



SURFACE VEHICLE RECOMMENDED PRACTICE	J2962™-2	FEB2024
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Communication Transceivers Qualification Requirements - CAN		

RATIONALE

Historically, Original Equipment Manufacturers (OEMs) had their own communication transceiver qualification requirements that varied over time. The intent of this standard is to minimize test variation and to consolidate requirements among OEMs.

FOREWORD

The purpose of this SAE Recommended Practice is to define a common test plan for approval of ICs that contain controller area network (CAN) communication transceivers. This document will define test circuits, bus load requirements, test procedures, and pass/fail criteria to validate transceivers.

NOTE: Understanding of this document requires a working knowledge of ISO EMC publications and SAE J2284.

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1. SCOPE

This document covers the requirements for transceiver qualification. Requirements stated in this document will provide a minimum standard level of performance for the CAN transceiver in the IC to which all compatible transceivers shall be designed. No other features in the IC are tested or qualified as part of this recommended practice. This will assure robust serial data communication among all connected devices, regardless of supplier.

The goal of SAE J2962-2 is to commonize approval processes of CAN transceivers across OEMs.

The intended audience includes, but is not limited to, CAN transceiver suppliers, component release engineers, and vehicle system engineers.

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.

SAE J2284-1 High-Speed CAN (HSC) for Vehicle Applications at 125 kbps

SAE J2284-2 High-Speed CAN (HSC) for Vehicle Applications at 250 kbps

SAE J2284-3 High-Speed CAN (HSC) for Vehicle Applications at 500 kbps

2.1.2 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 Disturbances from Conduction and Coupling - Part 1: Definitions and General Considerations

ISO 7637-2 Road Vehicles - Electrical Disturbances from Conduction and Coupling - Part 2: Electrical Transient Conduction Along Supply Lines Only

ISO 7637-3 Road Vehicles - Electrical Disturbances from Conduction and Coupling - Part 3: Electrical Transient Transmission by Capacitive And Inductive Coupling via Lines other Than Supply Lines

ISO 10605 Road Vehicles - Test Methods for Electrical Disturbances from Electrostatic Discharge

ISO 11452-4 Road Vehicles - Component Test Methods for Electrical Disturbances from Narrowband Radiated Electromagnetic Energy - Part 4: Harness Excitation Methods

ISO 11898-1 Road Vehicles - Controller Area Network (CAN) - Part 1: Data Link Layer and Physical Signaling

ISO 11898-2 Road Vehicles - Controller Area Network (CAN) - Part 2: High-Speed Medium Access Unit

2.1.3 IEC Publications

Available from IEC Central Office, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, www.iec.ch.

IEC 62228-1 General Part and Conditions

IEC 62228-3 Integrated Circuits - EMC Evaluation of CAN Transceivers

2.1.4 Other Publications

Bosch CAN Specification 2.0, Parts A and B

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

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 BUSOFF

This is the state that the CAN controller reaches after a number of errors have been detected on the link. The state is latched such that the bus remains in the recessive state until the CAN controller has been reset by application software.

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-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.

3.5 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.

3.6 DATA LINK LAYER

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

3.7 DATA SAMPLE POINT (t_{SAMPLE})

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

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

3.8 DIAGNOSTIC LINK CONNECTOR

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

3.9 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.

3.10 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.

3.11 ELECTRONIC CONTROL UNIT (ECU)

An on- or off-vehicle electronic assembly from which CAN SAE J2284-4 messages may be sent and/or received.

3.12 MUST

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

3.13 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.

3.14 RADIATED EMISSIONS

Radiated emissions consist of energy that emanates from the CAN bus wires. Electric field strength in dB μ V/m is the typical measure of radiated emissions.

3.15 RADIATED IMMUNITY

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

3.16 RECESSIVE STATE

The recessive state is represented by an inactive state differential voltage that is approximately 0.0 V. The recessive state represents a logic “1” bit value.

3.17 SHALL

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

- a. To state a binding requirement on the CAN interfaces that 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.

