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

**Part 4:  
Time-triggered communication**

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

*Partie 4: Déclenchement temporel des communications*

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# Contents

Page

|  |    |
|--|----|
| Foreword .....   | iv |
| Introduction .....   | v  |
| 1 Scope .....  | 1  |
| 2 Normative references .....                                 | 1  |
| 3 Terms and definitions .....                                | 1  |
| 4 Abbreviated terms .....                                    | 6  |
| 5 Basic concepts of time-triggered CAN .....                 | 6  |
| 5.1 General conventions .....                                | 6  |
| 5.2 General principle of protocol .....                      | 8  |
| 5.3 Reference message .....                                  | 10 |
| 6 Timing and synchronisation features .....                  | 12 |
| 6.1 Levels 1 and 2 .....                                     | 12 |
| 6.2 Generation of local time .....                           | 12 |
| 6.3 Cycle_Time parameter .....                               | 14 |
| 6.4 Synchronisation in Level 2 .....                         | 14 |
| 6.5 Global time in Level 2 (local time + local offset) ..... | 14 |
| 6.6 External clock synchronisation .....                     | 15 |
| 7 Sending and receiving .....                                | 15 |
| 7.1 General .....  | 15 |
| 7.2 Transmission of messages .....                           | 15 |
| 7.3 Reception of messages .....                              | 17 |
| 7.4 Transmission of reference messages .....                 | 17 |
| 8 Initialisation and fault tolerance of time masters .....   | 18 |
| 8.1 General .....  | 18 |
| 8.2 Initialisation procedure .....                           | 19 |
| 8.3 Failure of current time master .....                     | 20 |
| 8.4 Shutdown .....   | 20 |
| 9 Failure handling .....                                     | 21 |
| 9.1 General .....  | 21 |
| 9.2 Message status count .....                               | 22 |
| 9.3 Interrupt_Status_Vector .....                            | 22 |
| 9.4 Master state .....                                       | 23 |
| 10 Visible interfaces .....                                  | 25 |
| 10.1 Configuration interfaces .....                          | 25 |
| 10.2 Application interfaces .....                            | 28 |
| 10.3 Optional interfaces .....                               | 30 |
| Bibliography .....   | 32 |

## 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 11898-4 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

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*

## Introduction

In the classic CAN network, communication is event-triggered; peak loads can occur when the transmission of several messages is requested at the same time. The non-destructive arbitration mechanism of CAN guarantees the sequential transmission of all messages according to their identifier priority. For hard real-time systems, a scheduling analysis of the entire system is done to ensure that all transmission deadlines are met even at peak bus loads.

Some real-time operating systems (RTOS) are based on static cyclic scheduling of all tasks in the application system (control unit). They build a schedule of time slots and place each task in at least one slot. Tasks of high priority appear in more than one slot. All activity in one slot, including interrupt handling, must be completed before the beginning of the next slot.

If such an RTOS is considered for a distributed application system consisting of control units linked by a CAN network, system integration and composability are served when the communication on the CAN network also follows a synchronised schedule.

The time-triggered communication option for CAN-based networks (see ISO 11898-1) gives the prerequisites for the synchronisation of all nodes in the CAN network. When the nodes are synchronised, any message may be transmitted at a specific time slot, without competing with other messages for the bus. Thus the loss of arbitration is avoided; the latency time becomes predictable.

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# Road vehicles — Controller area network (CAN) —

## Part 4: Time-triggered communication

### 1 Scope

This part of ISO 11898 specifies time-triggered communication in the controller area network (CAN): a serial communication protocol that supports distributed real-time control and multiplexing for use within road vehicles. It is applicable to setting up a time-triggered interchange of digital information between electronic control units (ECU) of road vehicles equipped with CAN, and specifies the frame synchronisation entity that coordinates the operation of both logical link and media access controls in accordance with ISO 11898-1, to provide the time-triggered communication schedule.

**NOTE** Time-triggered CAN is a higher level protocol layer additional to the CAN protocol itself, which remains unchanged within the time-triggered communication. Time-triggered communication keeps the latency time of each message at a specified value independent of the CAN bus load. Time-triggered CAN is implemented on two levels: Level 1 is restricted to the cyclic message transfer, while Level 2, in addition, supports a global system time. Time-triggered CAN's cyclic, periodical communication is based on reference messages transmitted by a time master. Each period starting with a reference message is called a basic cycle and is subdivided into several time windows. The reference messages are used to synchronise and calibrate the time bases of all nodes to the time master's time base, providing a global time for the network. A mechanism is provided for alternative time masters to substitute for a failing time master.

