



**BSI Standards Publication**

# **Integrated circuits — EMC evaluation of transceivers**

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Part 3: CAN transceivers

## National foreword

This British Standard is the UK implementation of EN IEC 62228-3:2019. It is identical to IEC 62228-3:2019, incorporating corrigendum June 2023. It supersedes DD IEC/TS 62228:2007, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductors.

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Integrated circuits - EMC evaluation of transceivers - Part 3:  
CAN transceivers  
(IEC 62228-3:2019)

Circuits intégrés - Évaluation de la CEM des émetteurs-  
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(IEC 62228-3:2019)

Integrierte Schaltungen - Bewertung der  
elektromagnetischen Verträglichkeit von Sende-  
Empfangsgeräten - Teil 3: CAN-Sende-Empfangsgeräte  
(IEC 62228-3:2019)

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## **European foreword**

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In the official version, for Bibliography, the following notes have to be added for the standards indicated:

|               |      |                            |
|---------------|------|----------------------------|
| IEC 61000-4-4 | NOTE | Harmonized as EN 61000-4-4 |
| CISPR 16-1-1  | NOTE | Harmonized as EN 55016-1-1 |

## Annex ZA

(normative)

### Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: [www.cenelec.eu](http://www.cenelec.eu).

| <u>Publication</u> | <u>Year</u> | <u>Title</u>                                                                                                                                                        | <u>EN/HD</u>   | <u>Year</u> |
|--------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-------------|
| IEC 61967-1        | -           | Integrated circuits - Measurement of electromagnetic emissions - Part 1: General conditions and definitions                                                         | EN IEC 61967-1 | -           |
| IEC 61967-4        | -           | Integrated circuits - Measurement of electromagnetic emissions, 150 kHz to 1 GHz - Part 4: Measurement of conducted emissions, 1 ohm/150 ohm direct coupling method | EN 61967-4     | -           |
| IEC 62132-1        | -           | Integrated circuits - Measurement of electromagnetic immunity - Part 1: General conditions and definitions                                                          | EN 62132-1     | -           |
| IEC 62132-4        | -           | Integrated circuits - Measurement of electromagnetic immunity 150 kHz to 1 GHz - Part 4: Direct RF power injection method                                           | EN 62132-4     | -           |
| IEC 62215-3        | -           | Integrated circuits - Measurement of impulse immunity - Part 3: Non-synchronous transient injection method                                                          | EN 62215-3     | -           |
| IEC 62228-1        | -           | Integrated circuits - EMC evaluation of transceivers - Part 1: General conditions and definitions                                                                   | EN IEC 62228-1 | -           |
| ISO 7637-2         | -           | Road vehicles - Electrical disturbances from conduction and coupling - Part 2: Electrical transient conduction along supply lines only                              | -              | -           |
| ISO 10605          | -           | Road vehicles - Test methods for electrical disturbances from electrostatic discharge                                                                               | -              | -           |
| 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                                                                               | -              | -           |

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INTEGRATED CIRCUITS –  
EMC EVALUATION OF TRANSCEIVERS –****Part 3: CAN transceivers****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62228-3 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

This first edition cancels and replaces the first edition of IEC TS 62228 published in 2007 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC TS 62228:

- a) introduction of CAN transceivers with partial networking functionality and CAN transceivers with flexible data rate capability and addition of operation modes and test descriptions in the respective subclauses of the document;
- b) introduction of minimal communication network with two CAN transceivers;
- c) update of the test requirements and targets in Annex C;
- d) addition of Annex D for common mode choke characterization.

The text of this standard is based on the following documents:

| CDV          | Report on voting |
|--------------|------------------|
| 47A/1050/CDV | 47A/1069/RVC     |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62228 series, published under the general *title Integrated circuits – EMC evaluation of transceivers*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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# INTEGRATED CIRCUITS – EMC EVALUATION OF TRANSCEIVERS –

## Part 3: CAN transceivers

### 1 Scope

This part of IEC 62228 specifies test and measurement methods for EMC evaluation of CAN transceiver ICs under network condition. It defines test configurations, test conditions, test signals, failure criteria, test procedures, test setups and test boards. It is applicable for CAN standard transceivers, CAN transceivers with partial networking functionality and CAN transceivers with flexible data rate capability and covers

- the emission of RF disturbances,
- the immunity against RF disturbances,
- the immunity against impulses, and
- the immunity against electrostatic discharges (ESD).

