

Integrated circuits — EMC evaluation of CAN transceivers

ICS 31.200

National foreword

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This Draft for Development was published under the authority of the Standards Policy and Strategy Committee on 30 March 2007

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ISBN 978 0 580 50359 7

Amendments issued since publication

Amd. No.	Date	Comments

TECHNICAL SPECIFICATION

IEC TS 62228

First edition
2007-02

Integrated circuits – EMC evaluation of CAN transceivers



Reference number
IEC/TS 62228:2007(E)

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INTEGRATED CIRCUITS – EMC EVALUATION OF CAN TRANSCEIVERS

1 Scope

This document specifies test and measurement methods, test conditions, test setups, test procedures, failure criteria and test signals for the EMC evaluation of CAN transceivers concerning:

- the immunity against RF common mode disturbances on the signal lines,
- the emissions caused by non-symmetrical signals regarding the time and frequency domain,
- the immunity against transients (function and damage), and
- the immunity against electrostatic discharges – ESD (damage).

All measurements and functional tests except ESD are performed in a small (three transceiver) network. For ESD damage tests a single transceiver configuration on a special test board is used.

External protection circuits are not applied during the tests in order to get results for the transceiver IC only.

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.

IEC 61967 (all parts), *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz*

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

IEC 62132 (all parts), *Integrated circuits – Measurement of electromagnetic immunity, 150 kHz to 1 GHz*

IEC 62132-1, *Integrated circuits – Measurement of electromagnetic immunity, 150 kHz to 1 GHz – 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 61000-4-2:1995, *Electromagnetic compatibility – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test*¹⁾
Amendment 1 (1998)
Amendment 2 (2000)

ISO 7637-2: 2004, *Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only*

¹⁾ A consolidated edition 1.2 exists, including IEC 61000-4-2:1995 and its Amendment 1 (1998) and Amendment 2 (2000)

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61967 and IEC 62132 apply.

4 Measurements and tests

4.1 General

For evaluation of the EMC characteristic of CAN transceivers different test conditions and test set-ups are used:

- configuration of three powered transceivers in a CAN network for:
 - evaluation of narrowband emission at the bus lines and
 - evaluation of RF and transient immunity at the bus lines, voltage supply line V_{Bat} and the wake-up line;
- configuration of single unpowered transceiver for testing the damage immunity against ESD of the pins for bus lines, V_{Bat} and wake-up on a test board with functional required external components.

An overview of the requested measurements and tests is given in Table 1.

Table 1 – Overview of requested measurements and tests

Transceiver state	Required test	Test method	Evaluation	Transceiver mode
Active (powered)	RF emission	150 Ω direct coupling (IEC 61967-4)	Spectrum and asymmetry	Normal
	RF immunity	DPI (IEC 62132-4)	Function	Normal
				Stand by
				Sleep
	Transient immunity	Supply lines- direct galvanic coupling I/O lines- capacitive coupling Test pulse wave forms (ISO 7637-2)	Function	Normal
				Stand by
				Sleep
Passive (unpowered)	ESD	Contact discharge (IEC 61000-4-2)	Damage	Normal

In order to reduce the effort for the characterization and to increase the compatibility of the results of different transceiver types, the number of test methods is defined to a necessary minimum. The 150 Ω direct coupling, DPI and direct galvanic and capacitive coupling methods are chosen for the evaluation of the EMC characteristic of active transceivers in a network configuration with three CAN nodes. While using a conductive decoupling and coupling, these three test methods are based on the same approach. Thus it is possible to use the same PCB for all required active/functional tests and measurements. These tests can be performed on the same test board in a common test configuration and set-up.

To get more reproducible test results, all measurement and tests should be done with soldered transceivers.

The described test conditions, configurations and test procedures are based on present stand-alone CAN transceivers. In case of ASICs with an integrated CAN transceiver, the test conditions cannot be defined completely for any type of IC. If it is possible, the test conditions

of stand-alone CAN transceivers should be used. The configuration of the physical layer of the CAN bus should be the same.

