



# SURFACE VEHICLE RECOMMENDED PRACTICE

J2284™-3

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## High-Speed CAN (HSC) for Vehicle Applications at 500 kbps

### RATIONALE

Addition of stub length requirements for HS-CAN based on the presentation on 21st March and 25th April 2022.

### FOREWORD

The objective of SAE J2284-3 is to define a level of standardization in the implementation of a 500 kbps vehicle communication network using the controller area network (CAN) protocol. The goal is to achieve a standard electronic control unit (ECU) physical layer, data link layer, and media design criteria which will allow ECU and tool manufacturers to satisfy the needs of multiple end users with minimum modification to a basic design. Likewise, end users will benefit in lower ECU cost achieved from the high volumes of the basic design.

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## 1. SCOPE

This SAE Recommended Practice will define the physical layer and portions of the data link layer of the open systems interconnection model (ISO 7498) for a 500 kbps high-speed CAN (HSC) protocol implementation. Both electronic control unit (ECU) and media design requirements for networks will be specified. Requirements will primarily address the controller area network (CAN) physical layer implementation.

Requirements will focus on a minimum standard level of performance from the HSC implementation. All ECUs and media shall be designed to meet certain component level requirements in order to ensure the HSC implementation system level performance at 500 kbps. The minimum performance level shall be specified by system level performance requirements or characteristics described in detail in Section 5 of this document.

This document is designed such that if the ECU requirements defined in Section 6 are met, then the system level attributes should be obtainable.

This document will address only requirements which may be tested at the ECU and media level. No requirements which apply to the testing of the HSC implementation as integrated into a vehicle are contained in this document. However, compliance with all ECU and media requirements will increase the possibility of communication compatibility between separately procured components and will greatly simplify the task of successfully integrating a HSC communication system in a vehicle.

## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

#### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

|             |                                                                       |
|-------------|-----------------------------------------------------------------------|
| SAE J551-15 | Vehicle Electromagnetic Immunity - Electrostatic Discharge (ESD)      |
| SAE J1213-1 | Glossary of Vehicle Networks for Multiplexing and Data Communications |
| SAE J2962-2 | Communication Transceivers Qualification Requirements - CAN           |

#### 2.1.2 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

|                     |                                                                                                                                                          |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| ISO 10605           | Road Vehicles - Test Methods for Electrical Disturbances from Electrostatic Discharge                                                                    |
| ISO 11451-2         | Road Vehicles - Vehicle Test Methods for Electrical Disturbances from Narrowband Radiated Electromagnetic Energy - Part 2: Off-Vehicle Radiation Sources |
| ISO 11452-4         | Road Vehicles - Component Test Methods for Electrical Disturbances from Narrowband Radiated Electromagnetic Energy - Part 4: Harness Excitation Methods  |
| ISO 11898-1:2015(E) | Road Vehicles - Interchange of Digital Information - Controller Area Network (CAN), Part 1: Data Link Layer and Physical Signalling                      |
| ISO 11898-2:2016(E) | Road Vehicles - Interchange of Digital Information - Controller Area Network (CAN), Part 2: High-Speed Medium Access Unit                                |
| ISO 26262           | Road Vehicles - Functional Safety                                                                                                                        |

### 2.1.3 Other Publications

CISPR 25                      Limits and Methods of Measurement of Radio Disturbance Characteristics for the Protection of Receivers Used On-Board Vehicles

### 2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

#### 2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

SAE J1930                      Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms - Equivalent to ISO/TR 15031-2

SAE J1962                      Diagnostic Connector

SAE J2190                      Enhanced E/E Diagnostic Test Modes

SAE J2284-4                    High-Speed CAN for Vehicle Applications at 500 kbps with CAN FD Data at 2 Mbps

Dietmayer, K. and Overberg, K., "CAN Bit Timing Requirements," SAE Technical Paper 970295, 1997, <https://doi.org/10.4271/970295>.

#### 2.2.2 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 7498                      Data Processing Systems - Open Systems Interconnection Standard Reference Model

ISO 7637-1                    Road Vehicles - Electrical Disturbance by Conduction and Coupling

ISO 14229                    Road Vehicles - Diagnostic Systems - Specification of Diagnostic Services

#### 2.2.3 Other Publications

AUTOSAR Release 4.2.2, [www.autosar.org](http://www.autosar.org)

### 3. DEFINITIONS

The definitions provided in SAE J1213-1 apply to this document. Additional or modified definitions, acronyms, and abbreviations included in this document or relevant to the communication of information in a vehicle are catalogued in this section.