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 61967-1, *Integrated circuits – Measurement of electromagnetic emissions – Part 1: General conditions and definitions*

IEC 61967-4, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 4: Measurement of conducted emissions – 1  $\Omega$ /150  $\Omega$  direct coupling method*

IEC 62132-1, *Integrated circuits – Measurement of electromagnetic immunity – Part 1: General conditions and definitions*

IEC 62132-4, *Integrated circuits – Measurement of electromagnetic immunity 150 kHz to 1 GHz – Part 4: Direct RF power injection method*

IEC 62215-3, *Integrated circuits – Measurement of impulse immunity – Part 3: Non-synchronous transient injection method*

IEC 62228-1, *Integrated circuits – EMC evaluation of transceivers – Part 1: General conditions and definitions*

ISO 7637-2, *Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only*

ISO 10605, *Road vehicles – Test methods for electrical disturbances from electrostatic discharge*

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*

### 3 Terms, definitions and abbreviated terms

#### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62228-1, IEC 61967-1, IEC 62132-1, as well as the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

##### 3.1.1

###### **global pin**

pin that carries a signal or power, which enters or leaves the application board without any active component in between

##### 3.1.2

###### **CAN standard transceiver**

transceiver with functionality according to ISO 11898-2 with data rates up to 1 MBit/s and access to RxD and TxD signal

##### 3.1.3

###### **CAN PN transceiver**

transceiver with partial networking functionality according to ISO 11898-2 with access to RxD and TxD signal

##### 3.1.4

###### **CAN FD transceiver**

transceiver with flexible data rate capability according to ISO 11898-2 with data rates up to 2 MBit/s or 5 Mbit/s and access to RxD and TxD signal

##### 3.1.5

###### **Low Power – standby**

transceiver functional operation mode low power with active bus biasing

##### 3.1.6

###### **Low Power – sleep**

transceiver functional operation mode low power with inactive bus biasing

##### 3.1.7

###### **Low Power – PN standby**

transceiver functional operation mode low power with active bus biasing and frame detection active

##### 3.1.8

###### **Low Power – PN sleep**

transceiver functional operation mode low power with inactive bus biasing and frame detection configured

##### 3.1.9

###### **mandatory components, pl**

components needed for proper function of IC as specified by the IC manufacturer

### 3.2 Abbreviated terms

|      |                                         |
|------|-----------------------------------------|
| ASIC | application specific integrated circuit |
| CMC  | common mode choke                       |
| DUT  | device under test                       |
| DPI  | direct RF power injection               |
| ERR  | error                                   |
| FD   | flexible data rate                      |
| INH  | inhibit                                 |
| CAN  | controller area network                 |
| PCB  | printed circuit board                   |
| PN   | partial networking                      |
| RxD  | receive data                            |
| SBC  | system base chip                        |
| TxD  | transmit data                           |
| WUF  | wake-up frame                           |

## 4 General

The intention of this document is to evaluate the EMC performance of CAN transceivers under application conditions in a minimal network.

The evaluation of the EMC characteristics of CAN transceivers shall be performed in functional operation modes under network condition for RF emission, RF immunity and impulse immunity tests and on a single transceiver for electrostatic discharge tests.

The aim of these tests is to determine the EMC performance on dedicated pins of the CAN transceiver which are considered as EMC relevant in the application. For a CAN transceiver IC, these pins are CAN\_H, CAN\_L,  $V_{BAT}$  and WAKE. Depending on the IC and its functionality, other pins as for example  $V_{CC}$  should be considered as well.

The test methods used for the EMC characterization are based on the international standards for IC EMC tests and are described in Table 1.

**Table 1 – Overview of measurements and tests**

|                                                 | Test                   | Test method                                       | Evaluation | Functional operation mode        |
|-------------------------------------------------|------------------------|---------------------------------------------------|------------|----------------------------------|
| Transceiver network                             | RF emission (EMI)      | 150 $\Omega$ direct coupling (IEC 61967-4)        | Spectrum   | Normal                           |
|                                                 |                        |                                                   |            | Low Power – standby <sup>a</sup> |
|                                                 | RF immunity (RF)       | DPI (IEC 62132-4)                                 | Function   | Normal                           |
|                                                 |                        |                                                   |            | Low Power – standby <sup>a</sup> |
|                                                 |                        |                                                   |            | Low Power – sleep <sup>a</sup>   |
|                                                 | Impulse immunity (IMP) | Non-synchronous transient injection (IEC 62215-3) | Function   | Normal                           |
|                                                 |                        |                                                   |            | Low Power – standby <sup>a</sup> |
|                                                 |                        |                                                   |            | Low Power – sleep <sup>a</sup>   |
| Single transceiver                              | ESD                    | Contact discharge (ISO 10605)                     | Damage     | Unpowered                        |
| <sup>a</sup> If provided by the implementation. |                        |                                                   |            |                                  |

The 150  $\Omega$  direct coupling, DPI and non-synchronous transient injection test methods are chosen for the evaluation of the EMC characteristic of transceivers in network condition. These three test methods are based on the same approach using conductive coupling. Therefore it is possible to use the same test board for all tests in functional operation mode, which reduces the effort and increases the reproducibility and comparability of test results.

