

BS ISO 17458-5:2013



BSI Standards Publication

Road vehicles — FlexRay communications system

Part 5: Electrical physical layer conformance test specification

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National foreword

This British Standard is the UK implementation of ISO 17458-5:2013.

The UK participation in its preparation was entrusted to Technical Committee AUE/16, Electrical and electronic equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Road vehicles— FlexRay communications system —

Part 5: Electrical physical layer conformance test specification

Véhicules routiers — Système de communications FlexRay —

*Partie 5: Spécification d'essai de conformité de la couche d'application
électrique*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17458-5 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

ISO 17458 consists of the following parts, under the general title *Road vehicles — FlexRay communications system*:

- *Part 1: General information and use case definition*
- *Part 2: Data link layer specification*
- *Part 3: Data link layer conformance test specification*
- *Part 4: Electrical physical layer specification*
- *Part 5: Electrical physical layer conformance test specification*

Introduction

The FlexRay communications system is an automotive focused high speed network and was developed with several main objectives which were defined beyond the capabilities of established standardized bus systems like CAN and some other proprietary bus systems. Some of the basic characteristics of the FlexRay protocol are synchronous and asynchronous frame transfer, guaranteed frame latency and jitter during synchronous transfer, prioritization of frames during asynchronous transfer, single or multi-master clock synchronization, time synchronization across multiple networks, error detection and signalling, and scalable fault tolerance.

The FlexRay communications system is defined for advanced automotive control applications. It serves as a communication infrastructure for future generation high-speed control applications in vehicles by providing:

- A message exchange service that provides deterministic cycle based message transport;
- Synchronization service that provides a common time base to all nodes;
- Start-up service that provides an autonomous start-up procedure;
- Error management service that provides error handling and error signalling;
- Wakeup service that addresses the power management needs.

This bus system has been developed with several main objectives which were defined beyond the capabilities of existing bus systems like CAN and some other proprietary bus systems. This advanced automotive communication system specifies support for:

- Scalable static and dynamic message transmission (deterministic and flexible);
- High net data rate of 5 Mbit/sec; gross data rate approximately 10 Mbit/sec;
- Scalable fault-tolerance (single and dual channel);
- Error containment on the physical layer through an independent Bus Guardian;
- Fault tolerant clock synchronisation (global time base).

Since start of development the automotive industry world wide supported the specification development. The FlexRay communications system has been successfully implemented in production vehicles today.

The ISO 17458 series specifies the use cases, the communication protocol and physical layer requirements of an in-vehicle communication network called "FlexRay communications system".

This part of ISO 17458 has been established in order to define the use cases for vehicle communication systems implemented on a FlexRay data link.

To achieve this, it is based on the Open Systems Interconnection (OSI) Basic Reference Model specified in ISO/IEC 7498-1 [1] and ISO/IEC 10731 [6], which structures communication systems into seven layers. When mapped on this model, the protocol and physical layer requirements specified by ISO 17458 are broken into:

- Diagnostic services (layer 7), specified in ISO 14229-1 [7], ISO 14229-4 [9];
- Presentation layer (layer 6), vehicle manufacturer specific;
- Session layer services (layer 5), specified in ISO 14229-2 [8];

- Transport layer services (layer 4), specified in ISO 10681-2 [5];
- Network layer services (layer 3), specified in ISO 10681-2 [5];
- Data link layer (layer 2), specified in ISO 17458-2, ISO 17458-3;
- Physical layer (layer 1), specified in ISO 17458-4, ISO 17458-5;

in accordance with Table 1.

Table 1 — FlexRay communications system specifications applicable to the OSI layers

Applicability	OSI 7 layers	FlexRay communications system	Vehicle manufacturer enhanced diagnostics
Seven layer according to ISO 7498-1 and ISO/IEC 10731	Application (layer 7)	vehicle manufacturer specific	ISO 14229-1, ISO 14229-4
	Presentation (layer 6)	vehicle manufacturer specific	vehicle manufacturer specific
	Session (layer 5)	vehicle manufacturer specific	ISO 14229-2
	Transport (layer 4)	vehicle manufacturer specific	ISO 10681-2
	Network (layer 3)	vehicle manufacturer specific	
	Data link (layer 2)	ISO 17458-2, ISO 17458-3	
	Physical (layer 1)	ISO 17458-4, ISO 17458-5	

Table 1 shows ISO 17458 Parts 2 – 5 being the common standards for the OSI layers 1 and 2 for the FlexRay communications system and the vehicle manufacturer enhanced diagnostics.

The FlexRay communications system column shows vehicle manufacturer specific definitions for OSI layers 3 – 7.

The vehicle manufacturer enhanced diagnostics column shows application layer services covered by ISO 14229-4 which have been defined in compliance with diagnostic services established in ISO 14229-1, but are not limited to use only with them. ISO 14229-4 is also compatible with most diagnostic services defined in national standards or vehicle manufacturer's specifications. The presentation layer is defined vehicle manufacturer specific. The session layer services are covered by ISO 14229-2. The transport protocol and network layer services are specified in ISO 10681.

Road vehicles — FlexRay communications system — Part 5: Electrical physical layer conformance test specification

IMPORTANT — According to ISO 17458-4, the FlexRay communications system was specified focusing on a data rate of 10 Mbit/s. Therefore this conformance test specification regards the use of systems with a data rate of 10 Mbit/s only whereas the physical layer also works properly in systems with data rates in the range from 2,5 Mbit/s to 10 Mbit/s according to ISO 17458-4.

1 Scope

This part of ISO 17458 specifies the conformance test for the electrical physical layer of the FlexRay communications system.

This part of ISO 17458 defines a test that considers ISO 9646 and ISO 17458-4.

The purpose of this part of ISO 17458 is to provide a standardized way to verify whether FlexRay Bus Driver and Active Star products are compliant to ISO 17458-4. The primary motivation is to ensure a level of interoperability of FlexRay Bus Drivers and Active Stars from different sources in a system environment.

This part of ISO 17458 provides all necessary technical information to ensure that test results will be identical even on different test systems, provided that the particular test suite and the test system are compliant to the content of this part of ISO 17458.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 17458-1, *Road vehicles — FlexRay communications system — Part 1: General information and use case definition*

ISO 17458-2, *Road vehicles — FlexRay communications system — Part 2: Data link layer specification*

ISO 17458-4, *Road vehicles — FlexRay communications system — Part 4: Electrical physical layer specification*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17458-1, ISO 17458-2, ISO 17458-4 and the following apply.

3.1.1

bus driver – communication controller interface

BD-CC-interface

see “*BD-BD interface*” when replacing one *BD* by a *CC*

3.1.2

cable

term that summarises all necessary components to implement a FlexRay *transmission line*:

two twisted or untwisted wires to be connected to *BP* and *BM*, isolators to mount the wires, an optional shield, an optional wire to strengthen the shield, an optional sheath, etc.

3.1.3

communication controller – bus driver interface

CC-BD-interface

see “*BD-CC-interface*”

3.1.4

communication channel

FlexRay allows a single *CC* to distribute data-frames independent from each other on two different hardware paths or *topologies*. From an abstract view each path is named “*communication channel*”.

3.2 Abbreviated terms

LT lower tester

UT upper tester

4 Document reference according to OSI model

Figure 1 depicts the FlexRay document reference according to OSI model.

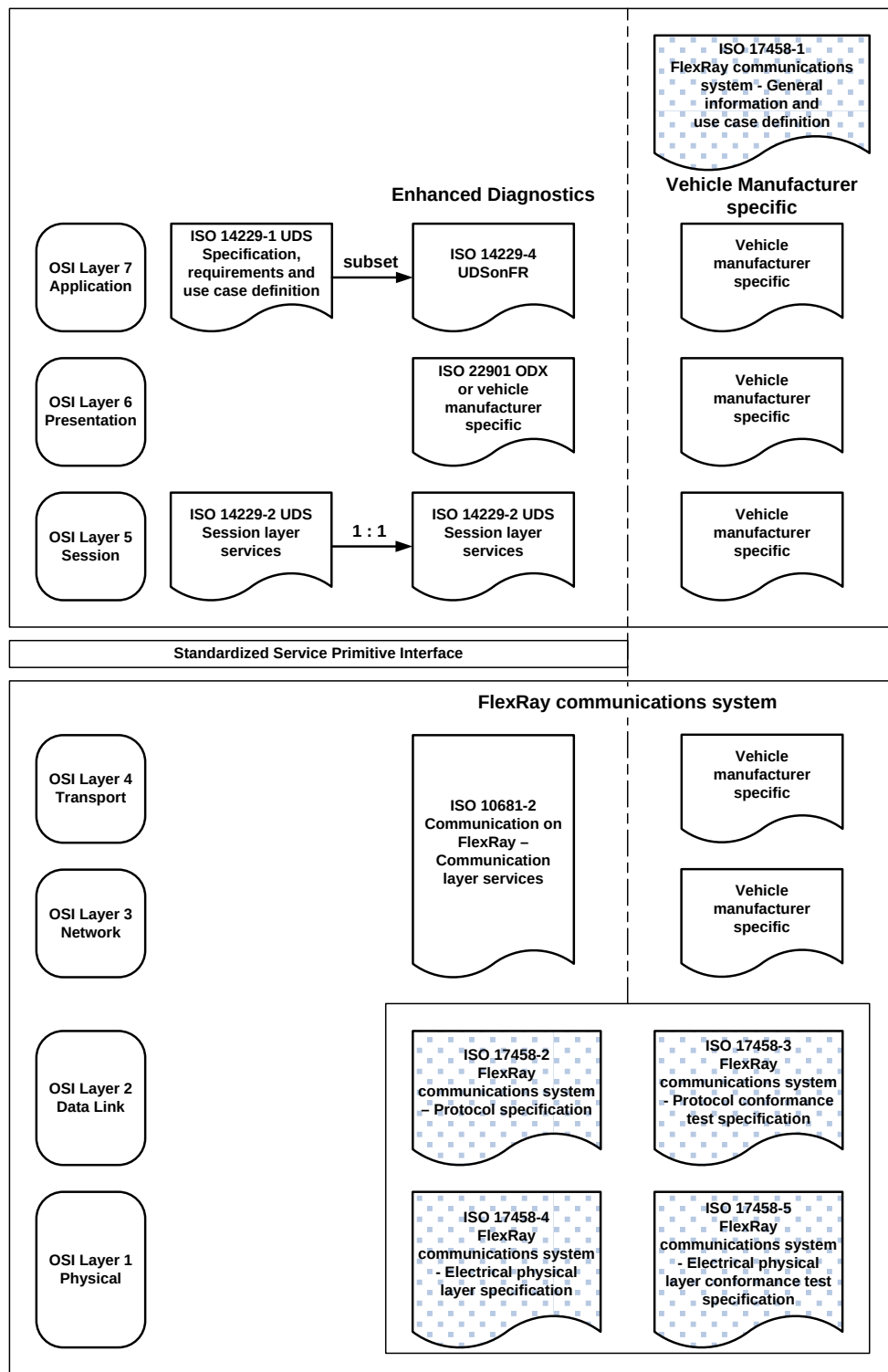


Figure 1 — FlexRay document reference according to OSI model

5 Conventions

5.1 General

ISO 17458, ISO 10681 and ISO 14229-4 are based on the conventions specified in the OSI Service Conventions (ISO/IEC 10731) as they apply for physical layer, protocol, network & transport protocol and diagnostic services.