#### 3.1 ARBITRATION BIT TIME

See nominal bit time (3.22).

#### 3.2 CAN\_H

The CAN\_H bus wire is fixed to a mean voltage level during the recessive state and is driven in a positive voltage direction during the dominant bit state.

### 3.3 CAN\_L

The CAN\_L bus wire is fixed to a mean voltage level during the recessive state and is driven in a negative voltage direction during the dominant bit state.

### 3.4 CAN ACTIVITY FILTER TIME

Duration for which the bus needs to be continuously in the same state to enable the signal to pass the bus wake-up filter.

### 3.5 CAN BUS

Subnet where a number of ECUs communicate via a two-wire link (CAN\_H, CAN\_L) and where the CAN protocol is used as data link layer (DLL).

### 3.6 CAN IDENTIFIER

Bit pattern of 11 bits or 29 bits, located at the beginning of a message that denotes message content and also reflects message priority.

### 3.7 CLASSICAL CAN MESSAGE

Bus message according to ISO 11898:1993/Amd.1:1995(E). Bus message according to ISO 11898-1:2015(E) where the FDF bit is dominant, also known as CAN 2.0.

### 3.8 CAN FD MESSAGE

Bus message according to ISO 11898-1:2015(E) where the FDF bit is recessive. A CAN FD message typically employs different bit rates in the data field and in the arbitration field.

### 3.9 DATA BIT TIME

Length of a single bit in those parts of CAN FD messages where a dedicated separately configurable data bit time is used. The data bit time is not used anywhere in classical CAN messages and is not used in those CAN FD messages where the BRS bit is dominant.

### 3.10 DATA LINK LAYER

Provides the reliable transfer of information across the physical layer. This includes message qualification and error control.

### 3.11 DATA SAMPLE POINT ( $t_{\text{SAMPLE}}$ )

The sample point is the time within the bit period at which the single bit sample captures the logical state of the bus. The programmable bit sample point is located between  $t_{\text{SEG1}}$  and  $t_{\text{SEG2}}$ . Equation 1 shows the relationship of  $t_{\text{SAMPLE}}$  to  $t_{\text{SEG2}}$ :

$$t_{\text{SAMPLE}} = t_{\text{BIT}} - t_{\text{SEG2}} \quad (\text{Eq. 1})$$

### 3.12 DIAGNOSTIC CONNECTOR

Provides the electrical connection between off-board and on-board ECUs. For some vehicles, the diagnostic connector is the SAE J1962 connector.

### 3.13 DISABLING OF DLC MATCHING

When this functionality is supported and active, then the bus transceiver will not compare message data length code (DLC) values as to whether or not they match to configured DLC values when scanning messages for presence of valid wake-up requests.

### 3.14 DOMINANT STATE

The dominant state is represented by a differential voltage greater than a minimum threshold between the CAN\_L and CAN\_H bus wires. The dominant state overwrites the recessive state and represents a logic “0” bit value.

### 3.15 ELECTRONIC CONTROL UNIT (ECU)

An On- or Off-vehicle electronic assembly from which CAN SAE J2284-3 messages may be sent and/or received.

### 3.16 ECU Delay ( $t_{\text{ECU}}$ )

An ECU's loop delay includes the following four delays:

- a. Transmitter propagation delay ( $t_{\text{TX}}$ , this includes device delay and slew).
- b. Receiver propagation delay ( $t_{\text{RX}}$ ).
- c. Receiver logic delay ( $t_{\text{LOGIC}}$ ).
- d. Common mode choke ( $t_{\text{CHK}}$ , optional, includes both Tx and Rx choke delays).

$$t_{\text{ECU}} = (t_{\text{TX}} + t_{\text{RX}} + t_{\text{LOGIC}} + t_{\text{CHK}}) \quad (\text{Eq. 2})$$

### 3.17 FD\_Receive/FD\_Transmit

Status flags indicating whether the bus controller employs CAN FD data bit timing presently.

