INTERNATIONAL STANDARD

ISO 11519-2

First edition
1994-06-15

Road vehicles — Low-speed serial data communication —

Part 2:
Low-speed controller area network (CAN)

Véhicules routiers — Communication en série de données à basse vitesse —

Partie 2: Réseau local à commande à basse vitesse (CAN)

Reference number
ISO 11519-2:1994(E)

Contents

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

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.

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.

International Standard ISO 11519-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Sub-Committee SC 3, *Electrical and electronic equipment*.

ISO 11519 consists of the following parts, under the general title *Road vehicles — Low-speed serial data communication*:

— *Part 1: General and definitions*

— *Part 2: Low-speed controller area network (CAN)*

— *Part 3: Vehicle area network (VAN)*

— *Part 4: Class B data communication network interface (J1850)*

Road vehicles — Low-speed serial data communication —

Part 2:
Low-speed controller area network (CAN)

1 Scope

This part of ISO 11519 specifies the data link layer and the physical layer of the low-speed Controller Area Network (CAN), a communications network up to 125 kbit/s, for road vehicle application. The low-speed CAN is a serial communication protocol supporting distributed real-time control and multiplexing.

This specification describes the general architecture of CAN in terms of the hierarchical layers defined in the ISO-OSI model according to ISO 7498.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 11519. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 11519 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7498:1984, *Information processing systems — Open Systems Interconnection — Basic Reference Model.*

ISO 8802-2:1989, *Information processing systems — Local area networks — Part 2: Logical link control.*

ISO/IEC 8802-3:1993, *Information technology — Local and metropolitan area networks — Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.*

ISO 11519-1:1994, *Road vehicles — Low-speed serial data communication — Part 1: General and definitions.*

3 Definitions and abbreviations

For the purposes of this part of ISO 11519 the definitions given in ISO 11519-1 apply. The following additional definitions and abbreviations are specific to this part of ISO 11519.

3.1 Data link layer definitions

3.1.1 bit stuffing: Technique used in bit-oriented protocols in order

— to achieve data transparency (arbitrary bit patterns may not be interpreted as protocol information) and

— to provide "dominant" to "recessive" edges, and vice versa, which are necessary for correct resynchronization when using a non-return-to-zero bit representation.

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 stuffbit — into the outgoing bit stream. Receivers destuff the frame, i.e. the inverse procedure is carried out.

3.1.2 bus value: One of two complementary logical values: "dominant" or "recessive". The "dominant" value represents the logical "0" and the "recessive" represents the logical "1". During simultaneous transmission of "dominant" and "recessive" bits, the resulting bus value will be "dominant".

3.1.3 multicast: Method by which a single frame is addressed to a group of nodes simultaneously.

3.1.4 broadcast: Special case of multicast, whereby a single frame is addressed to all nodes simultaneously.

3.1.5 receiver: Device that converts signals used for transmission back into logical information or data signals.

3.1.6 transmitter: Device that converts information or data signals to electrical or optical signals so that these signals can be transferred across the communication medium.

3.2 Physical layer definitions

3.2.1 common mode bus voltage range: Boundary voltage levels of V_{CAN_L} and V_{CAN_H}, for which proper operation is guaranteed if the maximum number of electronic control units (ECUs) are connected to the bus line.

3.2.2 differential internal capacitance, C_{diff}: Capacitance of an ECU which is seen between CAN_L and CAN_H during the recessive state when the ECU is disconnected from the bus line (see figure 1).

3.2.3 differential internal resistance, R_{diff}: Resistance of an ECU which is seen between CAN_L and CAN_H during the recessive state when the ECU is disconnected from the bus line (see figure 1).

3.2.4 differential voltage, V_{diff}:

$$V_{diff} = V_{CAN\_L} - V_{CAN\_H}$$

where V_{CAN_L} and V_{CAN_H} are the voltages of CAN_L and CAN_H, respectively, relative to ground of each individual ECU.

3.2.5 internal capacitance, C_{in}: Capacitance of an ECU which is seen between CAN_L (or CAN_H) and ground during the recessive state when the ECU is disconnected from the bus line (see figure 1).