5.2 Notational conventions

Notational conventions are listed in ISO 17458-4.

6 Test environment

6.1 Test case architecture

Each test case is specified with the following parts that must all be described unambiguous:

- Test case name
a name for this test case.
- Test purpose
a description of the motivation for this test case.
- Configuration
the state of the test environment for this test case.
- Preamble (setup state)
the steps to do before the specified test case could be executed.
- Test execution
the description of the execution of this test case.
- Postamble
the steps to do after the specified test case in order to have a defined state.
- Pass criteria
the criteria to judge the test result.
- Test instances
this is an optional part and contains test cases, that are summarised in tabular form because they are executed separately with only minor changes in comparison to the first test case within this group.

Every test case is independent from the other test cases.

Several test cases are performed with the presence of stress conditions in order to check the robustness of the IUT. These stress conditions are specified in detail in Clause 7.

The test parameters are FlexRay variables or constants that are defined in ISO 17458-4. These test parameters are specified in detail in Clause 8.

Every test case starts at the beginning of the preamble and ends after the postamble. There is no delay between the preamble and the test execution and between the test execution and the postamble.

The pass criteria are related only to the test execution.

Product specific items are not part of this International Standard.

6.2 Test method

6.2.1 General

The FlexRay BD has several interfaces, that are supplied by specified power supplies and stimuli and observed by external components (signal measurements). The requirements for those generators and signal measurements are specified in 6.5.

The interfaces of the BD are separated in two parts:

- Analog interface
bus (service provider) and supply pins.
- Digital interface
the pins for connecting the BD with the FlexRay protocol components.

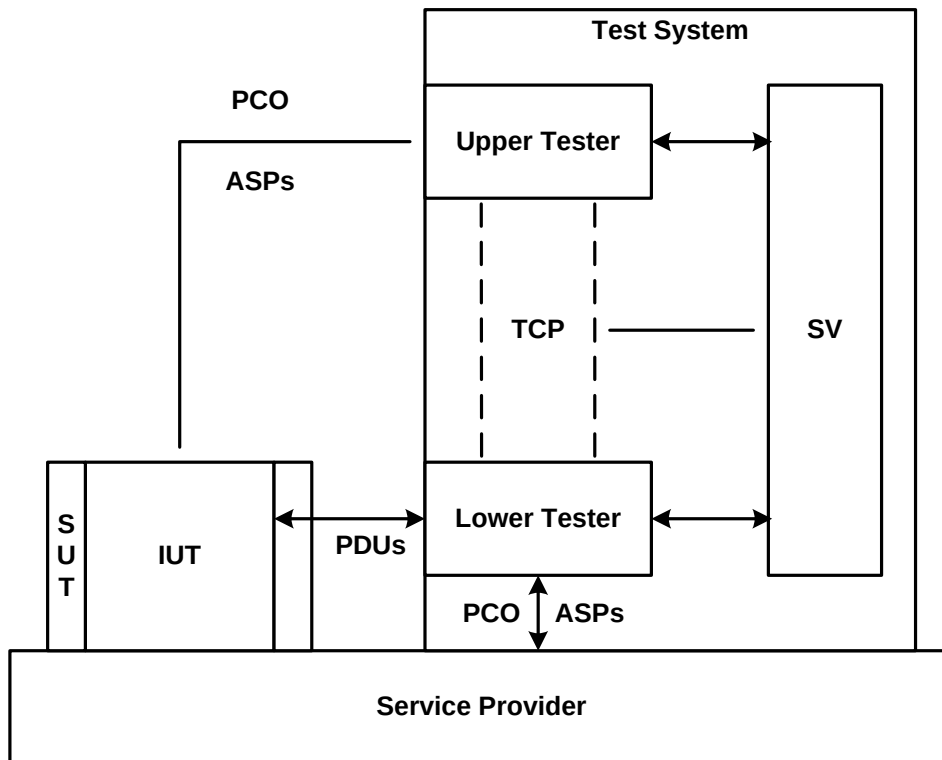
Each test case describes the used pins for supplying, stimulation and observation.

The used test method for the FlexRay PL regarding [2] is the local test method, see also Figure 2.

The local test method contains a Lower Tester (LT) for the analog interface (bus) and an Upper Tester (UT) for the digital interface. Both are part of the test system. The coordination of the test cases is done by the test coordination procedure (TCP).

The whole test is controlled by the supervisor (SV) that is also part of the test system. The SV controls the UT and LT with the TCP.

Figure 2 depicts the local test method of ISO 9646-1:1994.



Key

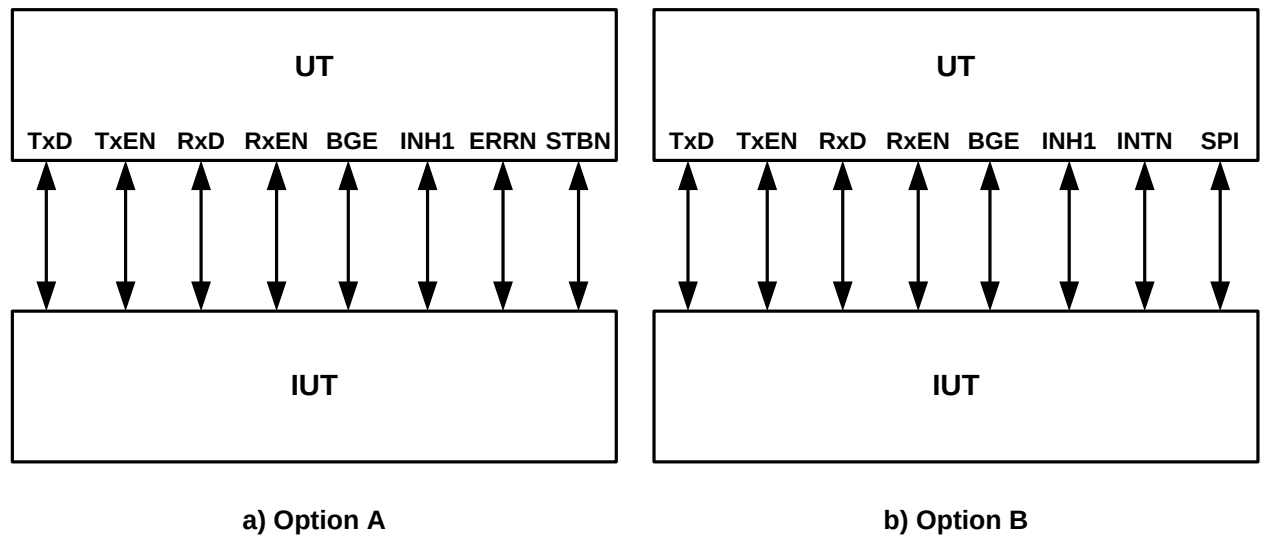
ASP	Abstract service primitive
IUT	Implementation under test
PCO	Point of control and observation
PDU	Protocol data unit
SV	Supervisor
SUT	System under test
TCP	Test control procedure

Figure 2 — Local test method

6.2.2 Upper Tester

The UT has to provide test data, control and observe the IUT at its upper interface. The implementation has to keep in mind the possibility of two different host interfaces of the IUT as specified in ISO 17458-4.

Figure 3 shows the mandatory signals of the IUT that the conformance test considers:



Components

IUT	Implementation Under Test
UT	Upper Tester

Connections and supplies

BGE	Bus guardian enable
ERRN	Error not
INH1	Inhibit 1
INTN	Inhibit n
RxD	Receive data
RxEN	Receive enable
SPI	Serial peripheral interface
STBN	Standby not
TxD	Transmit data
TxEN	Transmit enable not

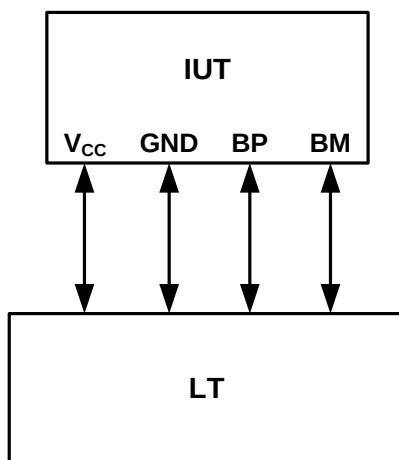
Figure 3 — Upper Tester

The tasks of the UT are:

- Provide test data streams
- Change the mode of the IUT
- Observe and acquire the error line
- Observe and acquire the received data stream
- Provide IUT functions to the supervisor
- Provide test system functionality to the IUT

6.2.3 Lower Tester

The Lower Tester has to provide data and observe the IUT at its lower interface – the supply and bus interface of the IUT. Figure 4 shows an overview of the Lower Tester.