### 3.18 HANDLE

Hardware object label of one or multiple LLC frames (LPDU). Identifies hardware element used for transaction. Used to facilitate cancellation of pending message transmission requests.

### 3.19 MEDIA

The physical entity which conveys the electrical (or equivalent means of communication) transmission between ECUs on the network (e.g., unshielded twisted pair wires). Media is defined as all elements between the connector pins of the communicating ECUs through which the signals pass.

### 3.20 MEDIA DELAY ( $t_{\text{BUS}}$ )

Media delay is defined as the time required for a signal to pass through the media at the longest specified distance. See Tables 1, 2, 3, and 8.

### 3.21 MUST

The word “must” is used to indicate that a binding requirement exists on components or devices which are outside the scope of this specification.

### 3.22 NOMINAL BIT TIME

Length of a single bit in Classical CAN messages. Length of a single bit in CAN FD messages, except where data bit timing applies. Also known as arbitration bit time.

### 3.23 PCS STATUS

Indicates what logical level is presently being received or transmitted and whether or not CAN FD data bit timing applies presently. For details, refer to ISO 11898-1:2015(E).

### 3.24 PHYSICAL LAYER

Concerns the transmission of an unstructured bit stream over physical media: deals with the mechanical, electrical, functional, and procedural characteristics to access the physical media.

### 3.25 PROTOCOL

Formal set of conventions or rules for the exchange of information between ECUs. This includes the specification of frame administration, frame transfer, and physical layer.

### 3.26 RADIATED EMISSIONS

Radiated emissions consists of energy that emanate from the CAN bus wires. Electric field strength in dBμV/m is the typical measure of radiated emissions.

### 3.27 RADIATED IMMUNITY

A property that ensures that the CAN bus wires will not suffer degraded functional operation within its intended electromagnetic environment.

### 3.28 RECESSIVE STATE

The recessive state is represented by an inactive state differential voltage that is approximately 0. The recessive state represents a logic “1” bit value.

### 3.29 PROPAGATION DELAY ( $t_{\text{PROP}}$ )

Part of bit cell that serves compensation of data signal delay times in a network. Because CAN is an arbitrating protocol, the propagation delay must take into account the time required for a signal to make a complete round trip from one CAN controller to another and back. This translates to Equations 3 or 4.

$$t_{\text{PROP}} = 2(t_{\text{TX}} + t_{\text{RX}} + t_{\text{LOGIC}} + t_{\text{CHK}} + t_{\text{BUS}}) \quad (\text{Eq. 3})$$

or

$$t_{\text{PROP}} = 2(t_{\text{ECU}} + t_{\text{BUS}}) \quad (\text{Eq. 4})$$

### 3.30 SECONDARY SAMPLE POINT (SSP)

Sample point that applies to data bit timing in CAN FD (BRS = recessive) messages when the transmitter delay compensation functionality is configured to be enabled/active. The transmitting bus controller automatically determines/adapts/delays the location of the bit sample point based on observed data signal delay of the particular transmitter implementation, unless transmitter delay compensation disabled.

### 3.31 SELECTIVE WAKE-UP BUS TRANSCEIVER

Bus transceiver capable to monitor bus messages while in low power mode and capable to generate a wake-up interrupt when valid messages present on the bus match configured message content (identifier, data field).

### 3.32 SHALL

The word “shall” is to be used in the following ways:

- a. To state a binding requirement on the CAN interfaces which comprise the ECU, which is verifiable by external manipulation and/or observation of an input or output.
- b. To state a binding requirement upon an ECU that is verifiable through a review of the document.

### 3.33 SHOULD

The word “should” is used to denote a preference or desired conformance.

### 3.34 SPLIT BUS TERMINATION

Bus termination where the resistance between CAN\_H and CAN\_L is split into two parts of equal value. Resistance center tap connected to ground via a capacitor unless otherwise specified. Figure 1 is for informative reference only. See 6.4 for passive component values.