4.2 RF and transient tests

4.2.1 General test conditions and configurations

4.2.1.1 Test conditions

The general test conditions are given in Table 2:

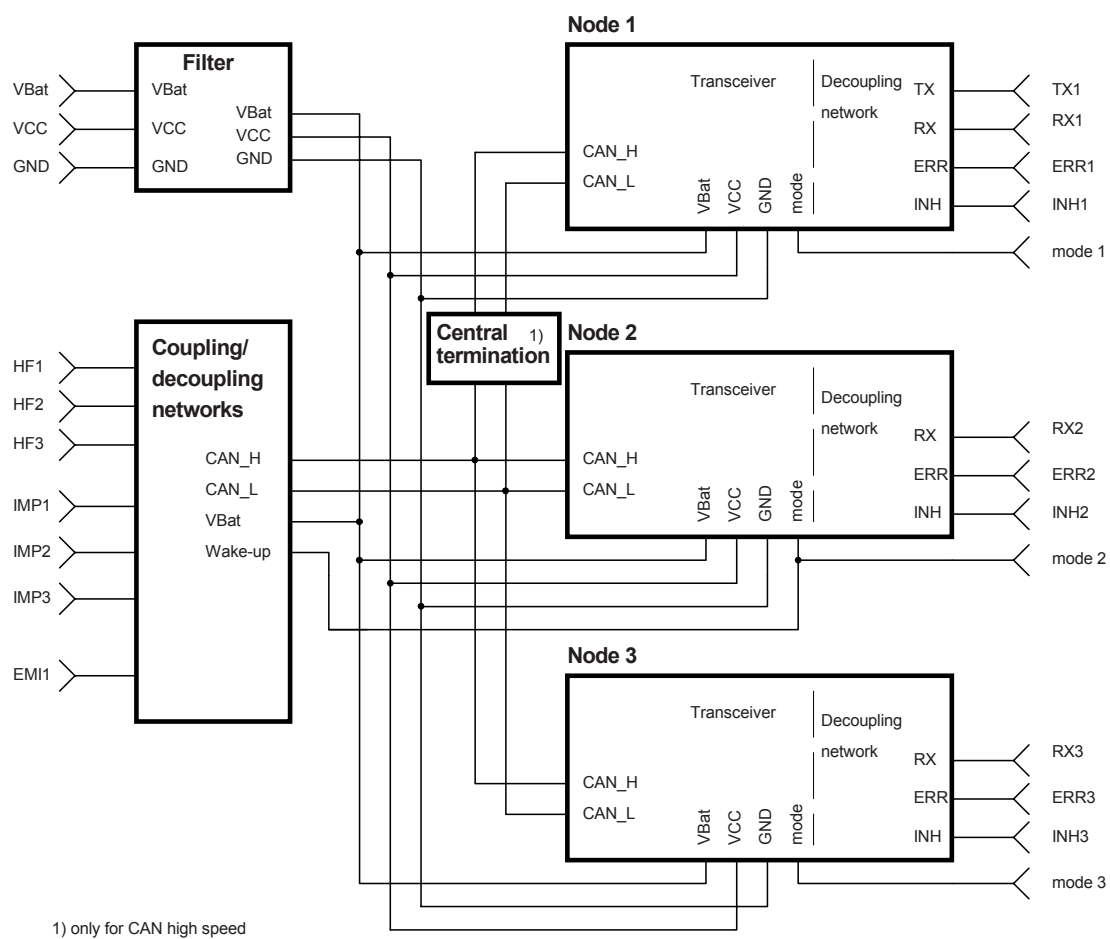
Table 2 – General test conditions

Parameter	Value
Voltage supply V_{Bat}	$(14 \pm 0,2) \text{ V}$
Voltage supply V_{CC}	$(5 \pm 0,1) \text{ V}$ (default)
Voltage supply V_{IO}	$(5 \pm 0,1) \text{ V}$ (default)
Test temperature	$(23 \pm 5) ^\circ\text{C}$

The ambient noise floor for emission measurements shall be below the expected signal noise and shall be documented in the test report.