Components

IUT	Implementation Under Test
LT	Lower Tester

Connections and supplies

BM	Bus minus
BP	Bus plus
GND	Ground connection
V _{CC}	Supply voltage for digital signals

Figure 4 — Lower Tester

The tasks of the Lower Tester are:

- Generate and control bus failures
- Generate ground shift
- Control the supply voltages
- Provide IUT functions to the supervisor
- Provide test system functionality to the IUT

6.2.4 Supervisor

The SV has to control and observe the whole test system and communicates with the IUT via the LT and UT.

The tasks of the SV are:

- Control the LT and UT
- Observe and acquire the LT and UT
- Control and observe optional measurement devices
- Execute and coordinate test procedures
- Create the test report

6.3 Test environment

The following parameters are constants within the conformance test and used in the *standard environment*:

- Temperature: ambient
- Moisture: ambient
- Test topology: as described in 6.4
- Termination: as described in the test topology; differences are specified in the used test case
- Amount of nodes: as described in the test topology
- Amount of Stars: as described in the test topology
- Baud rate: 10 Mbit/s (gdBit = 100 ns) as part of the harmonized baud rates in the FlexRay consortium
- Common mode choke: as specified in 6.4.6

6.4 Test topology

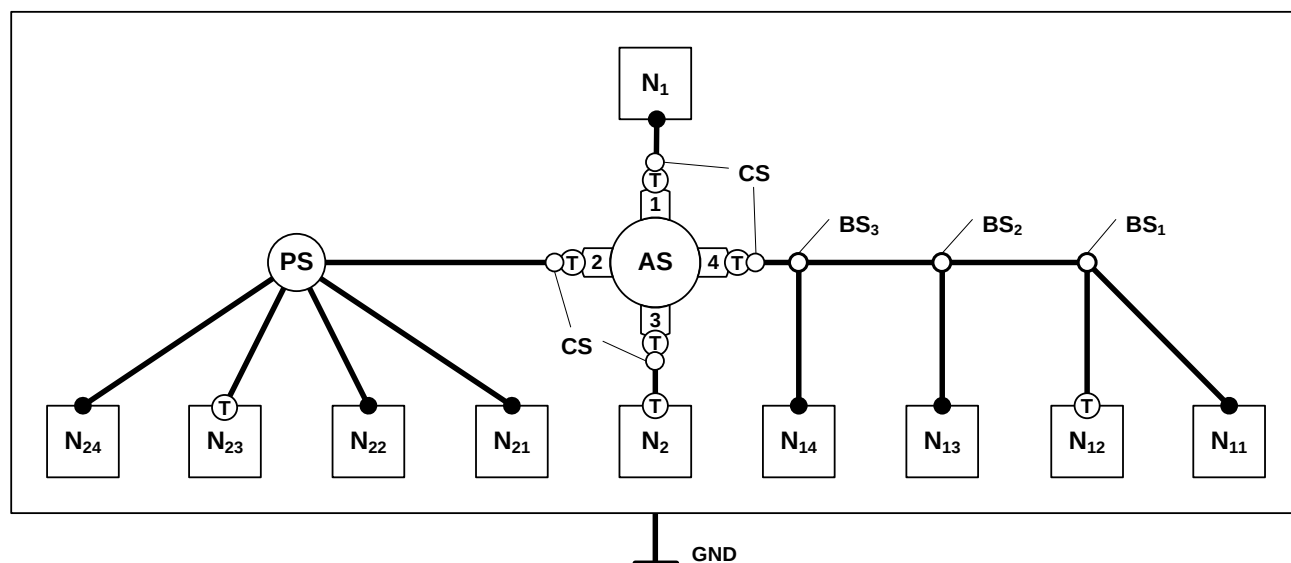
6.4.1 General

The purpose is to test the expected worst case of a possible topology with the maximum number of cascaded Active Stars, one passive star and one passive bus.

It is sufficient to test only with one physical channel, because the behaviour of the physical layer is independent from the number of used channels in a communication network.

The used test topology is described in the following subclauses and shown in Figure 5.

Figure 5 depicts the conformance test topology.



Components

AS	Active Star
BS _x	Bus splice x
CS	Cable shield connection
N _x	FlexRay node x
PS	Passive Star
T	Bus termination

Connections and supplies

GND	System ground
-----	---------------

NOTE 1 V_{ANY} is not a supply voltage. It is a voltage used as stress condition where BP and BM are short-circuit to this voltage. V_{ANY} is product-specific and varies from the implementation of supply voltages of the IUT and the ground shift.

NOTE 2 Further details of the cable lengths used in the test topology are given in Table 2.

Figure 5 — Conformance test topology

Description of the test topology:

- For detailed description of the AS hardware see 6.4.7.
- A detailed description of the passive star hardware is given in 6.4.8.
- A detailed description of the passive bus hardware is given in 6.4.9.
- Nodes without ground shift stress shall be connected with their negative terminal to one of the ground splices that are mounted on the stainless steel chassis.
- The four ground splices shall be mounted near the nodes and the AS to consider the length of the GND cables of the nodes and the AS. The following nodes are connected to one of the GND splices:
GND splice 1: Nodes 11, 12, 13 and 14
GND splice 2: Nodes 21, 22, 23 and 24
GND splice 3: Nodes 1, 2 and the AS
GND splice 4: negative terminal of all supplies

- Nodes that are stressed with ground shift are connected to a switch¹⁾ that guarantees that these nodes could be connected directly to ground or are stressed by ground shift. This switch shall be controllable by the SV. The attenuation of the used switches shall be as small as possible. The switch shall be on the nodes and the AS. The connections from the switch to the terminals shall be as short as possible.
- The ground shift terminal of the nodes and the AS are connected to the positive terminal of the ground shift generator. The length of this cable is 1 m.
- The negative terminal of the ground shift generator is connected to the GND splice of the test system (chassis). The length of this cable is 1 m.
- All nodes shall be connected to the V_{BAT} splice (+) that is mounted on the chassis. The V_{BAT} splice is a separate board on which the splices for the supply voltages are placed.
- The AS shall be connected to the V_{BAT} splice (+) for the AS that is mounted on the chassis.
- The AS shall be connected to the V_{CC} splice (+) for the AS that is mounted on the chassis.
- The AS shall be connected to the V_{IO} splice (+) for the AS that is mounted on the chassis.
- The AS shall be connected to the V_{ANY} splice with a cable length of 3 m.
- Node 24 shall be connected to the V_{BAT} splice (+) for the node that is mounted on the chassis.
- Node 24 shall be connected to the V_{CC} splice (+) for the node that is mounted on the chassis.
- Node 24 shall be connected to the V_{IO} splice (+) for the node that is mounted on the chassis.
- Node 24 shall be connected to the V_{ANY} splice with a cable length of 3 m.
- Node 23 shall be connected to the V_{CC} splice (+) for the node that is mounted on the chassis.
- Node 23 shall be connected to the V_{IO} splice (+) for the node that is mounted on the chassis.
- Node 21 shall be connected to the V_{CC} splice (+) for the node that is mounted on the chassis.
- Node 21 shall be connected to the V_{IO} splice (+) for the node that is mounted on the chassis.
- The chassis shall be a steel plate for the ground connections of the IUTs and the power supply.
- The chassis is connected to the negative terminal of the power supply (clamp 31).
- The V_{BAT} splice is connected to the positive terminal of the power supply (clamp 30).
- The V_{BAT} splice for the nodes is connected to the positive terminal of the nodes V_{BAT} power supply.
- The V_{BAT} splice for the AS is connected to the positive terminal of the AS V_{BAT} power supply.
- The V_{CC} splice for the AS is connected to the positive terminal of the first +5 V power supply.
- The V_{BAT} splice for the node 24 is connected to the positive terminal of the V_{BAT} power supply for node 24.

1) The switch shall be on the nodes and the AS. The connections from the switch to the terminals shall be as short as possible.

- The V_{CC} splice for the node 24 is connected to the positive terminal of the second +5 V power supply.
- The V_{IO} splice for the node 24 is connected to the positive terminal of the V_{IO} reference voltage.
- All communication channels shall be terminated regarding ISO 17458-4.
- The shield of every link shall be terminated regarding ISO 17458-4.
- The bus cables shall meet the requirements of ISO 17458-4; see also 6.4.10.1. All bus cables are shielded. The shield is only connected at the AS (see also 6.4.3).
- The supply cables shall meet the requirements specified in 6.4.10.2.

The following topics are part of the implementation of the conformance test, but have to meet ISO 17458-4:

- the type of mounting of the IUTs on the chassis
- the type and manufacturer of the cables
- the type and manufacturer of the connectors
- the type of the splices
- the wiring of the IUT

6.4.2 Cable overview of the test topology

Table 2 gives a full overview of the cables of the test topology

Table 2 — Cable overview of test topology

No.	Type	From	To	Length m	Termination	Remarks
1	Bus wire	Node 1	Active Star	1	Both ends	—
2	Ground wire	Node 1	GND splice 3	0,5	—	—
3	Supply wire	Node 1	V_{BAT} splice	2	—	—
4	Bus wire	Node 2	Active Star	3,5	Both ends	—
5	Ground wire	Node 2	GND splice 3	5	—	This node emulates an ECU in a roof of a vehicle where no ground splice in the roof is available.
6	Supply wire	Node 2	V_{BAT} splice	6	—	—
7	Bus wire	Node 11	Bus splice 1	0,3	No termination	Part of the passive bus
8	Ground wire	Node 11	GND splice 1	0,5	—	—
9	Supply wire	Node 11	V_{BAT} splice	6	—	—
10	Bus wire	Node 12	Bus splice 1	0,3	Only at node 12	Part of the passive bus