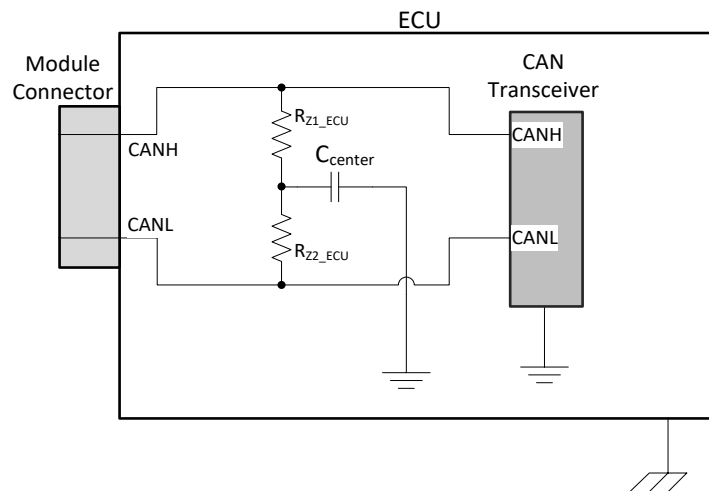


**Figure 1 - Split bus termination**

### 3.35 SYNCHRONIZATION JUMP WIDTH ( $t_{SJW}$ )

This time interval is the maximum amount of time by which  $t_{SEG1}$  may be lengthened or  $t_{SEG2}$  shortened to compensate for synchronization differences between ECUs on the CAN network. This is accomplished automatically in the CAN controller as a basic part of the protocol. However, the amount of skew tolerated is adjustable by software programming.

### 3.36 SYNCHRONIZATION SEGMENT ( $t_{SYNC\_SEG}$ )

This time interval is used to synchronize all ECUs on the bus. If all ECUs are fully synchronized, then all bit edges occur in this interval, which has a fixed period of one time quantum.

### 3.37 TIME QUANTUM ( $t_Q$ )

This is the basic unit of time for bit timing. This time is derived from the microcontroller's oscillator clock and is programmable based on the CAN controller's divide register values.

### 3.38 TRANSMITTER DELAY COMPENSATION (TDC)

For data bit timing in CAN FD messages the transmitting CAN controller automatically will compensate the signal delay caused by the ECU-internal transmitter implementation, unless TDC functionality disabled. Functionality inactive for arbitration bit timing in CAN FD messages and generally inactive in Classical CAN messages. For details, refer to ISO 11898-1:2015(E).

### 3.39 TSEG1 ( $t_{SEG1}$ )

This time interval is used to compensate for positive phase errors in synchronization between ECUs on the network. If an edge occurs during this interval,  $t_{SEG1}$  is lengthened to compensate for synchronization differences with other ECUs on the CAN network.  $T_{SEG1}$  is equivalent to the combination of the Prop\_Seg and Phase\_Seg1 parts of the bit period defined in ISO 11898-1:2015(E).

$$t_{SEG1} = t_{BIT} - 1 (t_Q) - t_{SEG2} \quad (\text{Eq. 5})$$

### 3.40 TSEG2 ( $t_{SEG2}$ )

This time interval is used to compensate for negative phase errors in synchronization between ECUs on the network. If an edge occurs during this interval,  $t_{SEG2}$  is shortened to compensate for synchronization differences with other ECUs on the CAN network.  $T_{SEG2}$  is equivalent to the Phase\_Seg2 part of the bit period defined in ISO 11898-1:2015(E).

### 3.41 WILL

The word “will” is used to state an immutable law of physics.

## 4. ACRONYMS

|        |                                            |
|--------|--------------------------------------------|
| ASIL   | Automotive safety integrity level          |
| BRS    | Bit rate switch                            |
| CAN    | Controller area network                    |
| CAN FD | CAN with flexible data rate                |
| CAN ID | CAN identifier                             |
| DLC    | Data length code                           |
| ECU    | Electronic control unit                    |
| EMC    | Electromagnetic compatibility              |
| ESD    | Electrostatic discharge                    |
| ESI    | Error status indicator                     |
| FD     | Flexible data rate (message format)        |
| FDF    | Flexible data rate format                  |
| HSC    | High-speed CAN                             |
| ISO    | International Standardization Organization |
| kbps   | Kilobits per second                        |
| LLC    | Logical link control (layer)               |
| LPDU   | LLC protocol data unit (frame)             |
| MAC    | Media access control (layer)               |
| Mbps   | Megabits per second                        |