4.2.1.2 Test configuration

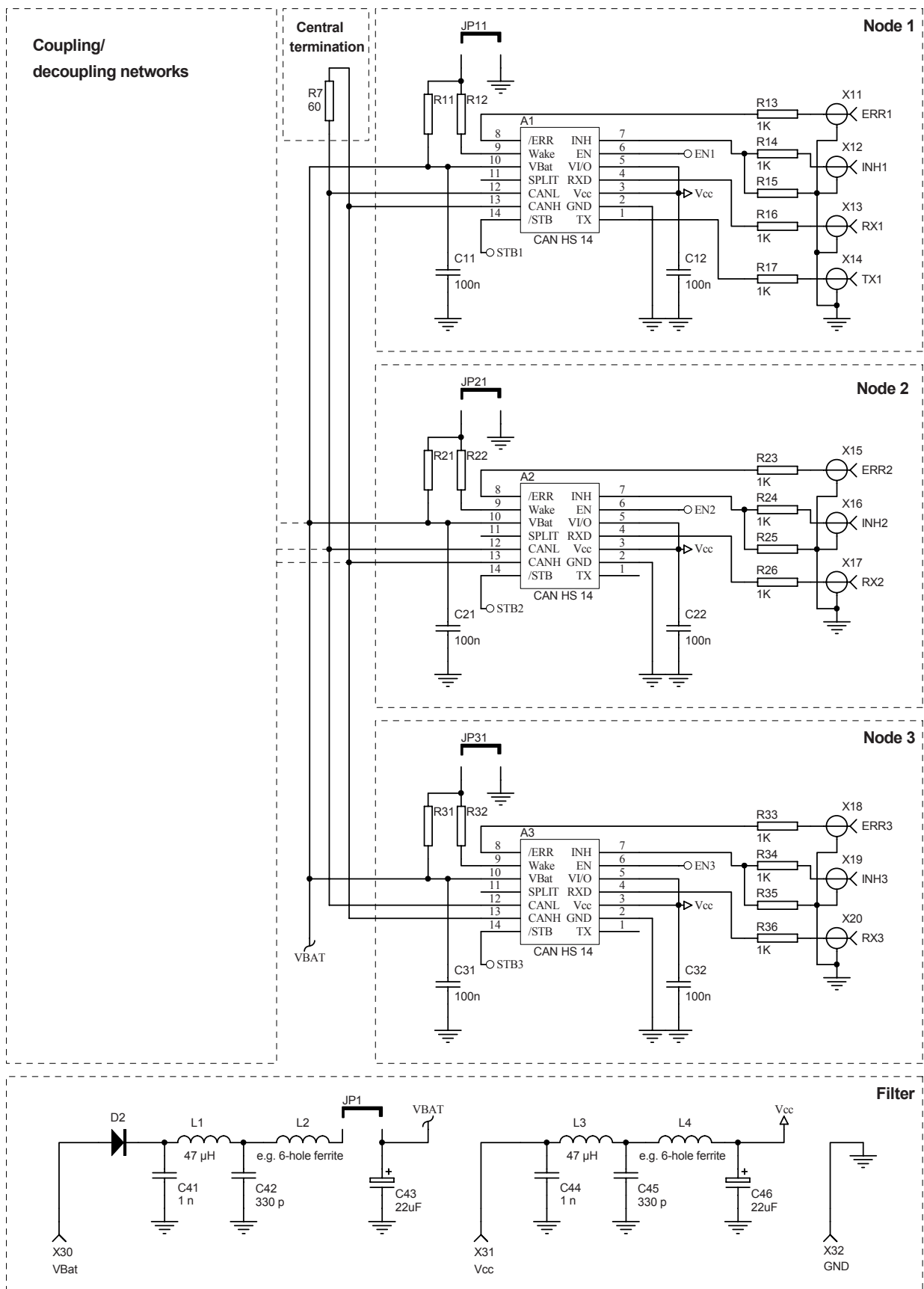
For the transceiver EMC analysis, a minimum network of three bus nodes has to be set up according to Figure 1.