No.	Type	From	To	Length m	Termination	Remarks
11	Ground wire	Node 12	GND splice 1	0,5	—	—
12	Supply wire	Node 12	V _{BAT} splice	8	—	—
13	Bus wire	Node 13	Bus splice 2	0,3	No termination	Part of the passive bus
14	Ground wire	Node 13	GND splice 1	0,5	—	—
15	Supply wire	Node 13	V _{BAT} splice	9	—	—
16	Bus wire	Node 14	Bus splice 3	0,3	No termination	Part of the passive bus
17	Ground wire	Node 14	GND splice 1	0,5	—	—
18	Supply wire	Node 14	V _{BAT} splice	10	—	—
19	Bus wire	Node 21	Passive star	0,25	No termination	Connected to the passive star
20	Ground wire	Node 21	GND splice 2	0,5	—	—
21	Supply wire	Node 21	V _{BAT} splice	4	—	—
22	Bus wire	Node 22	Passive star	0,25	No termination	Connected to the passive star
23	Ground wire	Node 22	GND splice 2	0,5	—	—
24	Supply wire	Node 22	V _{BAT} splice	3	—	—
25	Bus wire	Node 23	Passive star	1	Only at node 23	Connected to the passive star
26	Ground wire	Node 23	GND splice 2	0,5	—	—
27	Supply wire	Node 23	V _{BAT} splice	5	—	—
28	Ground shift wire ^a	V _{GS} supply	Node 23	2	—	Connected to positive terminal
29	Ground shift wire ^b	V _{GS} supply	GND splice 4	1	—	Connected to negative terminal (ground wire of node 23)
30	Bus wire	Node 24	Passive star	0,25	No termination	Connected to the passive star
31	Ground wire	Node 24	GND splice 2	0,5	—	—
32	Supply wire	Node 24	V _{BAT} splice	4	—	—
33	Ground shift wire ^a	V _{GS} supply	Node 24	2	—	Connected to positive terminal
34	Ground shift wire ^b	V _{GS} supply	GND splice 4	1	—	Connected to negative terminal (ground wire of node 24)

No.	Type	From	To	Length m	Termination	Remarks
35	Ground wire	Active Star	GND splice 2	0,5	—	—
36	Supply wire	Active Star	V _{BAT} splice	4	—	—
37	Supply wire	Active Star	V _{CC} splice	4	—	—
38	Bus wire	Active Star	Passive star	11	Only at Active Star	—
39	Bus Wire	Active Star	Bus splice 3	1,5	Only at Active Star	—
40	Ground shift wire ^a	V _{GS} supply	Active Star	2	—	Connected to positive terminal
41	Ground shift wire ^b	V _{GS} supply	GND splice 4	1	—	Connected to negative terminal (ground wire of AS)
42	Bus wire	Bus splice 1	Bus splice 2	10	No termination	Part of the passive bus
43	Bus wire	Bus splice 2	Bus splice 3	0,15	No termination	Part of the passive bus
44	Supply wire	Battery	V _{BAT} splice	3	—	V _{BAT} supply for nodes
45	Ground wire	Battery	GND splice 4	1,5	—	V _{BAT} supply for nodes
46	Supply wire	Battery	V _{BAT} splice	3	—	V _{BAT} supply for AS
47	Ground wire	Battery	GND splice 4	1,5	—	V _{BAT} supply for AS
48	Supply wire	V _{CC} Supply	V _{CC} splice	3	—	V _{CC} supply for AS
49	Ground wire	V _{CC} Supply	GND splice 4	1,5	—	V _{CC} supply for AS
50	Supply wire	V _{IO} Supply	V _{CC} splice	4	—	V _{IO} supply for AS
51	Ground wire	V _{IO} Supply	GND splice 4	1,5	—	V _{IO} supply for AS
52	Supply wire	Battery	V _{BAT} splice	4	—	V _{BAT} supply for node 24
53	Ground wire	Battery	GND splice 4	1,5	—	V _{BAT} supply for node 24
54	Supply wire	V _{CC} Supply	V _{CC} splice	4	—	V _{CC} supply for node 21, 23 & 24
55	Ground wire	V _{CC} Supply	GND splice 4	1,5	—	V _{CC} supply for node 21, 23 & 24
56	Supply wire	V _{IO} Supply	V _{IO} splice	4	—	V _{IO} supply for node 21, 23 & 24
57	Ground wire	V _{IO} Supply	GND splice 4	1,5	—	V _{IO} supply for node 21, 23 & 24
58	Ground wire	Passive star	GND splice 2	0,3	—	Ground connection of PS

No.	Type	From	To	Length m	Termination	Remarks
59	Stress wire	V _{any} supply	Node 24	3	—	Stress voltage for node 24
60	Stress wire	V _{any} supply	Active Star	3	—	Stress voltage for AS
61	Bus wire	Node 1	Active Star	1	Both ends	—
62	Ground wire	Node 1	GND splice 3	0,5	—	—
63	Supply wire	Node 1	Battery splice	2	—	—
64	Bus wire	Node 2	Active Star	3,5	Both ends	—
65	Ground wire	Node 2	GND splice 3	5	—	—
66	Supply wire	Node 2	Battery splice	6	—	—
67	Bus wire	Node 11	Bus splice 1	0,3	No termination	Part of the passive bus
68	Ground wire	Node 11	GND splice 1	0,5	—	—
69	Supply wire	Node 11	Battery splice	6	—	—
70	Bus wire	Node 12	Bus splice 1	0,3	Only at node 12	Part of the passive bus
71	Ground wire	Node 12	GND splice 1	0,5	—	—
72	Supply wire	Node 12	Battery splice	8	—	—
73	Bus wire	Node 13	Bus splice 2	0,3	No termination	Part of the passive bus
74	Ground wire	Node 13	GND splice 1	0,5	—	—
75	Supply wire	Node 13	Battery splice	9	—	—
76	Bus wire	Node 14	Bus splice 3	0,3	No termination	Part of the passive bus
77	Ground wire	Node 14	GND splice 1	0,5	—	—
78	Supply wire	Node 14	Battery splice	10	—	—
79	Bus wire	Node 21	Passive star	0,25	No termination	Connected to the passive star
80	Ground wire	Node 21	GND splice 2	0,5	—	—
81	Supply wire	Node 21	Battery splice	4	—	—

No.	Type	From	To	Length m	Termination	Remarks
82	Bus wire	Node 22	Passive star	0,25	No termination	Connected to the passive star
83	Ground wire	Node 22	GND splice 2	0,5	—	—
84	Supply wire	Node 22	Battery splice	3	—	—
85	Bus wire	Node 23	Passive star	1	Only at node 23	Connected to the passive star
86	Ground wire	Node 23	GND splice 2	0,5	—	—
87	Supply wire	Node 23	Battery splice	5	—	—
88	Ground shift wire ^a	V _{GS} supply	Node 23	2	—	Connected to positive terminal
89	Ground shift wire ^b	V _{GS} supply	GND splice 4	1	—	Connected to negative terminal (ground wire of node 23)
90	Bus wire	Node 24	Passive star	0,25	No termination	Connected to the passive star
91	Ground wire	Node 24	GND splice 2	0,5	—	—
92	Supply wire	Node 24	Battery splice	4	—	—
93	Ground shift wire ^a	V _{GS} supply	Node 24	2	—	Connected to positive terminal
94	Ground shift wire ^b	V _{GS} supply	GND splice 4	1	—	Connected to negative terminal (ground wire of node 24)
95	Ground wire	Active Star	GND splice 2	0,5	—	—
96	Supply wire	Active Star	V _{BAT} splice	4	—	—
97	Supply wire	Active Star	V _{CC} splice	4	—	—
98	Bus wire	Active Star	Passive star	11	Only at Active Star	—
99	Bus Wire	Active Star	Bus splice 3	1,5	Only at Active Star	—
100	Ground shift wire ^a	V _{GS} supply	Active Star	2	—	Connected to positive terminal
101	Ground shift wire ^b	V _{GS} supply	GND splice 4	1	—	Connected to negative terminal (ground wire of AS)
102	Bus wire	Bus splice 1	Bus splice 2	10	No termination	Part of the passive bus
103	Bus wire	Bus splice 2	Bus splice 3	0,15	No termination	Part of the passive bus
104	Supply wire	Battery	Battery splice	3	—	V _{BAT} supply for nodes

No.	Type	From	To	Length m	Termination	Remarks
105	Ground wire	Battery	GND splice 4	1,5	—	V _{BAT} supply for nodes
106	Supply wire	Battery	Battery splice	3	—	V _{BAT} supply for AS
107	Ground wire	Battery	GND splice 4	1,5	—	V _{BAT} supply for AS
108	Supply wire	V _{CC} Supply	V _{CC} splice	3	—	V _{CC} supply for AS
109	Ground wire	V _{CC} Supply	GND splice 4	1,5	—	V _{CC} supply for AS
110	Supply wire	V _{IO} Supply	V _{CC} splice	4	—	V _{IO} supply for AS
111	Ground wire	V _{IO} Supply	GND splice 4	1,5	—	V _{IO} supply for AS
112	Supply wire	Battery	Battery splice	4	—	V _{BAT} supply for node 24
113	Ground wire	Battery	GND splice 4	1,5	—	V _{BAT} supply for node 24
114	Supply wire	V _{CC} Supply	V _{CC} splice	4	—	V _{CC} supply for node 21 & 24
115	Ground wire	V _{CC} Supply	GND splice 4	1,5	—	V _{CC} supply for node 21 & 24
116	Supply wire	V _{IO} Supply	V _{IO} splice	4	—	V _{IO} supply for node 21 & 24
117	Ground wire	V _{IO} Supply	GND splice 4	1,5	—	V _{IO} supply for node 21 & 24
118	Ground wire	Passive star	GND splice 2	0,3	—	Ground connection of PS
119	Stress wire	V _{any} supply	Node 24	3	—	Stress voltage for node 24
120	Stress wire	V _{any} supply	Active Star	3	—	Stress voltage for AS
^a Positive terminal of the Ground Shift Generator ^b Negative terminal of the Ground Shift Generator						

6.4.3 Shield

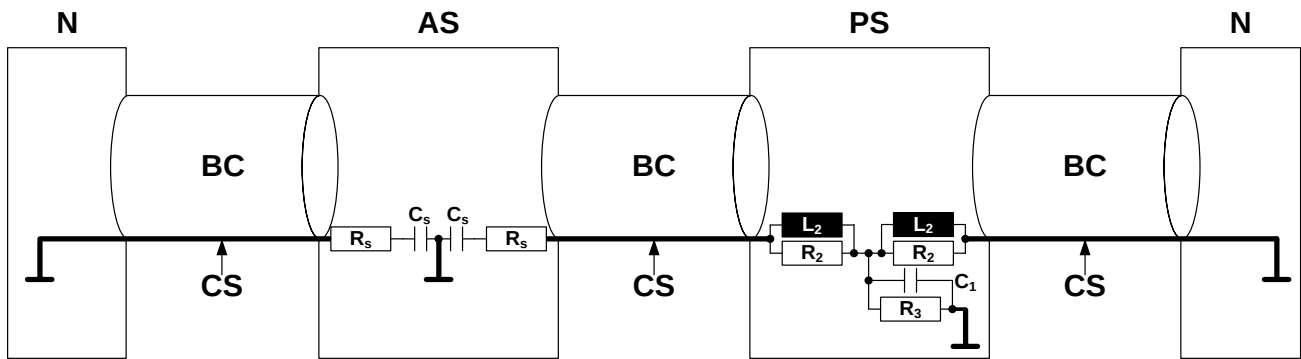
Each communication link shall have one cable shield connection. The conformance test uses one Active Star, that is the central point of shield connection in the topology.