3.18 SHOULD

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

3.19 WILL

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

4. ACRONYMS

ALSE	Absorber-Lined Shielded Enclosure
AM	Amplitude Modulation
BCI	Bulk Current Injection Testing
CAN	Controller Area Network
CAN-FD	CAN with Flexible Data Rate
CBCI	Common Mode BCI
CW	Continuous Wave Modulation
DBCI	Differential Mode BCI
DCC	Direct Capacitor Coupling
DLC	Data Length Code
DUT	Device Under Test
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
FD	Flexible Data Rate (Message Format)
FDF	Flexible Data Rate Format
INH	Inhibit State Output Signal
ISO	International Standardization Organization
kbps	Kilobits per Second
LED	Light Emitting Diode (Indicator)
Mbps	Megabits per Second

MCU	Microprocessor Control Unit
PK	Peak Limit
QP	Quasi-Peak Limit
RE	Radiated Emissions Testing
RF	Radio Frequency
RXD	Receive Data Signal Line
TVS	Transient Voltage Suppression
TXD	Transmit Data Signal Line
Vbatt	Power Supply for the ECUs Present in a Communication Network (12 V nominal)

5. REQUIRED TEST CIRCUIT

5.1 Primary Device Under Test (DUT)

5.1.1 Microcontroller-Based Primary DUT Behavior

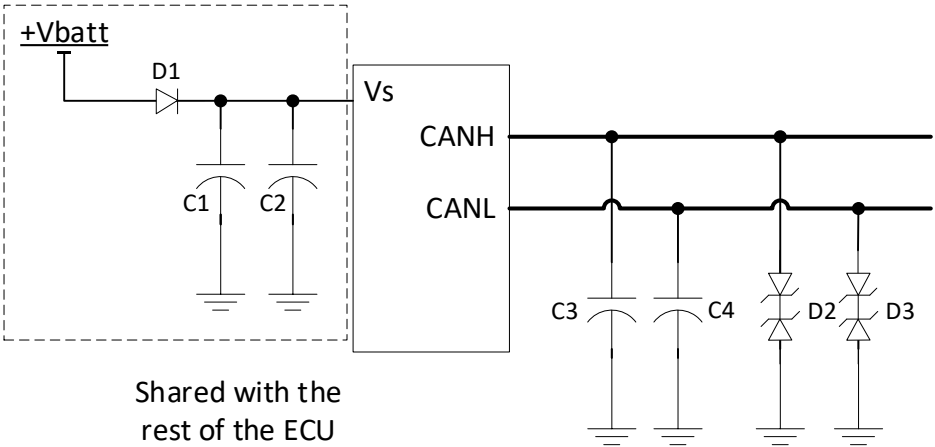
- Primary DUT responds to traffic from the monitoring DUT.
- Total bus bandwidth shall be a minimum of 90%.
- If the monitoring DUT and the primary DUT contain the same transceiver, the traffic shall be symmetrical during the test.
- If the monitoring DUT does not have the same transceiver as the primary DUT, the primary DUT shall contribute 80% of the bus traffic on average.
- The primary DUT shall indicate the state of health of the mother board (e.g., LED, fault output). Some examples of faults to be indicated are: microprocessor control unit (MCU) reset, loss of power, watchdog timeout, or anything else that can prevent the CAN controller from operating correctly.

5.1.2 Square Wave-Based Primary DUT Behavior

- Primary DUT traffic generated from a square wave connected to the transmit data signal line (TXD) with 50% duty cycle. Frequency of operation determined by each test setup.
- Total bus bandwidth shall be 100%.

5.1.3 Primary DUT Application Circuit

The primary DUT is configured as a non-terminated node (termination is provided in load simulator circuit).