IEC 206/07

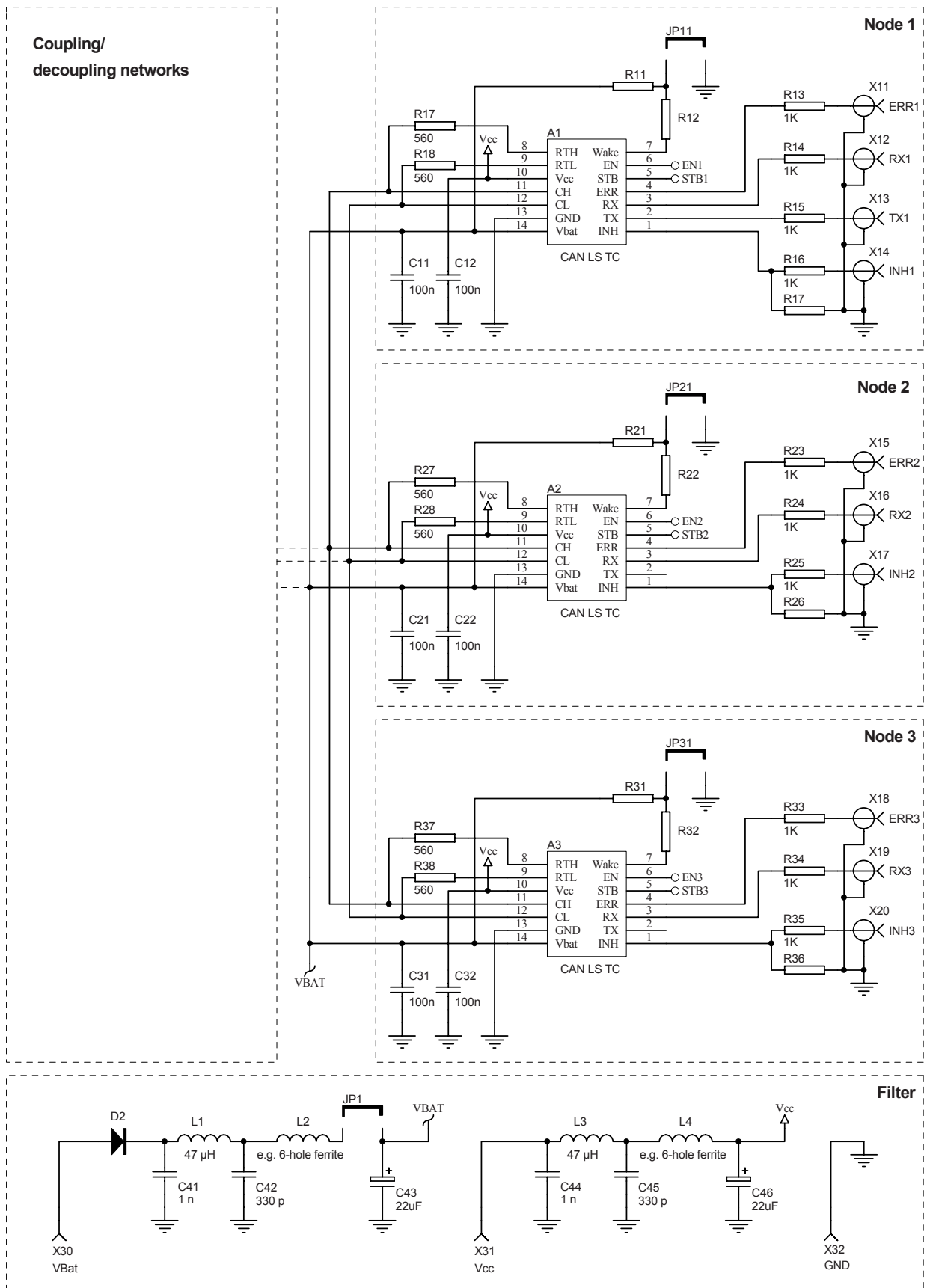
Figure 1 – Overview of a minimum configuration of a CAN system for emission and immunity tests against transient and RF disturbances