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### 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 11898-1, *Road vehicles — Controller area network (CAN) — Part 1: Data link layer and physical signalling*

ISO 11898-2, *Road vehicles — Controller area network (CAN) — Part 2: High-speed medium access unit*

ISO 11898-3, *Road vehicles — Controller area network (CAN) — Part 3: Low-speed fault-tolerant, medium dependant interface*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11898-1, ISO 11898-2 and ISO 11898-3, and the following apply.

**NOTE** Parameter terms (Cycle\_Time, Cycle\_Count, etc.) are given as proper nouns, connected by an underscore where the parameter consists of two or more words.

3.1

**application watchdog**

entity which verifies that the application is operating properly

3.2

**arbitrating time window**

time window assigned to messages that share the same time window

3.3

**basic cycle**

row of the system matrix of several consecutive time windows

3.4

**Cycle\_Time**

difference between the local time of an FSE and its Ref\_Mark

3.5

**Cycle\_Count**

number of the current basic cycle of the matrix cycle

3.6

**Cycle\_Count\_Max**

value of Cycle\_Count of the last basic cycle in the given system matrix of the network

3.7

**Cycle\_Offset**

parameter specifying, within a matrix cycle, the first basic cycle for which an Rx\_Trigger or Tx\_Trigger is valid

3.8

**Disc\_Bit**

part of the reference message signalling a discontinuity in global time caused by an external clock correction by the time master

3.9

**error severity**

levels of distinguished severity of an error

3.10

**exclusive time window**

time window assigned to a specific message transmitted periodically without competition for the CAN bus

3.11

**Expected\_Tx\_Trigger**

local parameter which specifies, for each FSE, the number of Tx\_Triggers the FSE is expected to activate between two starts of a matrix cycle

3.12

**Frame\_Synchronisation**

pulse, generated in each FSE and for each data frame and remote frame in the CAN network at the sample point of start of frame (SOF) bit, synchronous in the whole network, disregarding signal propagation times, and with an optionally added time offset referencing to the sync\_segment of the SOF-Bit, to compensate for variations of bit timing configuration in the system

3.13

**frame synchronisation entity**

**FSE**

part coordinating the operation of logical link control and media access control

NOTE Each CAN controller in a time-triggered CAN network has its own FSE.



**3.14****free time window**

time window free of messages scheduled in the system matrix

**3.15****global time**

node view of the global time of the current time master

**3.16****Global\_Ref\_Mark**

parameter saved on successful reception of a reference message

**3.17****Global\_Sync\_Mark**

current value of the node view of global time, saved at the pulse of Frame\_Synchronisation

**3.18****Init\_Watch\_Trigger**

value of the maximum of cycle time

**3.19****Initial\_Ref\_Offset**

initialisation value that loads the Ref\_Trigger\_Offset

**3.20****level**

level of implementation of time-triggered CAN in accordance with this part of ISO 11898

NOTE There are two levels, Level 1 and Level 2, with Level 2 an extension of Level 1.

**3.21****local time**

time generated by a cyclic incrementing counter

**3.22****Local\_Offset**

difference between Global\_Ref\_Mark and Ref\_Mark, saved at each successful completion of the reference message

**3.23****master state**

vector which combines the FSE states referring to error, synchronisation and master-slave relation, i.e. a triplet (error level, sync\_mode, master-slave\_mode)

**3.24****Master\_Ref\_Mark****MRM**

parameter transmitted by the time master in the reference message

**3.25****matrix cycle**

cycle of all basic cycles in the system matrix, consecutive from the first to the last basic cycle

NOTE The matrix cycle is the same as the basic cycle if the system matrix consists of one basic cycle only.