Table 3 defines the specified shield connection with bus cable, connectors, Active Star and node:

Table 3 — Shield connection components

Name	Description	Typ	Unit
R_s	Damping resistance	1 000	Ω
	Tolerance	1	%
C_s	Capacitance	470	nF
	Tolerance	10	%
L_2 , R_2 , R_3 and C_1		Components of the passive star, see 6.4.8.	

Figure 6 depicts the cable shield connection.



Components

- AS Active Star
- BC Bus cable
- CS Cable shield
- C_1 Capacitor of the Passive Star (see Table 3)
- C_s Capacitor of the Active Star (see Table 3)
- L_2 Inductor of the Passive Star
- N FlexRay node
- PS Passive Star
- R_1 Resistor of the Passive Star (see Table 3)
- R_2 Resistor of the Passive Star (see Table 3)
- R_3 Resistor of the Passive Star (see Table 3)
- R_s Resistor of the Active Star (see Table 3)

Figure 6 — Cable shield connection

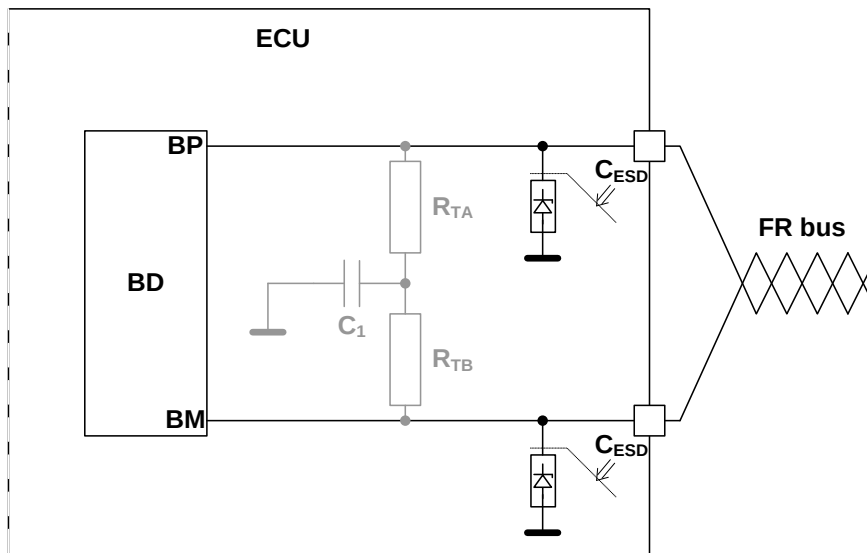
The cable shield of each branch at the PS is connected via L_2 and R_2 to C_1 and R_3 to the local ground of the PS, see 6.4.8.

The shield shall be interrupted between the housings of the Active Star, N23 and N24 due to ground shift condition at those nodes.

The shield shall not be interrupted between the housings of N1, N2, N11-14, N21 and N22, because those nodes have no ground shift condition.

6.4.4 ESD protection

An ESD protection element shall be connected to each BD and each connected branch of AS in order to increase ESD protection capabilities. The implemented protection device shall not exceed the maximum rating (see Figure 7).



Components

BD	Bus Driver
C_1	Termination capacitor
C_{ESD}	Capacitor between BP/BM and GND
ECU	Electronic Control Unit
R_{TA}	Termination resistor towards BP
R_{TB}	Termination resistor towards BM

Connections and supplies

BM	Bus minus
BP	Bus plus

Figure 7 — ESD load circuit

Table 4 defines the ESD load circuit.

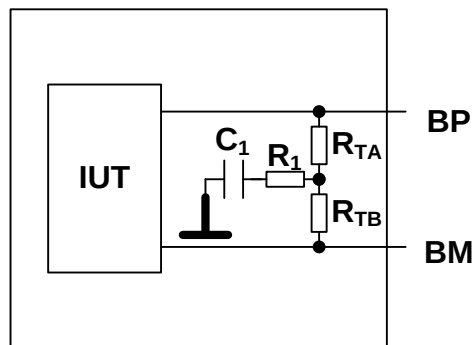
Table 4 — ESD load circuit

Name	Description	Max	Unit
C_{ESD}	Capacitance of BP/BM to GND	20	pF
	Tolerance; NP0 dielectric	1	%

As described in Figure 7 the ESD load circuit is placed on the board between the termination and the bus terminals. If no termination exist the ESD load circuit is placed between the CMC and the bus terminals.

6.4.5 Termination

Each terminated node and star as described in the test topology shall have a split termination as shown in Figure 8. Node 2 is an example of a terminated node (see Figure 5).



Components

C_1	Termination capacitor
IUT	Implementation Under Test
R_1	Termination resistor
R_{TA}	Termination resistor towards BP
R_{TB}	Termination resistor towards BM

Connections and supplies

BP	Bus plus
BM	Bus minus

Figure 8 — Terminated node

The *RDCLoad* is specified in ISO 17458-4. For the nominal (default) *RDCLoad* the termination resistor, as specified in ISO 17458-4, is defined as follows:

$$R_T = R_{TA} + R_{TB}$$

where

R_T is the resulting termination resistor

R_{TA} is the termination resistor connected to BP

R_{TB} is the termination resistor connected to BM

Table 5 lists the values of the split termination components.

Table 5 — Split termination components

Name	Description	Typ	Unit
R_{TA}	Resistor of split termination	$\frac{Z_0}{2}$ ^a	Ω
	Tolerance	1	%
R_{TB}	Resistor of split termination	$\frac{Z_0}{2}$ ^a	Ω
	Tolerance	1	%
R_1	Resistor	5	Ω
	Tolerance	1	%
C_1	Ceramic capacitor	4,7	nF
	Tolerance	10	%
^a Z_0 : characteristic impedance of the used cable. See also 6.4.10.1.			

The value of Z_0 depends on the used bus cable. This cable is defined in 6.4.10.1.

Some nodes in the test topology have no termination. Node 14 is an example of an unterminated node (see Figure 5).

Figure 9 shows the bus connection of an unterminated node.

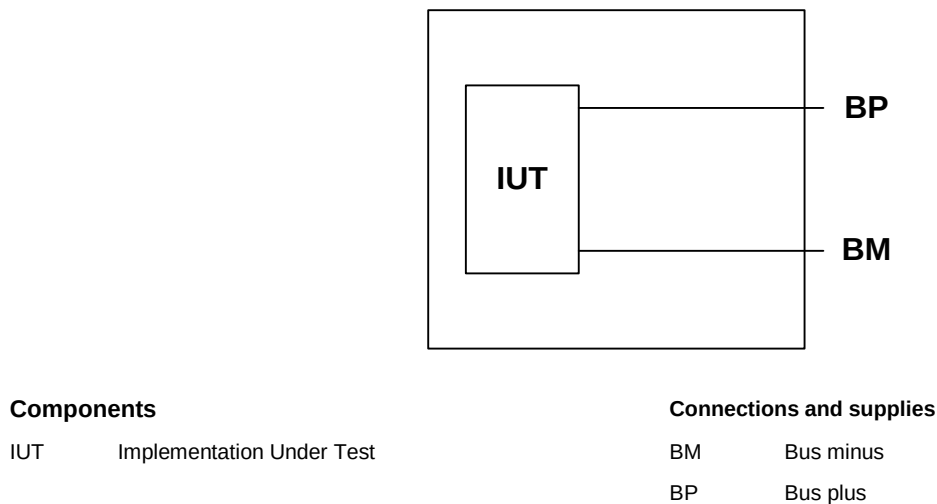
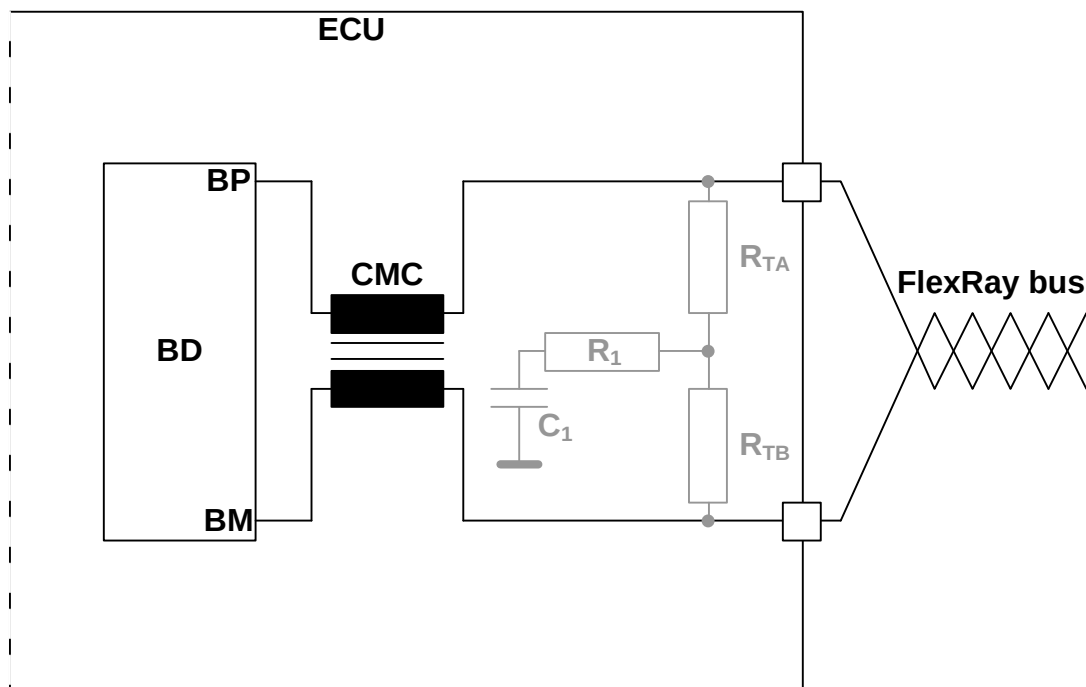


Figure 9 — Unterminated node

NOTE According to [12], all non-terminated nodes should have a high-ohmic split termination (e.g. 2 x 1 300 Ω + 4,7 nF).