The ESD test is performed on single transceiver on a separate test board.

All measurements and tests should be done with soldered transceivers on special test boards as described in Annex B to ensure application like conditions and avoid setup effects by sockets. For automotive applications, test limit examples are described in Annex C.

In general, the test definition is done for stand-alone CAN transceivers. CAN transceiver IP core embedded in SBCs or ASICs shall follow the test methods for single CAN transceivers, adapting test conditions and targets as necessary. Such adaptations shall be done individually for the dedicated IC but shall follow the general definitions.

In order to verify filter effects on the EMC performance of CAN transceivers, configurations with and without a bus filter (e.g. common mode choke, capacitor) at the CAN\_H and CAN\_L pins are defined in this document. As a consequence, the frequency characteristic of these filter elements shall be taken into account for the interpretation of the test results. See Annex D for more information about common mode choke characterization.

## 5 Test and operating conditions

### 5.1 Supply and ambient conditions

For all tests and measurements under operating conditions, the settings are based on systems with 12 V power supply, which is the main application of CAN transceivers. If a transceiver is designed or targeted for other power supply voltages, the test conditions and test targets shall be adapted and documented accordingly. The defined supply and ambient conditions for functional operation are given in Table 2.

**Table 2 – Supply and ambient conditions for functional operation**

| Parameter                                                                                                | Value                       |
|----------------------------------------------------------------------------------------------------------|-----------------------------|
| Voltage supply $V_{BAText}^a$                                                                            | $(14 \pm 0,2)$ V (default)  |
| Voltage supply $V_{CCext}^a$                                                                             | $(5 \pm 0,1)$ V (default)   |
| Voltage supply $V_{IOext}^a$                                                                             | $(3,3 \pm 0,1)$ V (default) |
| Test temperature                                                                                         | $(23 \pm 5)$ °C             |
| <sup>a</sup> $V_{ext}$ means voltage at external terminal on the test board as shown e.g. in Figure A.1. |                             |

For RF emission measurements, the ambient noise floor shall be at least 6 dB below the applied target limit and documented in the test report.

For ESD tests, the requirements of ISO 10605 climatic environmental conditions shall be applied.

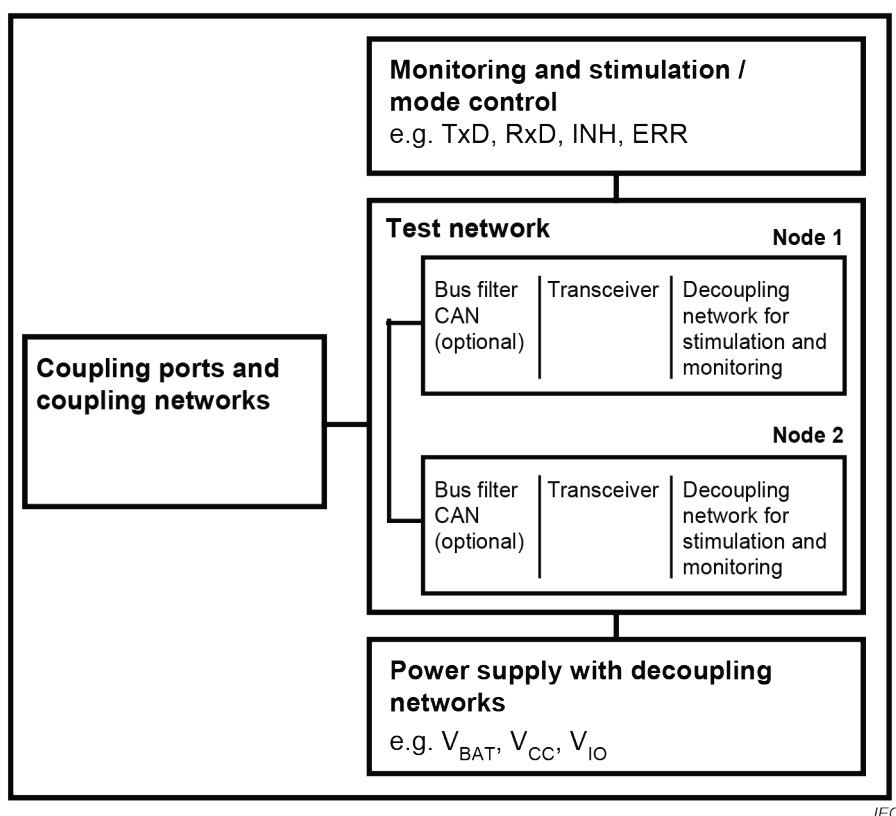
## 5.2 Test operation modes

The CAN transceivers shall be tested in functional operation modes and unpowered according to Table 1.