3.2.6 internal delay time, t_{ECU}: Sum of all asynchronous delay times of an ECU occurring on the transmitting and receiving paths, relative to the bit timing logic unit of the protocol IC of each individual ECU disconnected from the bus line.

3.2.7 internal resistance, R_{in}: Resistance of an ECU which is seen between CAN_L (or CAN_H) and ground during the recessive state when the ECU is disconnected from the bus line (see figure 1).

3.2.8 physical layer: Electrical circuit realization that connects an ECU to a bus. The total number of ECUs connected on a bus is limited by electric loads on the bus line.

3.2.9 physical media: Pair of parallel wires of the bus, shielded or unshielded, depending on EMC requirements. The individual wires are denoted as CAN_L and CAN_H. The corresponding pins of ECUs are also denoted by CAN_L and CAN_H.

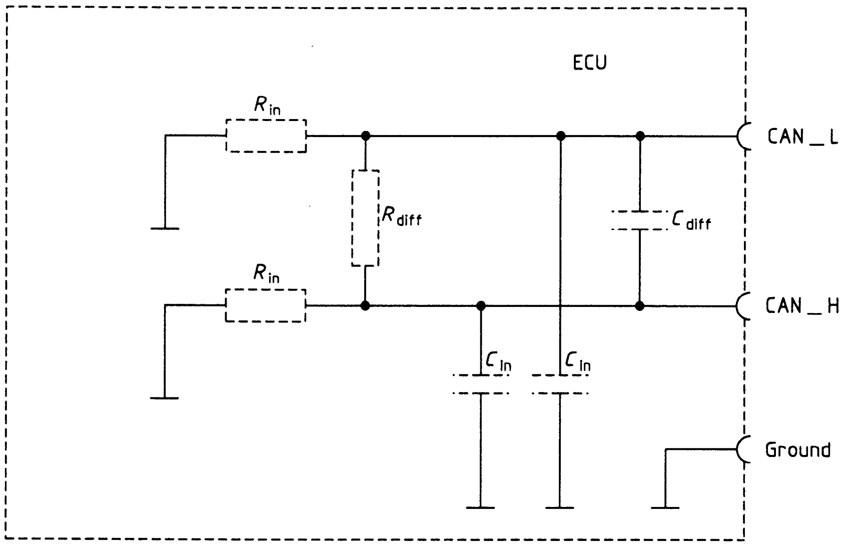


Figure 1 — Definitions of internal capacitances and internal resistances of an ECU

3.3 List of abbreviations

ACK Acknowledgement

ECU Electronic Control Unit

EOF End Of Frame

CAN Controller Area Network

CRC Cyclic Redundancy Check

DLC Data Length Code

IC Integrated Circuit

FCE Fault Confinement Entity

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

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
PL	Physical Layer
PLS	Physical Signalling
PMA	Physical Medium Attachment
RTR	Remote Transmission Request
SOF	Start Of Frame

4 Basic concepts of CAN

CAN has the following properties:

— multimaster 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.

This part of ISO 11519 specifies the low-speed CAN for applications up to 125 kbit/s.

4.1 Frames

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

4.2 Bus access method

When the bus is free, 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 is resolved by contention-based arbitration using the identifier. The mechanism of arbitration guarantees that neither information nor time is lost. The transmitter with the frame of highest priority gains bus access.

4.3 Information routing

In CAN systems a node does 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.

4.4 System flexibility

Nodes can 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 (see 8.3.1).

4.5 Data consistency

Within a CAN network it is guaranteed that a frame is simultaneously accepted either by all nodes or by no node. Thus data consistency is a property of the system, achieved by the concepts of multicast and by error handling.

4.6 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 are named by the same identifier.

4.7 Error detection

The following measures are provided for detecting errors:

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

— 15-bit cyclic redundancy check;

— variable bit stuffing with a stuff width of 5;

— frame check.