**3.26****merged arbitrating time window**

single window into which consecutive arbitrating time windows are merged

- 3.27**  
**message object**  
buffer providing storage of an LLC frame together with control and status information
- 3.28**  
**message status count**  
**MSC**  
error counter providing means for detecting scheduling errors for messages sent in exclusive time windows
- 3.29**  
**network time unit**  
**NTU**  
unit measuring all times and providing a constant of the whole network
- 3.30**  
**network view**  
system aspect of network parameter
- 3.31**  
**node view**  
local aspect of network parameter
- 3.32**  
**node view of global time**  
integer part of the sum of local time of the node and its Local\_Offset
- 3.33**  
**potential time master**  
frame synchronisation entity that is allowed to send a reference message by system configuration
- 3.34**  
**Ref\_Mark**  
parameter saved on each successful completion of the reference message  
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- 3.35**  
**Ref\_Trigger\_Offset**  
parameter used to modify the time mark within a Tx\_Ref\_Trigger such that it sends a reference message
- 3.36**  
**reference message**  
message (data frame) that starts a basic cycle
- 3.37**  
**Repeat\_Factor**  
parameter specifying the repetition rate of a message within a transmission column, being a part of Tx\_Trigger or Rx\_Trigger parameters
- NOTE The unit of the repetition rate is “rows in the system matrix”.
- 3.38**  
**Rx\_Trigger**  
parameter that specifies when the successful reception of a message will be verified
- 3.39**  
**Sync\_Mark**  
current value of the local time saved at the pulse of Frame\_Synchronisation

**3.40****system matrix**

form containing all messages of all nodes in the network, organised as components and consisting of time windows organised in basic cycles (rows of the matrix) and transmission columns (columns of the matrix)

NOTE The system matrix specifies the correlation between messages and time windows (type and time mark). The first basic cycle in the system matrix starts with Cycle\_Count 0.

**3.41****time gap**

time between the end of a basic cycle and the beginning of the next basic cycle, when the beginning of the next basic cycle is synchronised to an event

**3.42****time mark**

mark within a frame synchronisation entity specifying an instant of Cycle\_Time (in NTUs) at which a certain action is expected or planned

**3.43****time master**

frame synchronisation entity sending the reference message

**3.44****time window**

amount of time allocated for a specific transmission column in the system matrix

**3.45****transmission column**

column of the system matrix whose elements correlate to a particular time window repeated in each basic cycle

**NOTE**

Transmission rows are the basic cycles of the system matrix.

**3.46****time unit ratio****TUR**

ratio between the length of a NTU and the length of the FSE specific basic time unit (e.g. local oscillator period) used for clock synchronisation

**NOTE**

TUR is, in principle, a non-integer number. The node view of a NTU is implemented by the value of TUR.

**3.47****Tx\_Count**

counter that is reset at each start of a matrix cycle, i.e. after identification of the corresponding reference message with Cycle\_Count equal to zero

**3.48****Tx\_Enable**

time period within which the transmission of a message may be started

**3.49****Tx\_Overflow**

status flag set when more Tx\_Triggers occur than specified by Expected\_Tx\_Trigger

**3.50****Tx\_Ref\_Trigger**

special Tx\_Trigger parameter referring only to the triggering of reference messages

3.51

**Tx\_Trigger**

parameter specifying when a certain message will be transmitted and which consists of a time mark, the position within the transmission column in respect of the first sending (Cycle\_Offset) and the repetition rate (Repeat\_Factor) within that transmission column, and a reference to a message object for which the Tx\_Trigger is valid

NOTE The Tx\_Trigger also contains information about the window type (exclusive, arbitrating, merged).

3.52

**Tx\_Underflow**

status flag set when less Tx\_Triggers occur than specified by Expected\_Tx\_Trigger

3.53

**Watch\_Trigger**

time mark used to check whether the time since the last valid reference message has been too long

**4 Abbreviated terms**

|     |                              |
|-----|------------------------------|
| CAN | controller area network      |
| FSE | frame synchronisation entity |
| LLC | logical link control         |
| LSB | least significant bit        |
| MAC | medium access control        |
| MSB | most significant bit         |
| SOF | start of frame               |

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**5 Basic concepts of time-triggered CAN**

**5.1 General conventions**

For the purposes of this part of ISO 11898, the following conventions apply.

**Application watchdog:** regularly served by the Host\_Alive\_Sign parameter.

**Arbitrating time window** conflicts are resolved by the identifier arbitration of CAN and a CAN node may not start transmission if the bus is not idle. Several CAN nodes in the network may start a transmission within the Tx\_Enable window of an arbitrating time window. The immediate automatic retransmission is disabled. Exception: merging of time windows.

**Basic cycle** elements are several consecutive time windows. The number and length of the different time windows is specified off-line and is the same for the whole network. Each basic cycle of the system matrix consists of the same sequence of time windows, starting with the time window for the reference message.

**Cycle\_Time** is truncated to the most significant 16 bits of the difference between the local time of a FSE and its Ref\_Mark, Cycle\_Time = most significant 16 bits of (Local\_Time – Ref\_Mark).

**Cycle\_Count** starts counting at zero.

**Cycle\_Offset** is part of a Tx\_Trigger or Rx\_Trigger parameter.