## 5.3 Test configuration

### 5.3.1 General test configuration for transceiver network

The test configuration in general consists of CAN transceivers with mandatory external components and components for filtering and decoupling (CAN node) in a minimal test network, when filtered power supplies, signals, monitoring probes and coupling networks are connected as shown in Figure 1.



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**Figure 1 – General test configuration for tests in transceiver network**

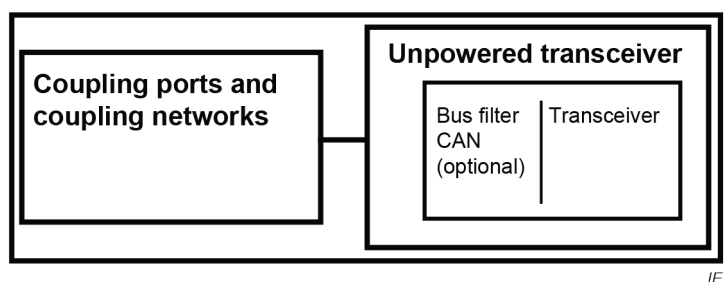
For evaluation of RF emission, RF immunity and impulse immunity characteristic of a CAN transceiver in functional operation mode a minimal CAN test network consisting of two CAN transceivers of same type shall be used.

NOTE In specific cases or for analyses, a deviation from this setup can be agreed between the users of this document and noted in the test report.

General drawings of schematics with more details are given in Annex A.

### 5.3.2 General test configuration for unpowered ESD test

The general test configuration for unpowered ESD test of CAN transceivers consists of a single CAN transceiver with mandatory external components and components for filtering on a test board with discharge coupling networks as shown in Figure 2.



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**Figure 2 – General test configuration for unpowered ESD test**

### 5.3.3 Transceiver network tests – Coupling ports and networks

The coupling ports and coupling networks are used to transfer disturbances to or from the test network with a defined transfer characteristic. The schematic of the coupling ports, networks and pins are shown in Figure 3. The values of the components are depending on the test method and defined in Table 3. The tolerance of the components shall be 1 % or less. For the resistors  $R_{CP1a}$  and  $R_{CP1b}$  used for symmetrical decoupling, a maximum mismatch of 0,1 % is recommended.

NOTE Components can be selected by measurement of the value.