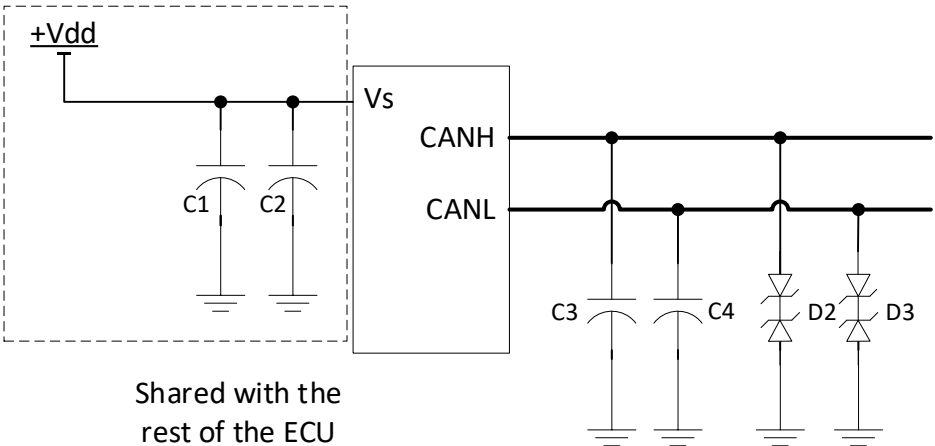


Shared with the rest of the ECU

Figure 1 - Primary DUT with battery supply

Table 1 - Battery supply components

Component Name	Label	Parameter	Min	Max	Unit
Capacitor	C1		4.7% ± 10% 50 V	22% ± 10% 50 V	µF
Capacitor	C2		100% ± 10% 50 V		nF
Diode	D1	Forward Voltage Drop		1	Volts
		Reverse Breakdown Voltage	100		Volts
		Current	100		mA



Shared with the rest of the ECU

Figure 2 - Primary DUT with Vdd supply

Table 2 - Vdd supply components

Component Name	Label	Parameter	Min	Max	Unit
Capacitor	C1		Follow Vreg manufacturer's recommendations		
Capacitor	C2		100% ± 10% 35 V		nF

5.2 Electrostatic Discharge (ESD) Protection Options

Table 3A - Parameters for TVS component performance

	Option A	Option B
C_{MAX} (pF)	<20 pF	<50 pF
V_{RM}	>20 V	>20 V
V_{BR min}	≥24 V	≥24 V
Directionality	Bi-directional	Bi-directional
TLP V_{CL} @ 16 A	<80 V	<40 V
ESD_{MAX} IEC 61000-4-2 contact	≥15 kV	≥15 kV
Example Parts (but not limited to these)	NXP PESD1CAN (SOT23), ST ESDCAN04-2BLY (SOT23), ST ESDCAN04-2BWY (SOT323), ST ESDCAN03-2BWY (SOT323)	On Semi MMBZ27x (SOT23 or SOT323), ST ESDCAN01-2BLY (SOT23)

The ESD protection components shall be selected for performance according to Table 3A.

The specific transceiver circuit allows for a few options as recommended by the chipset supplier. At least one of the following three options as shown in Table 3B shall be tested.

Table 3B - ESD protection components

Option No.	Component Name	Label	Maximum Value
1	Capacitor	C3, C4	100 pF ± 5% ^(1,2,3) 100 V
	Zener, TVS	D2, D3	Not populated
2	Capacitor	C3, C4	82 pF ± 5% ^(1,2,3) 100 V
	Zener, TVS	D2, D3	Option A (see Table 3A)
3	Capacitor	C3, C4	47 pF ± 5% ^(1,2,3) 100 V
	Zener	D2, D3	Option B (see Table 3A)

⁽¹⁾ Over entire voltage and temperature operating range.

⁽²⁾ According to SAE J2284-1, 6.3, the total ECU capacitance (C_{ECU}) must be lower than 130 pF:

$$130 \text{ pF} \geq C_{\text{ECU}} = C_{\text{Transceiver}} + C_{\text{ESD_protection}} + (C3 \text{ or } C4)$$

The values for C3 or C4 shall be selected to respect maximum C_{ECU} capacitance.

⁽³⁾ The values for C3 and C4 shall be greater than or equal to 47 pF. This minimum value may cause some transceivers with high input capacitance to be incompatible with external TVS selections (Options A and B).

NOTE: If any other protection components are required, the test setup has to be approved directly with the OEM.