4.8 Error signalling and recovery time

Corrupted frames are flagged by any transmitting node and any normally operating (error-active) receiving node. Such frames are aborted and will be retransmitted according to the implemented recovery procedure (see 6.4.3). The recovery time, from detecting an error until the possible start of the next frame, is typically 17 bit times to 23 bit times (in the case of a heavily disturbed bus up to 29 bit times), if there are no further errors.

4.9 Acknowledgement

All receivers check the consistency of the received frame, and will acknowledge a consistent frame and flag an inconsistent frame.

4.10 Automatic retransmission

Frames that have lost arbitration and frames that have been disturbed by errors during transmission will be re-transmitted automatically when the bus is idle again. A frame that will be retransmitted is handled like any other frame, i.e. it participates in the arbitration process in order to gain bus access.

4.11 Fault confinement

CAN nodes are able to distinguish short disturbances from permanent failures. Defective transmitting nodes are switched off. "Switched off" means that a node is logically disconnected from the bus line, so that it can neither send nor receive any frames.

4.12 "error-active"

An "error-active" node can normally take part in bus communication and send an active error flag when an error has been detected. The active error flag consists of six dominant consecutive bits and violates the rule of bit stuffing, all fixed formats appearing in a regular frame (see 11.1.5).

4.13 "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 is sent. The passive error flag consists of six recessive consecutive bits. After transmission, an "error-passive" node will wait an additional time before initiating a further transmission (see suspend transmission in 8.3.5 and 11.1.5).

4.14 "bus off"

A node is in the state "bus off" when it is switched off from the bus due to a request of a fault confinement entity. In the "bus off" state, a node can neither send nor receive any frames. A node can leave the "bus off" state only upon a user request.

5 Layered architecture of CAN

5.1 Reference to the OSI model

According to the OSI reference model, the CAN architecture represents two layers:

— data link layer,

— physical layer.

This standard describes the data link layer and physical layer of CAN, as shown in figure 2.

According to ISO 8802-2 and ISO 8802-3 (LAN standards), the data link layer is subdivided into:

— Logical Link Control (LLC);

— Medium Access Control (MAC).

The physical layer is subdivided into:

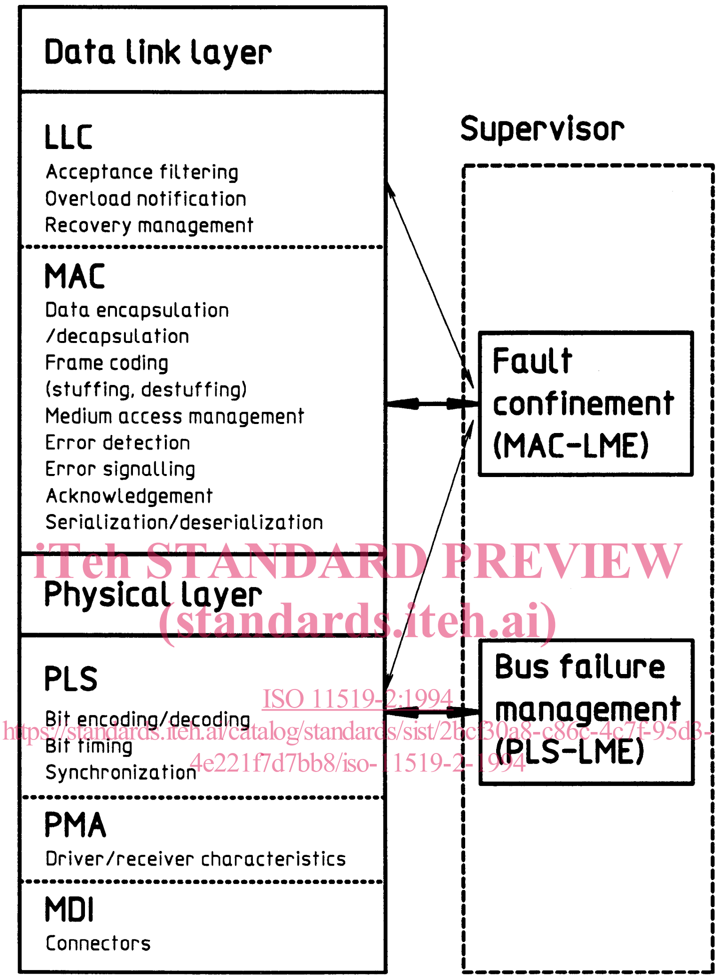
— Physical Signalling (PLS);

— Physical Medium Attachment (PMA);

— Medium-Dependent Interface (MDI).