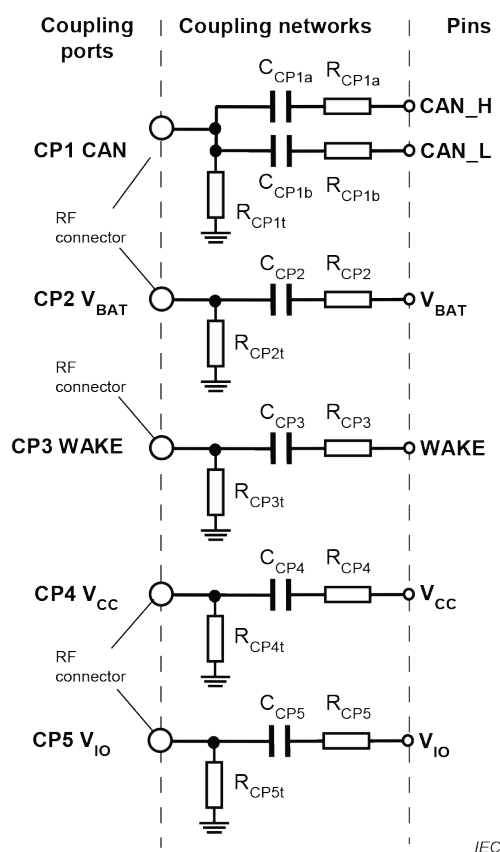


Figure 3 – Transceiver network tests – Coupling ports and networks

**Table 3 – Transceiver network tests – Component value definitions of coupling ports and networks**

| Port                                                                                                                                                      | Type | Purpose                                                    | Component                                          |                                                            |                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------------------------|----------------------------------------------------|------------------------------------------------------------|------------------------|
|                                                                                                                                                           |      |                                                            | $R_{CP1..3}$                                       | $C_{CP1..3}$                                               | $R_{CP1..3t}$          |
| CP1                                                                                                                                                       | EMI1 | RF emission measurement on CAN                             | $R_{CP1a} = 120 \Omega$<br>$R_{CP1b} = 120 \Omega$ | $C_{CP1a} = 4,7 \text{ nF}$<br>$C_{CP1b} = 4,7 \text{ nF}$ | $R_{CP1t} = 51 \Omega$ |
|                                                                                                                                                           | RF1  | RF symmetrical coupling for immunity test on CAN           | $R_{CP1a} = 120 \Omega$<br>$R_{CP1b} = 120 \Omega$ | $C_{CP1a} = 4,7 \text{ nF}$<br>$C_{CP1b} = 4,7 \text{ nF}$ | not used               |
|                                                                                                                                                           | RF1a | RF asymmetrical coupling for immunity test on CAN (+ 20 %) | $R_{CP1a} = 132 \Omega$<br>$R_{CP1b} = 108 \Omega$ | $C_{CP1a} = 4,7 \text{ nF}$<br>$C_{CP1b} = 4,7 \text{ nF}$ | not used               |
|                                                                                                                                                           | RF1b | RF asymmetrical coupling for immunity test on CAN (- 20 %) | $R_{CP1a} = 108 \Omega$<br>$R_{CP1b} = 132 \Omega$ | $C_{CP1a} = 4,7 \text{ nF}$<br>$C_{CP1b} = 4,7 \text{ nF}$ | not used               |
|                                                                                                                                                           | IMP1 | Impulse coupling on CAN                                    | $R_{CP1a} = 0 \Omega$<br>$R_{CP1b} = 0 \Omega$     | $C_{CP1a} = 1 \text{ nF}$<br>$C_{CP1b} = 1 \text{ nF}$     | not used               |
| CP2                                                                                                                                                       | EMI2 | RF emission measurement on $V_{BAT}$                       | $R_{CP2} = 120 \Omega$                             | $C_{CP2} = 6,8 \text{ nF}$                                 | $R_{CP2t} = 51 \Omega$ |
|                                                                                                                                                           | RF2  | RF coupling for immunity test on $V_{BAT}$                 | $R_{CP2} = 0 \Omega$                               | $C_{CP2} = 6,8 \text{ nF}$                                 | not used               |
|                                                                                                                                                           | IMP2 | Impulse coupling on $V_{BAT}$                              | $R_{CP2} = 0 \Omega$                               | shorted                                                    | not used               |
| CP3                                                                                                                                                       | EMI3 | RF emission measurement on WAKE                            | $R_{CP3} = 120 \Omega$                             | $C_{CP3} = 6,8 \text{ nF}$                                 | $R_{CP3t} = 51 \Omega$ |
|                                                                                                                                                           | RF3  | RF coupling for immunity test on WAKE                      | $R_{CP3} = 0 \Omega$                               | $C_{CP3} = 6,8 \text{ nF}$                                 | not used               |
|                                                                                                                                                           | IMP3 | Impulse coupling on WAKE                                   | $R_{CP3} = 0 \Omega$                               | $C_{CP3} = 1,0 \text{ nF}$                                 | not used               |
| CP4                                                                                                                                                       | EMI4 | RF emission measurement on $V_{CC}$                        | $R_{CP4} = 120 \Omega$                             | $C_{CP4} = 6,8 \text{ nF}$                                 | $R_{CP4t} = 51 \Omega$ |
| CP5                                                                                                                                                       | EMI5 | RF emission measurement on $V_{IO}$                        | $R_{CP5} = 120 \Omega$                             | $C_{CP5} = 6,8 \text{ nF}$                                 | $R_{CP5t} = 51 \Omega$ |
| NOTE $R_{CP1a}$ and $R_{CP1b}$ can be combined out of two resistors of the same type. They are intended to simulate a mode conversation in the bus lines. |      |                                                            |                                                    |                                                            |                        |

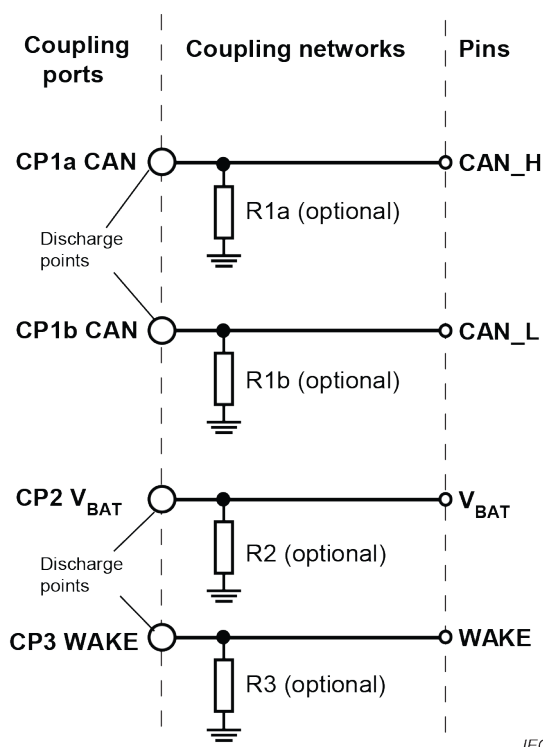
The test configurations with coupling ports and coupling networks connected to the CAN test network are given in the general drawing of schematics in Figure A.1.