6.4.6 Common mode chokes

Common mode chokes shall be used within the conformance testing of Bus Drivers as depicted in Figure 10.



Components		Connections and supplies	
BD	Bus Driver	BM	Bus minus
ECU	Electronic Control Unit	BP	Bus plus
R ₁	Termination resistor	CMC	Common Mode Choke
R _{TA}	Termination resistor towards BP	C ₁	Termination capacitor
R _{TB}	Termination resistor towards BM		

Figure 10 — Common mode choke implementation

As described in Figure 10, the CMC is placed on the board between the IUT and the termination. If no termination exist the CMC is placed between the IUT and the ESD protection circuit.

- The manufacturer²⁾ of the CMC is: Epcos
- The type of the CMC is: B82789C0104N002 (bifilar winding)

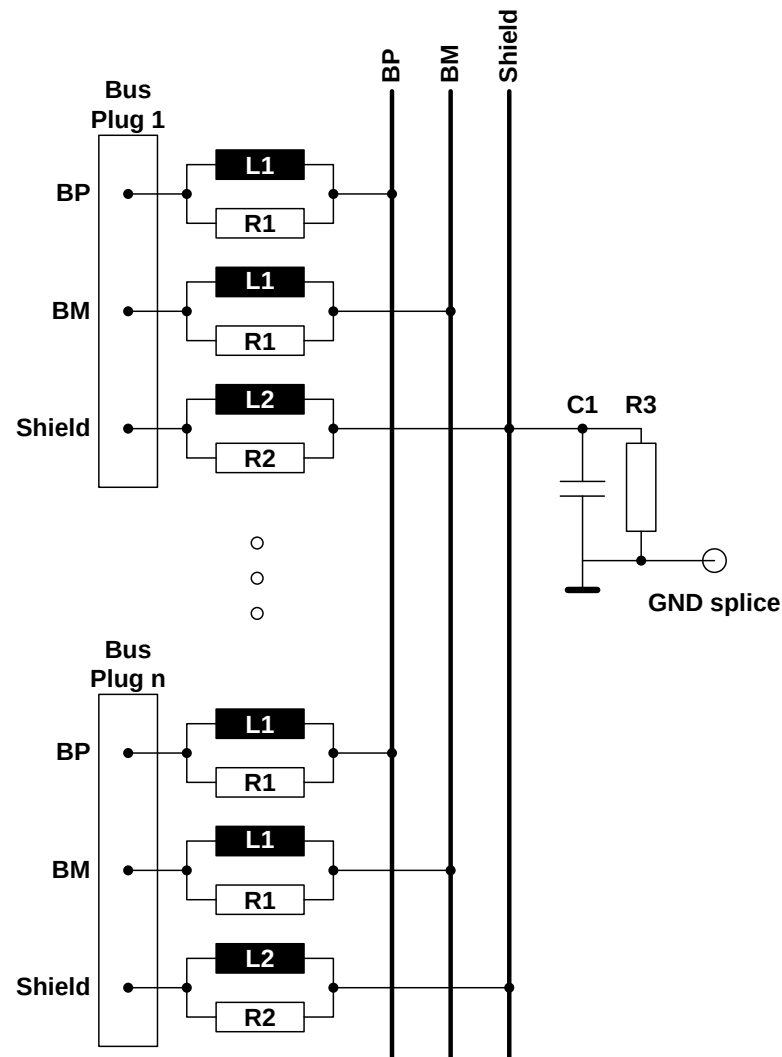
6.4.7 Active Star

The conformance test specification does not prescribe a certain implementation of the AS. This depends on the device specification of the IUT.

2) The suggested CMC is supplied by Epcos. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

6.4.8 Passive star

The passive star shall be implemented as depicted in Figure 11.



Components

C1	(see Table 6)
L1	(see Table 6)
L2	(see Table 6)
R1	(see Table 6)
R2	(see Table 6)
R3	(see Table 6)

Connections and supplies

BM	Bus minus
BP	Bus plus
Bus plug [1..n]	Generic node connector
GND splice	Connection to system ground
Shield	Cable shield

Figure 11 — Passive star implementation

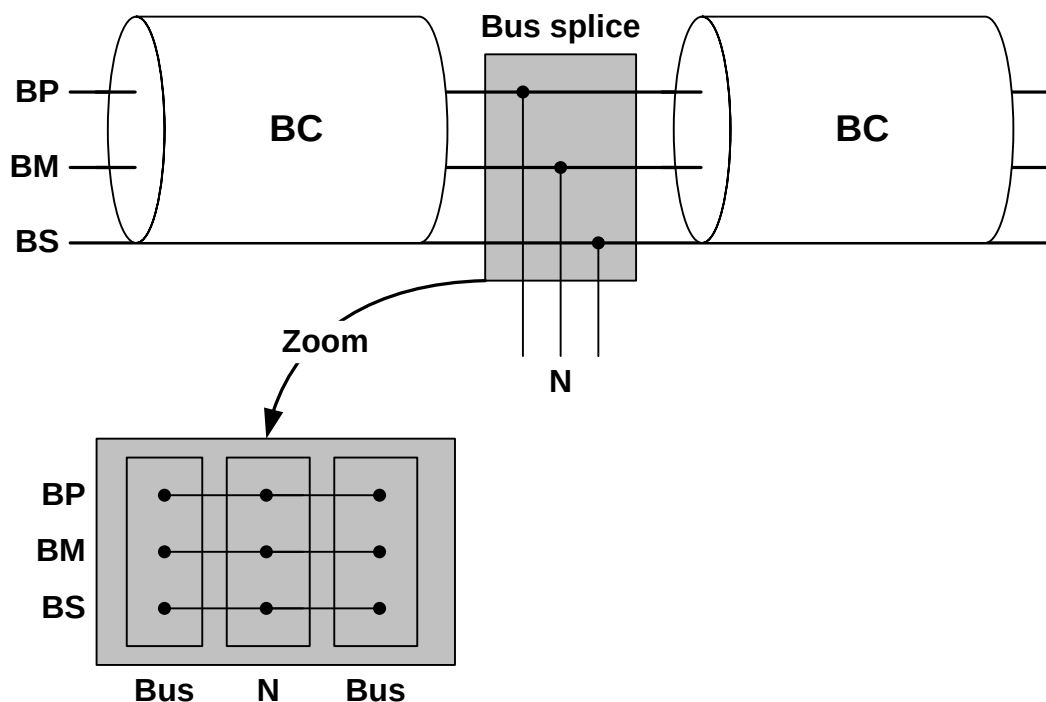
Table 6 lists the parameters of the passive star implementation.

Table 6 — Passive star implementation

Name	Description	Value	Unit
R₁	Series resistance on signal wire	22	Ω
	Tolerance	1	%
L₁	Series inductance on signal wire	220	nH
	Tolerance	10	%
R₂	Series resistance on signal wire	100	Ω
	Tolerance	1	%
L₂	Series inductance on signal wire	220	nH
	Tolerance	10	%
R₃	Inductance of shield to system ground	1	M Ω
	Tolerance	1	%
C₁	Capacitance to system ground	100	nF
	Tolerance	10	%
NOTE The ground of the passive star is connected to GND splice 2 with a ground wire of 0,1 m length.			

6.4.9 Passive bus

The passive bus shall be implemented as depicted in Figure 12.



Components

BC	Bus cable
BS	Bus shield

Connections and supplies

BM	Bus minus
BP	Bus plus
N	FlexRay node connection

Figure 12 — Passive bus implementation

The plugs shall be realized with 9 pin Sub-D connectors mounted on a small board. The wires between the connectors shall be as short as possible.

6.4.10 Cables

6.4.10.1 Bus Cables

The used bus cables in the conformance test shall have a shield and require the conditions listed in Table 7.

Table 7 — Bus cable impedance

Name	Description	Value	Tolerance	Unit
Z_0	Differential mode impedance at 10 MHz	90	$\pm 2 \%$	Ω

Table 8 — Bus cable characteristics

Name	Description	Min	Max	Unit
T'_0	Specific line delay	—	10	ns/m
α_5 MHz	Cable attenuation at 5 MHz	—	82	dB/km
ISubDistance _{M,N}	Distance between two network splices	150	—	mm

See further recommendations about bus cables in the application notes of ISO 17458-4.

EXAMPLE bus cable:

- Cable manufacturer³⁾: Gebauer & Griller
- Cable type: xF8FF_2_B56_FIM02YHBY

6.4.10.2 Power supply cables

The used cables in the conformance test shall require the following conditions:

Table 9 — Supply cable characteristics

Name	Description	Min	Max	Unit
A _{Cross section}	Cross section of GND and power supply wires	1,5	—	mm ²

EXAMPLE supply cable:

- Supply cable manufacturer⁴⁾: Coroplast
- Supply cable type: FLRY-A 2,5

6.4.11 Connectors

The used connectors in the conformance test shall require the conditions listed in Table 10.

