4.2).

6.14 Error-passive

An error-passive node shall not send an active error flag. It takes part in bus communication, but when an error has been detected a passive error flag shall be sent. The passive error flag shall consist of six (6) consecutive recessive bits. After transmission, an error-passive node shall wait some additional time before initiating a further transmission (see suspend transmission in 10.4.6.4, and 13.1.4.2).

6.15 Bus-off

A node shall be in the bus-off state when it is switched off from the bus due to a request of FCE. In the bus-off state, a node shall neither send nor receive any frames. A node shall start the recovery from bus-off state only upon a user request.

7 Layered architecture of CAN

7.1 Reference to OSI model

According to the OSI reference model, the CAN architecture of this part of ISO 11898 shall represent the two layers,

— DLL, and

— PL.

See Figure 1.

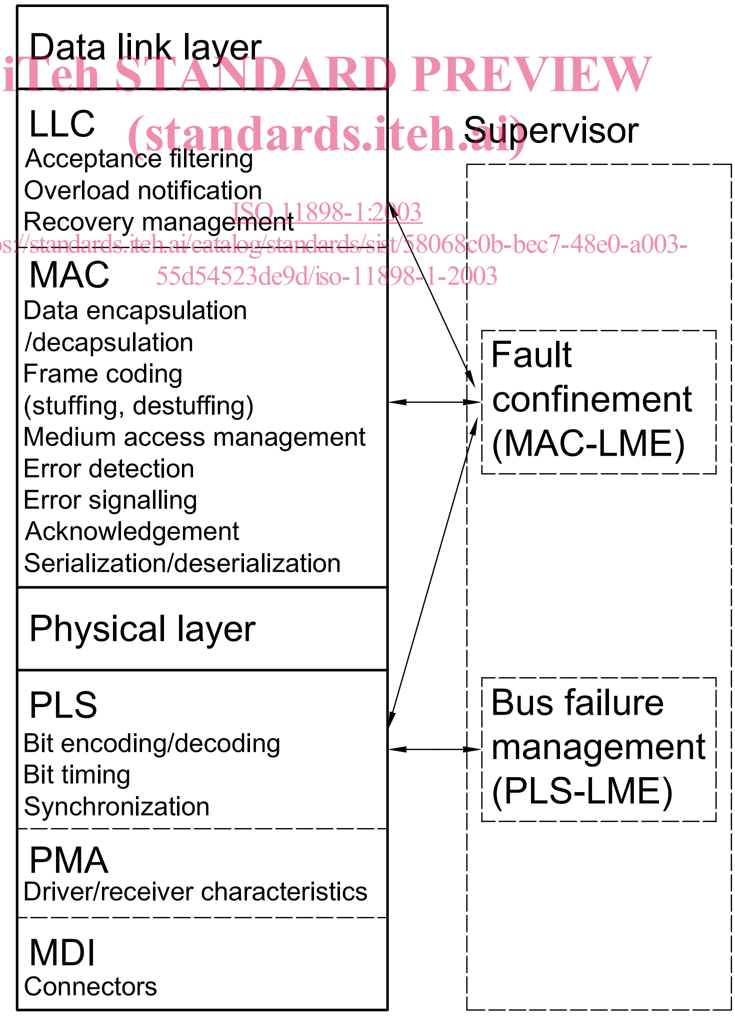

Figure 1 — Layered architecture of CAN

According to ISO/IEC 8802-2 and ISO/IEC 8802-3, the DLL has been subdivided into

— LLC, and

— MAC.

The PL has been subdivided into

— PLS,

— PMA, and

— MDI.

The MAC sublayer operations shall be supervised by an FCE. Fault confinement shall be a self-checking mechanism that distinguishes short disturbances from permanent failures (for fault confinement, see 13.1).

The PL may be supervised by an entity that detects and manages failures of the physical medium.

7.2 Protocol specification

Two peer protocol entities shall communicate with each other by exchanging frames or PDUs.