The characterization of the coupling ports and coupling networks is carried out as follows.

The magnitude of insertion losses ( $S_{21}$  measurement) between the ports CP1 to CP5 and the respective transceiver signal pads on the test board shall be measured and documented in the test report. The connection of signal pads using  $50 \Omega$  coaxial probe directly, and ground connection shall be as short as possible. For this characterization, the coupling port shall be configured for RF immunity or emission test and the CAN transceivers shall be removed. All other components which are directly connected to the coupling port (e.g. filter to power supply or loads) remain on the test board.

### 5.3.4 ESD tests – Coupling ports and networks

The discharge points are connected by the coupling networks to the CAN transceiver test circuitry. The schematic and definitions of the coupling ports, networks and pins are given in Figure 4 and Table 4.



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**Figure 4 – Coupling ports and networks for ESD tests**

**Table 4 – Definitions of coupling ports for ESD tests**

| Port | Type  | Purpose                          | Components                                       |
|------|-------|----------------------------------|--------------------------------------------------|
| CP1a | ESD1a | ESD coupling on CAN_H            | Metal trace for galvanic connection <sup>a</sup> |
| CP1b | ESD1b | ESD coupling on CAN_L            | Metal trace for galvanic connection <sup>a</sup> |
| CP2  | ESD2  | ESD coupling on V <sub>BAT</sub> | Metal trace for galvanic connection <sup>a</sup> |
| CP3  | ESD3  | ESD coupling on WAKE             | Metal trace for galvanic connection <sup>a</sup> |

<sup>a</sup> The optional resistors R1a, R1b, R2 and R3 with  $R \geq 200 \text{ k}\Omega$  are used to avoid static pre-charge of discharge point caused by the ESD generator. A spark over at these resistors at high test levels shall be avoided. If a static pre-charge is prevented by the ESD generator construction, these resistors are not needed. Alternatively, an external resistor can be used to remove pre-charges of each discharge point before each single test.

## 5.4 Test signals

### 5.4.1 General

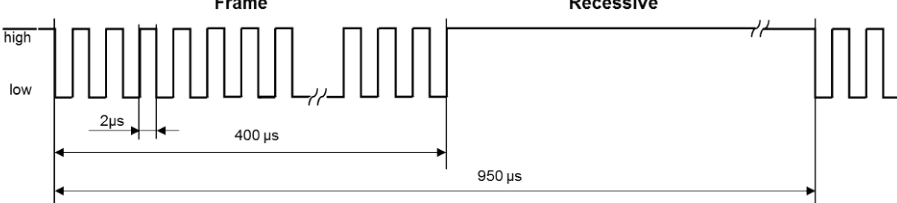
Depending on the transceiver type, different test signals are defined for communication in normal operation mode and wake-up from sleep or standby mode of the CAN transceivers.

### 5.4.2 Test signals for normal operation mode

#### 5.4.2.1 CAN standard transceiver

The communication test signal TX1 shall be used for testing CAN standard transceivers in normal operation mode. The parameters of this periodical signal are defined in Table 5.

**Table 5 – Communication test signal TX1**

| Test signal  | TX1                                                                                                                   |
|--------------|-----------------------------------------------------------------------------------------------------------------------|
| Signal type  | Standard test signal (periodic)<br> |
| Frequency    | 250 kHz                                                                                                               |
| Cycle time   | 950 µs                                                                                                                |
| Frame length | 400 µs                                                                                                                |
| Amplitude    | $V_{IO} \pm 0,1 \text{ V}$ or $V_{CC} \pm 0,1 \text{ V}$ (depending on the CAN transceiver)                           |

#### 5.4.2.2 CAN FD

The communication test signal TX2 shall be used for tests of CAN FD transceiver ICs with flexible data rate capability in normal mode. The signal is defined as a CAN frame with the parameters given in Table 6 for CAN FD 2 Mbit/s and Table 7 for CAN FD 5 Mbit/s. Depending on the test target, a section of the frame shown in Figure 5 should be sufficient.