The MAC sublayer operations are supervised by a management entity called the "Fault Confinement Entity" (FCE). Fault confinement is a self-checking mechanism that makes it possible to distinguish short disturbances from permanent failures (fault confinement, see 11.1).

The physical layer may be supervised by an entity that detects and manages failures of the physical medium (for example shorted or interrupted bus lines — bus failure management, see 11.2).



Key
LLC = Logical Link Control
MAC = Medium Access Control
PLS = Physical Signalling
PMA = Physical Medium Attachment
MDI = Medium-Dependent Interface
LME = Layer Management Entity

Figure 2 — Layered architecture of CAN

5.2 Protocol specification

Two peer protocol entities communicate with each other by exchanging frame or protocol data units (PDU). An N-layer protocol data unit (NPDU) consists of an N-layer-specific protocol control information (n-PCI) and N-user data. In order to transfer a NPDU it must be passed to an N-1 layer entity via an N-1 service access point [(N-1)-SAP]. The NPDU is passed by means of the N-1 layer Service Data Unit [(N-1)-SDU] to the N-1 layer, the services of which allow the transfer of the NPDU. The service data unit is the interface data whose identity is preserved between N layer entities, i.e. it represents the logical data unit transferred by a service. The data link layer of the CAN protocol does not provide means for mapping one SDU into multiple PDUs, nor means for mapping multiple SDUs into one SDU, i.e. an NPDU is directly constructed from the associate NSDU and the layer-specific control information N-PCI. Figure 3 illustrates the data link sublayer interactions.

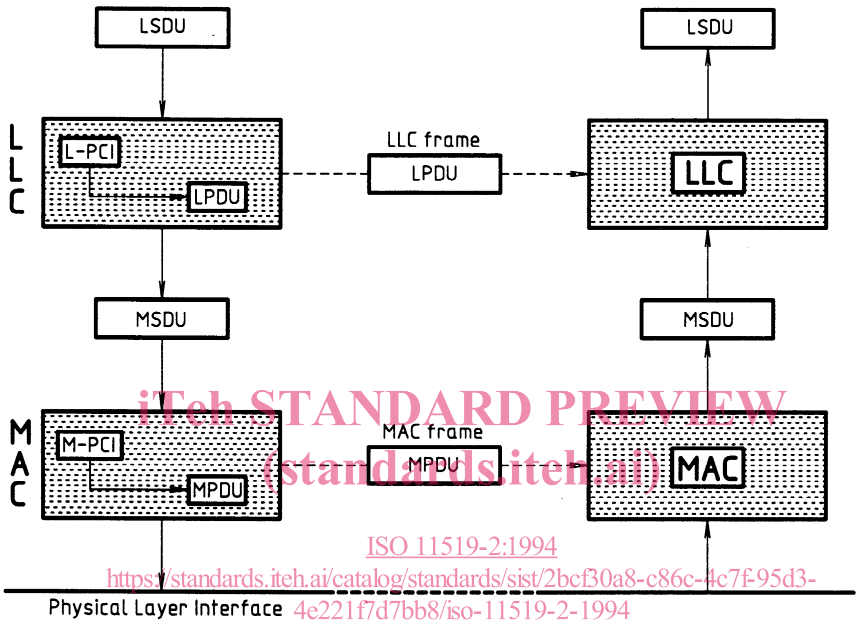


Figure 3 — Protocol layer interactions

5.3 Format description of services

5.3.1 Format description of service primitives

Service primitives are written in the form:

```
service.type(
            [parameter,...]
            ).
```

where

— "service" indicates the name of the service, e.g. L_DATA for data transfer service provided by the LLC sub-layer;

— "type" indicates the type of the service primitives (see 5.3.2);

— "[parameter,...]" is the list of values passed to the service primitives. The brackets indicate that this parameter list may be empty.