An NPDU shall consist of N-PCI and (N)-user data. NPDU shall be passed to a ($N-1$)-layer entity via a ($N-1$)-SAP. The NPDU shall be passed by means of the ($N-1$)-SDU to the ($N-1$)-layer, the services of which allow the transfer of the NPDU. The SDU shall be the interface data whose identity is preserved between (N)-layer entities, i.e. it represents the logical data unit transferred by a service. The DLL of the CAN protocol shall not provide either the means for mapping one SDU into multiple PDUs or for mapping multiple SDUs into one PDU, i.e. an NPDU is directly constructed from the associated NSDU and the layer-specific control information N-PCI. Figure 2 illustrates the data link sublayer interactions.

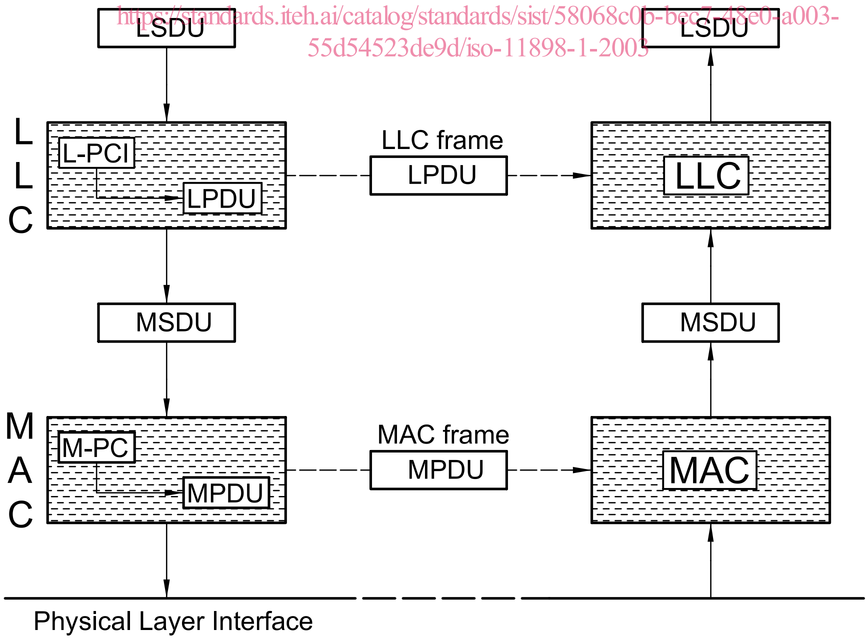

Figure 2 — Protocol layer interactions

7.3 Format description of services

7.3.1 Format description of service primitives

Service primitives shall be written as

service.type (

[parameter1,...]

)

where *service* indicates the name of the service, e.g. L_Data for data transfer service provided by the LLC sublayer, *type* indicates the type of the service primitives (see 7.3.2), and [parameter1,...] is the list of values passed to the service primitives. The square brackets indicate that this parameter list may be empty.

7.3.2 Types of service primitives

Service primitives shall be of three generic types:

a) Service.Request

The request primitive shall be passed from the (*N*)-user (service user) to the (*N*)-layer (service provider) to request initiation of the service.

b) Service.Indication

The indication primitive shall be passed from the (*N*)-layer to the (*N*)-user to indicate an internal (*N*)-layer (or sublayer) event which is significant to the (*N*)-user. This event may be logically related to a remote service request, or may be caused by an event internal to the (*N*)-layer (or sublayer).

c) Service.Confirm

The confirm primitive shall be passed from the (*N*)-layer (or sublayer) to the (*N*)-user to convey the results of one or more associated previous service request(s). This primitive may indicate either failure to comply or some level of compliance. It shall not necessarily indicate any activity at the remote peer interface.

7.4 LLC interface

The LLC sublayer shall offer two types of connectionless transmission services to the LLC user:

a) unacknowledged data transfer service;

b) unacknowledged remote data request service.

The interface service data sent from or to the user shall be as in 8.2.2. The messages sent between LLC user and LLC sublayer shall be as shown in a) and b) of Table 1.

The LLC interface messages sent from and to the supervisor FCE shall be as in 13.1.3.

Table 1 — Messages between LLC user and LLC sublayer

a) Message sent from LLC user to LLC sublayer	
User to LLC message	**Meaning**
Reset_Request	Request to set the node into an initial state
b) Messages sent from LLC sublayer to LLC user	
LLC to user message	**Meaning**
Reset_Response	Response to the Reset_Request
Node_Status	Indicates the current status of the node, i.e. it signals whether or not the node is in the bus-off state.