**Table 6 – Communication test signal TX2a**

| Test signal                                                                                                                                                                                                                                                                              | TX2a                                                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Signal type                                                                                                                                                                                                                                                                              | 2 Mbit/s data frame in FBFF (FD base frame format) according to ISO 11898-1 <sup>a</sup>                                                                       |
| CAN clock                                                                                                                                                                                                                                                                                | 40 MHz (tolerance $\pm 0,05 \%$ without jitter)                                                                                                                |
| Bit rate settings                                                                                                                                                                                                                                                                        | time quantum: $tq_A = tq_D = 25 \text{ ns}$<br>nominal bit rate: 500 kbit/s (SP at 80 %)<br>data bit rate: 2 Mbit/s (SP at 60 %, SSP at 55 %)<br>TDC = enabled |
| Transmission type                                                                                                                                                                                                                                                                        | periodic $\leq 730 \text{ µs}$                                                                                                                                 |
| CAN-ID                                                                                                                                                                                                                                                                                   | 0                                                                                                                                                              |
| Data field                                                                                                                                                                                                                                                                               | MSB to LSB: 21 bytes ( $55_{16}$ ), 21 bytes ( $00_{16}$ ), 21 bytes ( $FF_{16}$ ), 1 byte (counter increased by 1 per transmission)                           |
| Amplitude                                                                                                                                                                                                                                                                                | $V_{IO} \pm 0,1 \text{ V}$ or $V_{CC} \pm 0,1 \text{ V}$ (depending on the CAN transceiver)                                                                    |
| Use a CAN FD controller in error active mode to generate and monitor the CAN FD data frames. To achieve low-jitter, set the oscillator frequency equal to the CAN clock frequency. A signal generator with appropriate timing can be used for Rx mask test to minimize signal jittering. |                                                                                                                                                                |
| <sup>a</sup> With a DLC (data length code) of F16 (indicating a 64-byte data field).                                                                                                                                                                                                     |                                                                                                                                                                |

**Table 7 – Communication test signal TX2b**

| Test signal                                                                                                                                                                                                                                                                              | TX2b                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Signal type                                                                                                                                                                                                                                                                              | 5 Mbit/s data frame in FBFF (FD base frame format) according to ISO 11898-1 <sup>a</sup>                                                                                                      |
| CAN clock                                                                                                                                                                                                                                                                                | 80 MHz (tolerance $\pm 0,05$ % without jitter) default, 40 MHz optional <sup>b</sup>                                                                                                          |
| Bit rate settings                                                                                                                                                                                                                                                                        | time quantum: $tq_A = tq_D = 12,5$ ns default, 25 ns optional <sup>b</sup><br>nominal bit rate: 500 kbit/s (SP at 80 %)<br>data bit rate: 5 Mbit/s (SP at 75 %, SSP at 75 %)<br>TDC = enabled |
| Transmission type                                                                                                                                                                                                                                                                        | periodic $\leq 380$ $\mu$ s                                                                                                                                                                   |
| CAN-ID                                                                                                                                                                                                                                                                                   | 0                                                                                                                                                                                             |
| Data field                                                                                                                                                                                                                                                                               | MSB to LSB: 21 bytes ( $55_{16}$ ), 21 bytes ( $00_{16}$ ), 21 bytes ( $FF_{16}$ ), 1 byte (counter increased by 1 per transmission)                                                          |
| Amplitude                                                                                                                                                                                                                                                                                | $V_{IO} \pm 0,1$ V or $V_{CC} \pm 0,1$ V (depending on the CAN transceiver)                                                                                                                   |
| Use a CAN FD controller in error active mode to generate and monitor the CAN FD data frames. To achieve low-jitter, set the oscillator frequency equal to the CAN clock frequency. A signal generator with appropriate timing can be used for Rx mask test to minimize signal jittering. |                                                                                                                                                                                               |
| <sup>a</sup> With a DLC (data length code) of F16 (indicating a 64-byte data field).                                                                                                                                                                                                     |                                                                                                                                                                                               |
| <sup>b</sup> Double time quantum value $tq_A$ and $tq_D$ , leads to lower accuracy.                                                                                                                                                                                                      |                                                                                                                                                                                               |

### 5.4.3 Test signal for wake-up from low power mode

#### 5.4.3.1 CAN standard transceiver

The wake-up test signal TX3 shall be used for test of a wanted wake-up from low power mode for CAN standard transceivers. The parameters of this signal are defined in Table 8. It shall be send only once as wake-up request.

**Table 8 – Wake-up test signal TX3**

| Test signal                                                                                                                                                                                                                                                                                                                                                                                                | TX3                                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| Signal type                                                                                                                                                                                                                                                                                                                                                                                                | Standard single wake-up test signal<br><br><div style="text-align: center;"> <p><b>3 Bit wake-up request</b></p> </div> |
| Amplitude                                                                                                                                                                                                                                                                                                                                                                                                  | $V_{IO} \pm 0,1$ V or $V_{CC} \pm 0,1$ V (depending on the transceiver)                                                 |
| ISO 11898-2 defines two different filter times for wake-up at bus ( $t_{filter\_short} = 150$ ns to $1,8$ $\mu$ s, $t_{filter\_long} = 500$ ns to $5$ $\mu$ s). The TX signal is intended to represent this signal at bus level. If the transceiver does not support this wake-up request signal, it should be adjusted. Alternatively, the same signal with a longer bit time of $5$ $\mu$ s can be used. |                                                                                                                         |

#### 5.4.3.2 CAN PN

The test signals TX4a to TX4h shall be used for tests of CAN transceivers with partial networking functionality. The parameters of the test signals are defined in Table 9 to Table 18.