3) The suggested bus cables are supplied by Gebauer & Griller. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4) The suggested power supply cables are supplied by Coroplast. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Table 10 — Connectors characteristics

Name	Description	Min	Max	Unit
$R_{DCCContact}$	Contact resistance (including crimps)	—	50	mΩ
$Z_{Connector}$	Impedance of connector	70	200	Ω
$l_{Coupling}$	Length coupling connection ^a	—	150	mm
$d_{ContactInterruption}$	Contact interruption; $R_{DCCContact} > 1\Omega$ ^b	—	100	ns
^a To be measured from end to end of untwisted area in the connected cables				
^b The time limit reflects the state of the art measurements techniques and potentially needs to be lower				

See further recommendations about connectors in the application notes of ISO 17458-4.

An example for a connector is:

- Connector manufacturer⁵⁾: Erni
- Connector type: Sub-D 9 pin

6.5 Test equipment

6.5.1 General

In every test case the accuracy and the resolution of each generator and measurement device shall be taken into account.

INH1 is floating while the IUT is in sleep mode and is pulled to V_{BAT} level while the IUT is not in a sleep mode. A pull down resistor shall be used to force a floating INH1 output to ground.

The logical level of the optional signal INH1 shall be interpreted as:

- Logical High: $uINH1 > uV_{BAT} - 1\text{ V}$ while $uV_{BAT} \geq 5,5\text{ V}$
- Logical Low: $uINH1 < uV_{BAT} - 1\text{ V}$ while $uV_{BAT} \geq 5,5\text{ V}$

6.5.2 Power supply V_{BAT}

The power supply shall be connected with the negative terminal to the chassis of the test system (that is connected to the ground pin) and with the positive terminal to the V_{BAT} splice of the communication network. This supply simulates a battery in an automotive environment.

The default voltage of V_{BAT} is the maximal battery operational range defined in the data sheet of the IUT up to +42 V.

Alternatively, for some test cases, the IUT is powered by a low battery generator as defined in 6.5.6 instead.

5) The suggested connectors are supplied by Erni. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Table 11 lists the power supply characteristics for V_{BAT} .

Table 11 — V_{BAT} power supply characteristics

Output	Description	Min	Max	Unit
V_{BAT}	Supply voltage DC	0	+50	V
	I_{min}	5	—	A

EXAMPLE

— Supply manufacturer⁶⁾: Toellner

— Supply type: 8805-64

Used voltages of V_{BAT} : $V_{BATUndervoltage}$, +5,5 V...+42 V

All nodes shall support to be supplied independently by extra V_{BAT} power supplies.

Nodes 21, 23 and 24 shall support to be supplied independently by extra V_{CC} and V_{IO} power supplies.

The Active Star shall support to be supplied independently by extra V_{BAT} , V_{CC} and V_{IO} power supplies.

6.5.3 Power supply V_{CC}

The power supply shall be connected with the negative terminal to the chassis of the test system (that is connected to the ground pin) and with the positive terminal to the V_{CC} splice of the communication network. This supply simulates the voltage regulator inside an Active Star or a node in an automotive environment.

The default voltage of V_{CC} is +5,0 V. Table 12 lists the power supply characteristics of V_{CC} .

Table 12 — V_{CC} power supply characteristics

Output	Description	Min	Max	Unit
V_{CC}	Supply voltage DC	0	+5,05	V
	I_{min}	0,7	—	A

EXAMPLE

— Supply manufacturer⁷⁾: Toellner

— Supply type: 8842-32

The V_{CC} on the nodes shall be generated by local voltage regulators and are not independent from V_{BAT} .

Used voltages of V_{CC} : +5,0 V (normal), $V_{CCUndervoltage}$.

6) The suggested power supplies are supplied by Toellner. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

7) The suggested power supplies are supplied by Toellner. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Node 21, 23, Node 24 and the AS shall be supplied independently by an extra V_{CC} power supply.

6.5.4 Reference voltage V_{IO}

The reference voltage supply shall be connected with the negative terminal to the chassis of the test system (that is connected to the ground pin) and with the positive terminal to the V_{IO} splice of the communication network. This reference voltage supply simulates the voltage regulator inside a node in an automotive environment.

The default voltage of V_{IO} depends on the I/O voltage of the devices counterpart, i.e. the host. Table 13 lists the reference voltage characteristics of V_{IO} .

Table 13 — V_{IO} reference voltage characteristics

Output	Description	Min	Max	Unit
V_{IO}	Supply voltage DC	0	+5,05	V
	I_{min}	0,7	—	A

EXAMPLE

— Supply manufacturer⁸⁾: Toellner

— Supply type: TOE 8840

The V_{IO} on the nodes shall be generated by local voltage regulators and are not independent from V_{BAT} .

Standard voltage of V_{IO} : depends on implementation.

Undervoltage of V_{IO} : $V_{IOUndervoltage}$.

Node 21, 23, 24 and the Active Star shall be supplied independently by an extra V_{IO} reference voltage.

The logical high level of the digital signal is specified in ISO 17458-4.

6.5.5 Ground shift generator

This generator is used to simulate ground shift between selected nodes and stars of a communication network. It is connected between the predefined ground pin of the node or star and the chassis of the test system (ground connection of the power supply).

Table 14 lists the characteristics of the ground shift generator.

Table 14 — Ground shift generator characteristics

Output	Description	Min	Max	Unit
U_{GS}	Ground shift voltage DC	-5	+5	V
	I_{min}	0,8	—	A

8) The suggested power supplies are supplied by Toellner. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

EXAMPLE

- Supply manufacturer⁹⁾: Kepco
- Supply type: BOP 20-10 M

For the ground shift generator, a sink shall be implemented, e.g. in kind of a two-quadrant power supply.

6.5.6 Low battery generator

This generator is used to simulate a low battery voltage that appears when turning on the starter circuit. The power supply shall be connected with the negative terminal to the chassis (that is connected to the ground pin) and with the positive terminal to the V_{BAT} splice of the communication network. This supply may be the same as specified in 6.5.2 and depends on the test case.

The IUTs are supplied by either this low battery generator or a battery power supply as defined in 6.5.2.

The test signal is defined in ISO 7637-1:2002.

Table 15 lists the characteristics of the low battery generator.

Table 15 — Low battery generator characteristics

Output	Description	Min	Max	Unit
V_{BAT}	Low battery voltage DC	0	+50	V
	I _{min}	5	—	A

EXAMPLE

- Supply manufacturer¹⁰⁾: Toellner
- Supply type: 8842-64

6.5.7 Signal generator

The signal generator is connected to Tx_D, Tx_{EN} and BGE¹¹⁾ of the Bus Driver and its ground pin. The generator is used to provide various test patterns, that are described in the test case clauses below.

Table 16 lists the characteristics of the signal generator.

9) The suggested ground shift generator is supplied by Kepco. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

10) The suggested low battery generator is supplied by Toellner. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

11) Only if this signal is available.

Table 16 — Signal generator characteristics

Output	Description	Min	Max	Unit
U _{TxD}	Bit time in test pattern	70	—	ns
	Voltage level of test pattern for digital input	0	5	V
	I _{min}	10	—	mA
	Sum of rise and fall time of signal at digital input of IUT with a 25 nF load	—	9	ns

EXAMPLE generator

Generator manufacturer¹²⁾: Agilent

Generator type: 16720A

6.5.8 Analog signal measurement

The characteristics of the measurement device are described in this subclause. This may be an oscilloscope or equivalent device.

Table 17 lists the characteristics of the analog measurement device.

Table 17 — Analog measurement device characteristics

Input	Description	Min	Max	Unit
U _x	Voltage level of analog test signals	0	14	V
C _x	Input capacitance of probe	—	10	pF
R _x	Input resistance	1	—	MΩ
	Sample Rate	800	—	MSa/s
	Bandwidth	200	—	MHz

EXAMPLE oscilloscope

— Oscilloscope manufacturer¹³⁾: LeCroy

— Oscilloscope type: Waverunner 6050

6.5.9 Digital signal measurement

The characteristics of the measurement device are described in this subclause. This shall be a logic analyzer or equivalent device.

12) The suggested signal generator is supplied by Agilent. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

13) The suggested oscilloscope is supplied by LeCroy. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Table 18 lists the characteristics of the digital measurement device.

Table 18 — Digital measurement device characteristics

Input	Description	Min	Max	Unit
U _x	Voltage level of digital test signals	-5	5	V
	Bandwidth	2	—	GHz
C _x	Capacitance load	—	10	pF
R _x	Resistive load	0,1	—	MΩ
	Number of channels	96	—	—
	Timing sample rate (full channel mode)	2	—	ns
	Threshold	—	50 % of U _x	—

EXAMPLE logic analyzer

— Logic analyzer manufacturer¹⁴⁾: Agilent

— Logic analyzer type: 16911A

6.5.10 Data acquisition unit

The characteristics of the measurement device are described in this subclause. This shall be a unit for measuring voltages or currents.

Table 19 lists the characteristics of the data acquisition unit.

Table 19 — Data acquisition unit

Input	Description	Min	Max	Unit
U _x	Absolute input voltage	-5	5	V
I _x	Absolute input current	-1	1	A
	Number of channels	2	—	—
	Timing sample rate (full channel mode)	600	—	S/s

EXAMPLE data acquisition unit

— Data acquisition unit manufacturer¹⁵⁾: Agilent

— Data acquisition unit type: 34970A

14) The suggested logic analyzer is supplied by Agilent. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

15) The suggested data acquisition unit is supplied by Agilent. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

6.5.11 Broadband amplifier

The characteristics of this generator are described in this subclause. This device is necessary for dynamic ground shift.

Table 20 lists the characteristics of the broadband amplifier.