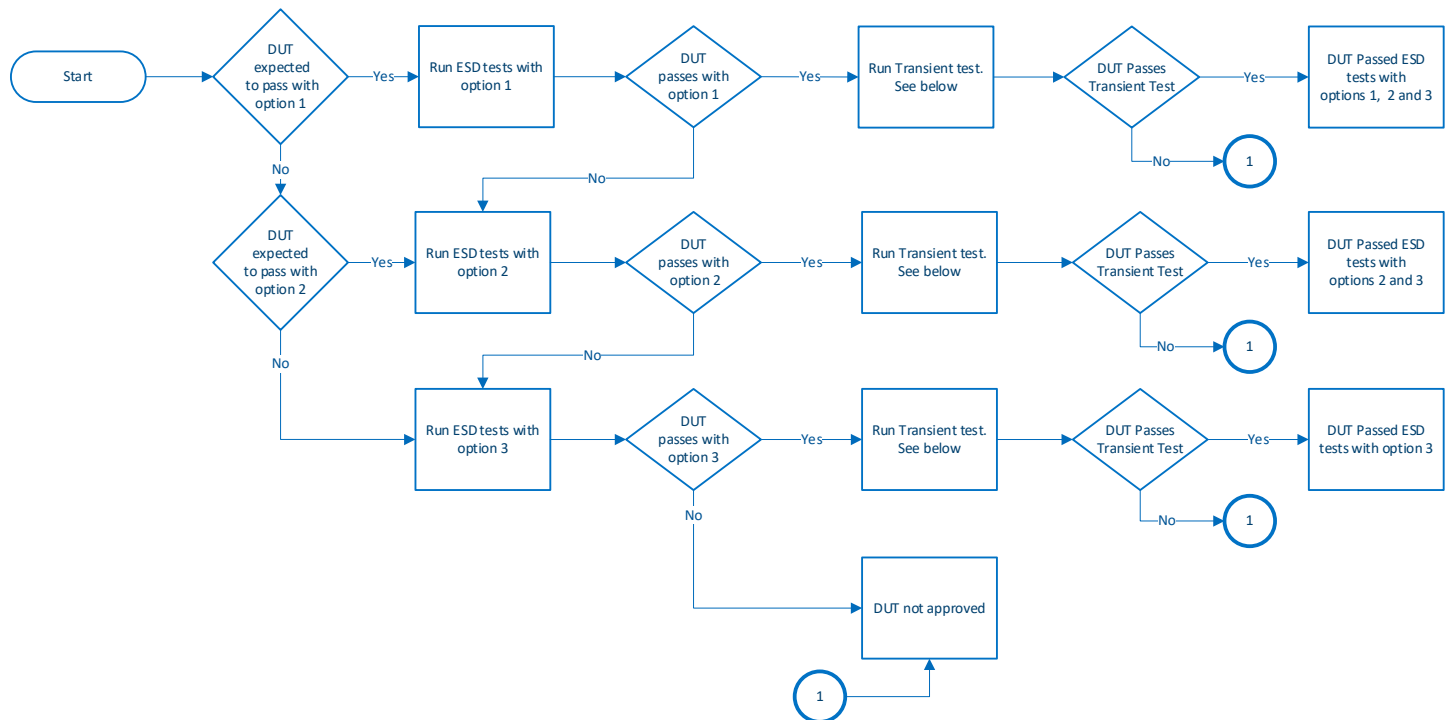


Figure 3 - ESD protection selection flowchart

5.3 Monitoring DUT

5.3.1 Microcontroller-Based Monitoring DUT Behavior

- Monitoring DUT initiates traffic and indefinitely reattempts communication.
- Total bus bandwidth shall be a minimum of 90%.
- If the monitoring DUT and the primary DUT contain the same transceiver, the traffic shall be symmetrical during the test.
- If the monitoring DUT does not have the same transceiver as the primary DUT, the primary DUT shall contribute 80% of the bus traffic on average.
- The monitoring DUT shall have the capability to indicate a communication fault (e.g., LED, fault output) when an active symbol error occurs.
 - The errors monitored by the monitoring DUT shall include:
 - BUSOFF condition from the microprocessor CAN module.
 - After logging the fault, the BUSOFF error will cause an immediate re-initialization of the CAN controller in the microcontroller clearing the BUSOFF condition. Some transceivers may need clearing of the BUSOFF condition as well.
 - The monitoring DUT receives less than 80% of expected responses from the primary DUT.
 - Incorrect CAN ID information, incorrect DLC, or incorrect data within the received message.
 - Unexpected RESET or status information.