An example of a test circuit diagram for filter and the transceiver network for CAN high speed systems is given in Figure 2 and for CAN low speed systems in Figure 3.



IEC 207/07

Figure 2 – Example of the circuit diagram of the minimum network for a CAN high speed system for measuring emission and immunity in respect to RF disturbances and transients



IEC 208/07

Figure 3 – Example of the circuit diagram of the minimum network for a CAN low speed system for measuring emission and immunity in respect to RF disturbances and transients

- CAN nodes:

A CAN node consists of a transceiver, mandatory external components for functional settings and support and decoupling networks at monitored pins or inputs. Node 1 operates as a transmitter for a bit pattern, which simulates a CAN message to be received and monitored at the RX output ports of all nodes in the configured network.

At all voltage supply ports (V_{Bat} , V_{CC}) of the transceiver buffer, ceramic capacitors shall be used corresponding to the manufacturers specifications (default value: 100 nF).

Every control input for operation modes shall be connected corresponding to the manufacturers specifications for a setting either to normal, stand by, or sleep mode. Connections to the peripheral control equipment shall be decoupled from the test circuit board.

The resistor values at the wake-up pin (R_{11} , R_{12} , R_{21} , R_{22} , R_{31} , R_{32}) are to be selected corresponding to the manufacturers specifications in the following way:

- resistors R_{11} , R_{21} and R_{31} : maximum specified value (default: 10 k Ω)
- resistors R_{12} , R_{22} and R_{32} : minimum specified value (default: 3,3 k Ω)

For RF decoupling of outputs (RX, ERR, INH) as well as the input TX₁ resistors $R = 1$ k Ω are used.

In respect to avoid a floating voltage at pin INH (stand by or sleep mode), a pull down resistor shall be used corresponding to the manufacturers specifications (default value $R = 10$ k Ω).

Before RF and transient testing the wake-up function needs to be tested by using the jumpers JP11, JP21 and JP31.

- Bus termination:

In the test circuit for CAN high speed systems as shown in Figures 1 and 2, the termination shall be realized by a central termination using the resistor $R_7 = 60$ Ω .

In the test circuit for CAN low speed systems, the termination shall be realized on every CAN node ($R = 560$ Ω , see Figure 3).

- Filter:

The central voltage supply is buffered by two electrolytic capacitors $C_{43} = C_{46} = 22$ μF . For the decoupling of external connected voltage supplies V_{CC} and V_{Bat} , two-stage LC-filters are connected to each of them (L_1 , C_{41} , L_2 , C_{42} at V_{Bat} and L_3 , C_{44} , L_4 , C_{45} at V_{CC}). The parts L_2 and L_4 should have an impedance above 400 Ω in the frequency range of interest (e.g. 6-hole- ferrites). The jumper JP1 is used to disconnect the supply and RF decoupling filter network for the transient tests at IMP3. In this case, the voltage supply V_{Bat} is directly provided via the IMP3 path.

4.2.1.3 Operation mode definitions

- Definitions of transceiver communication test signals

Two different communication test signals TX1 and TX2 are defined. Depending on partial emission measurement or immunity test, the respective communication test signal (transmitted by transceiver 1) shall be used. Emission measurements in the frequency domain on CAN high speed transceivers shall be done with the communication test signals TX1 and TX2, in the case of CAN low speed system only with communication test signal TX1.