**Table 9 – Communication test signal TX4a**

| Test signal                                                 | TX4a                                                                                    |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Signal type                                                 | CAN single frame 500 kbit/s                                                             |
| Protocol                                                    | ISO 11898-1                                                                             |
| Clock frequency                                             | 251 kHz (250 kHz + 0,4 %)                                                               |
| Parameter CAN ID                                            | CAN ID value: 3C2 <sub>16</sub><br>DLC: 0 byte<br>data: not applicable                  |
| Amplitude                                                   | $V_{IO} \pm 0,1 \text{ V}$ or $V_{CC} \pm 0,1 \text{ V}$ (depending on the transceiver) |
| NOTE The test signal is generated with a pattern generator. |                                                                                         |

**Table 10 – Communication test signal TX4b**

| Test signal                                                 | TX4b                                                                                    |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Signal type                                                 | CAN single frame 500 kbit/s                                                             |
| Protocol                                                    | ISO 11898-1                                                                             |
| Clock frequency                                             | 251 kHz (250 kHz + 0,4 %)                                                               |
| Parameter CAN ID                                            | CAN ID value: 784 <sub>16</sub><br>DLC: 0 byte<br>data: not applicable                  |
| Amplitude                                                   | $V_{IO} \pm 0,1 \text{ V}$ or $V_{CC} \pm 0,1 \text{ V}$ (depending on the transceiver) |
| NOTE The test signal is generated with a pattern generator. |                                                                                         |

**Table 11 – Communication test signal TX4c**

| Test signal                                                 | TX4c                                                                                    |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Signal type                                                 | CAN single frame 500 kbit/s                                                             |
| Protocol                                                    | ISO 11898-1                                                                             |
| Clock frequency                                             | 251 kHz (250 kHz + 0,4 %)                                                               |
| Parameter CAN ID                                            | CAN ID value: 18E <sub>16</sub><br>DLC: 0 byte<br>data: not applicable                  |
| Amplitude                                                   | $V_{IO} \pm 0,1 \text{ V}$ or $V_{CC} \pm 0,1 \text{ V}$ (depending on the transceiver) |
| NOTE The test signal is generated with a pattern generator. |                                                                                         |

**Table 12 – Communication test signal TX4d**

| Test signal                                                 | TX4d                                                                              |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Signal type                                                 | CAN single frame 500 kbit/s                                                       |
| Protocol                                                    | ISO 11898-1                                                                       |
| Clock frequency                                             | 251 kHz (250 kHz + 0,4 %)                                                         |
| Parameter CAN ID                                            | CAN ID value: 43C <sub>16</sub><br>DLC: 0 byte<br>data: not applicable            |
| Amplitude                                                   | V <sub>IO</sub> ± 0,1 V or V <sub>CC</sub> ± 0,1 V (depending on the transceiver) |
| NOTE The test signal is generated with a pattern generator. |                                                                                   |

**Table 13 – Communication test signal TX4e**

| Test signal                                                 | TX4e                                                                              |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Signal type                                                 | CAN single frame 500 kbit/s                                                       |
| Protocol                                                    | ISO 11898-1                                                                       |
| Clock frequency                                             | 251 kHz (250 kHz + 0,4 %)                                                         |
| Parameter CAN ID                                            | CAN ID value: 062 <sub>16</sub><br>DLC: 0 byte<br>data: not applicable            |
| Amplitude                                                   | V <sub>IO</sub> ± 0,1 V or V <sub>CC</sub> ± 0,1 V (depending on the transceiver) |
| NOTE The test signal is generated with a pattern generator. |                                                                                   |

**Table 14 – Communication test signal TX4f1**

| Test signal                                                 | TX4f1                                                                                                                                                                                                                  |
|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Signal type                                                 | CAN single frame 500 kbit/s                                                                                                                                                                                            |
| Protocol                                                    | ISO 11898-1                                                                                                                                                                                                            |
| Clock frequency                                             | 249 kHz (250 kHz – 0,4 %)                                                                                                                                                                                              |
| Parameter CAN ID                                            | CAN ID value: 07830F0F <sub>16</sub> (extended identifier)<br>DLC: 7 bytes<br>data: 87 <sub>16</sub> , 87 <sub>16</sub> , 87 <sub>16</sub> , 87 <sub>16</sub> , 87 <sub>16</sub> , 87 <sub>16</sub> , 87 <sub>16</sub> |
| Amplitude                                                   | V <sub>IO</sub> ± 0,1 V or V <sub>CC</sub> ± 0,1 V (depending on the transceiver)                                                                                                                                      |
| NOTE The test signal is generated with a pattern generator. |                                                                                                                                                                                                                        |