5.3.2 Types of service primitives

Service primitives are of three generic types.

a) *Service.request*

The request primitive is 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 is 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 is 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 does not necessarily indicate any activity at the remote peer interface.

5.4 LLC interface

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

— unacknowledged data transfer service,

— unacknowledged remote data request service.

The interface service data from or to the user is described in 6.2. The messages that can be exchanged between LLC user and LLC sublayer are given in tables 1 and 2.

Table 1 — Message sent from LLC user to LLC sublayer

User-to-LLC message	Meaning
Reset_Request	Request to set the node into an initial state

Table 2 — Message 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 status "bus off"

The LLC interface messages from and to the supervisor fault confinement entity are described in 11.1.3.1.

6 Description of the LLC sublayer

The LLC (logical link control) sublayer describes the upper part of the OSI data link layer. It is concerned with those protocol issues that are independent of the type of medium access method.

6.1 Service of the LLC sublayer

The LLC sublayer offers two types of connectionless-mode transmission services:

a) Unacknowledged data transfer service

This service provides means by which LLC users can exchange link service data units (LSDU) without the establishment of a data link connection. The data transfer can be point-to-point, multicast or broadcast.

b) Unacknowledged remote data request service

This service provides means by which LLC users can request another remote node to transmit a link service data unit (LSDU) without the establishment of a data link connection.

The way in which the remote node serves the data request is not specified here. Basically, there are two ways.

1) The requested data is prepared by the remote user for transmission. In this case the data is located in a remote node buffer and will be transmitted by the LLC entity upon reception of the remote request frame.

2) The requested data will be transmitted by the remote user upon reception of the remote request frame.

According to the two different LLC services there are two types of frames from or to the user:

— LLC data frame,

— LLC remote frame.

The LLC data frame carries data from a transmitter to a receiver. The LLC remote frame is transmitted to request the transmission of a data frame (with the same identifier) from a (single) remote node. In both cases, the LLC sublayer notifies the successful transmission (or reception) of a frame to (or from) the user.

6.2 Service primitive specification

This section describes in detail the LLC service primitives and their associated parameters. The complete list of LLC service primitives is given in table 3.

Table 3 — LLC service primitives overview

Unacknowledged data transfer service	
L_DATA.request	Request for data transfer
L_DATA.indication	Indication of data transfer
L_DATA.confirm	Confirmation of data transfer
Unacknowledged remote data request service	
L_REMOTE.request	Request for remote data transfer
L_REMOTE.indication	Indication of remote data request
L_REMOTE.confirm	Confirmation of remote data request

The parameters that are associated with the different LLC service primitives are listed in table 4.

Table 4 — List of LLC service primitive parameters

LLC service primitive parameters	
IDENTIFIER	Identifies the data and its priority
DLC	Data length code
DATA	Data the user wants to transmit
TRANSFER_STATUS	Confirmation parameter

6.2.1 L_DATA.request

a) Function

The L_DATA.request primitive is passed from the LLC user to the LLC sublayer to request that an LSDU be sent to one or more remote LLC entities.

b) Semantics of the L_DATA.request primitive

The primitive shall provide parameters as follows.


```
L_DATA.request(
                 IDENTIFIER
                 DLC
                 DATA
                 )
```


The parameter DATA is insignificant if the associated LLC data frame is of data length zero.

c) Effect on receipt

Receipt of this primitive causes the LLC sublayer to initiate the transfer of an LLC data frame by use of the data transfer service provided by the MAC sublayer (see 8.1.1).

6.2.2 L_DATA.indication

a) Function

The L_DATA.indication primitive is passed from the LLC sublayer to the LLC user to indicate the arrival of an LSDU.

b) Semantics of the L_DATA.indication primitive

The primitive shall provide parameters as follows.

```
L_DATA.indication(
                   IDENTIFIER
                   DLC
                   DATA
                   )
```

The parameter DATA is insignificant if the associated LLC data frame is of data length zero.