- Communication test signal TX1:

The communication test signal TX1 shall be used for emission measurements and immunity tests with communication (normal mode). The input signal is defined as a square wave with a duty cycle of 50 %. This represents a CAN signal with permanent data alternation (0-1-0 data) with the frequencies and bit rates as shown in Table 3.

Table 3 – Communication test signal TX1

Bus system	f kHz	Bit rate kBit/s
High speed	250	500
Low speed	50	100

- Communication test signal TX2:

The communication test signal TX2 shall be used only for emission measurements with CAN high speed systems additionally. The input signal is defined as a square wave with a duty cycle of 90 % with the frequency as shown in Table 4. This represents an asymmetrically data stream.

Table 4 – Communication test signal TX2

Bus system	f kHz
High speed	50

4.2.1.4 Definition of evaluation criteria for bus system immunity

4.2.1.4.1 Damage test evaluation criteria for bus system immunity

For evaluation of immunity against damages, a functional test of the transceiver shall be performed. The functional test includes:

- send- and receive-functionality,
- error detection,
- wake-up capability by the bus and by the wake-up pin, and
- operation mode setting.

All monitored functions shall be within the specifications given by the semiconductor manufacturer after expose to the disturbances.

4.2.1.4.2 Function test evaluation criteria for bus system immunity

The immunity of a CAN bus system shall be tested in different transceiver modes while the specified function is monitored at pins RX, ERR and INH according to the scheme in Table 5.

Table 5 – Basic scheme for immunity evaluation

Mode	Type of disturbance	Failure validation on pin
Normal	RF / Transients	RX, ERR, INH
Stand by	RF / Transients	RX, INH
Sleep	RF / Transients	INH

The boundary values for normal IC operation at different functional pins defined in Table 6 will be used for failure monitoring.

Table 6 – Boundary values for normal IC operation

Mode	Type of disturbance	TX-signal	Maximum voltage variations V			Maximum time variations μ s		
			RX ^{a,d}	ERR ^d	INH ^e	RX	ERR	INH
Normal	RF	With	$\pm 0,9$	$\pm 0,9$	± 5	$\pm 0,2^f$ $\pm 1,0^g$	– ^b	– ^b
	Transient	With	$\pm 0,9$	$\pm 0,9$	± 5	– ^b	– ^b	– ^b
Standby	RF / Transient	Without	$\pm 0,9$	– ^c	± 5	– ^b	– ^b	– ^b
Sleep	RF / Transient	Without	– ^c	– ^c	± 3	– ^b	– ^b	– ^b

^a The undisturbed voltage level depends on the tested transceiver. For the immunity evaluation, the monitored pin of all transceivers in the network with and without applied disturbances shall be compared by using an oscilloscope. The given values are the maximum allowed variation to the undisturbed signal.

^b Independent of the duration.

^c No evaluation, because the output has no function in this mode.

^d The definition for the maximum deviation of the voltage levels on the RX and/or ERR pin were done according to the transceiver specification.

^e The definition for the maximum deviation of the voltage levels on the pin INH were done under the following limit conditions: $V_{\text{drop\_typ\_CAN transceiver}} = 0,8 \text{ V}$; $V_{\text{on\_typ\_volt.reg.}} = 3,6 \text{ V}$; $V_{\text{off\_typ\_volt.reg.}} = 0,8 \text{ V}$ and possible RF superposition on pin INH with RF influencing of V_{Bat} with an amplitude of approx. 3 V

^f Only for CAN high speed, 10 % variation of bit time TX1.

^g Only for CAN low speed, 10 % variation of bit time TX1.

The boundary values for normal IC operation apply to all three transceivers. As soon as at least one transceiver in the network violates a boundary value an error event has occurred. In some cases, a reset of the system may be necessary before the test can be continued.

NOTE To reset an error indicated by the ERR pin, a dominant or recessive level is required for a minimum time at the communication test signal TX1. This minimum reset time is to be chosen according to the semiconductor manufacturer information (typical value > 40 μ s).