Table 20 — Broadband amplifier

Output	Description	Min	Max	Unit
U _x	Absolute output voltage	0	10	V
	Gain	—	13	dB
	I _{min}	1	—	A

EXAMPLE broadband amplifier

— Broadband amplifier manufacturer¹⁶⁾: Toellner

— Broadband amplifier type: 7608

The used broadband amplifier shall support at least 2 quadrants.

6.5.12 Arbitrary function generator

The characteristics of this generator are described in this subclause. This device is necessary for dynamic ground shift.

Table 21 lists the characteristics of the arbitrary function generator.

Table 21 — Arbitrary function generator

Output	Description	Min	Max	Unit
U _x	Voltage level of digital test signals	0	2	V
	Frequency range (-3dB)	0	500	kHz
	Sample rate	50	—	MS/s

EXAMPLE arbitrary function generator

— Arbitrary function generator manufacturer¹⁷⁾: Agilent

— Arbitrary function generator type: 33250A

16) The suggested broadband amplifier is supplied by Toellner. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

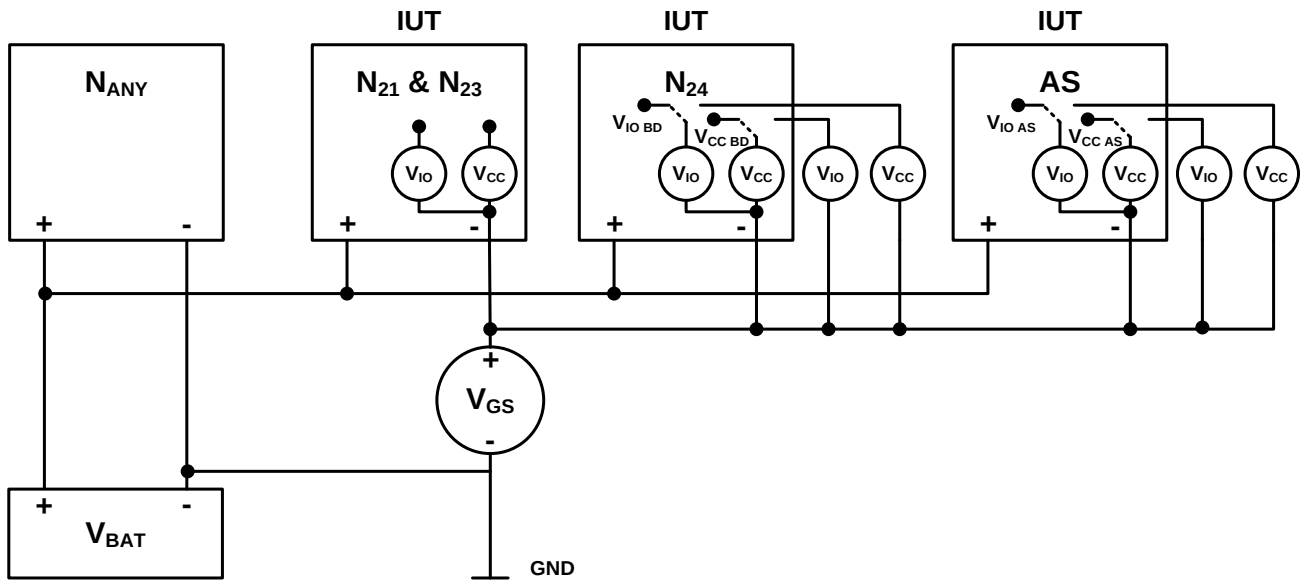
17) The suggested arbitrary function generator is supplied by Agilent. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

7 Stress Conditions

7.1 Ground shift

The ground shift is located between the chassis and the predefined ground connection of the used IUTs. In every test case separate information are given about the usage of the ground shift and the IUT affected.

Figure 13 depicts the usage of ground shift.



Components

AS	Active Star
IUT	Nodes that are used as Implementation Under Test
N_x	FlexRay node x
V_{BAT}	Battery voltage
V_{CC}	Node supply voltage
$V_{CC\ BD}$	Supply voltage of the Bus Driver
$V_{CC\ AS}$	Supply voltage of the Active Star
V_{GS}	Ground shift voltage
V_{IO}	Input/output voltage
$V_{IO\ AS}$	Input/output voltage of the Active Star
$V_{IO\ BD}$	Input/output voltage of the Bus Driver

Connections and supplies

GND	System ground
-----	---------------

Figure 13 — Usage of ground shift

Table 14 depicts the ground shift.

Table 22 — Ground shift

Signal	Description	Min	Max
U_{GS}	Static ground shift voltage	—	+5,0 V

Figure 14 depicts the location of ground shift in the test topology. The ground shift is injected in the emphasised nodes (N_{23} , N_{24} , AS).

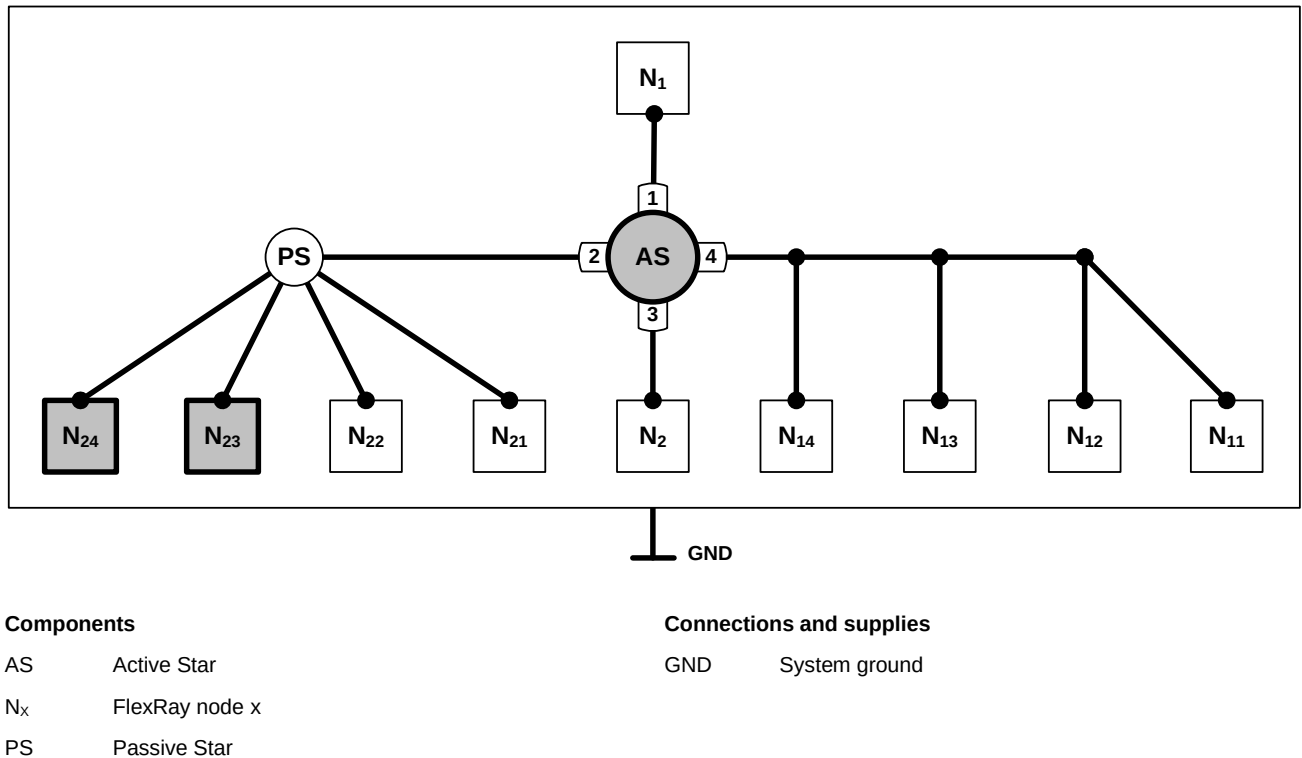


Figure 14 — Location of ground shift

7.2 Low battery voltage inside operational range

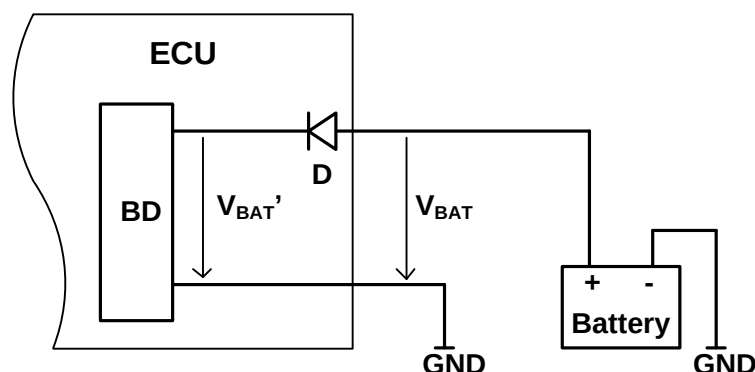
The test condition in case of a heavily discharged battery inside the operational range (with respect to the supply voltage boundaries specified in ISO 17458-4) is called low battery voltage inside operational range. The behaviour of the IUT during this stress condition is very important regarding the low power operation modes and the wakeup mechanism.

Since the kind of reverse connection protection (e.g. Schottky diode) inside the ECU varies from application to application V_{BAT}' is the stress voltage instead of V_{BAT} . The difference between V_{BAT} (supply voltage at the ECU) and V_{BAT}' (the voltage at the Bus Driver pin), is described in Figure 15.

Requirements:

All nodes including the IUTs and hosts of the topology (in Bus Driver test cases) / the Active Star (in Active Star test cases) shall be supplied by this low battery voltage.

Figure 15 depicts the description of V_{BAT} and V_{BAT}' .



Components

BD	Bus Driver
D	Diode
ECU	Electronic control unit (FlexRay node or Active Star)

Connections and supplies

GND	System ground
V_{BAT}	Battery voltage outside the ECU
V_{BAT}'	Battery voltage inside the ECU (after the diode)

Figure 15 — Description of V_{BAT} and V_{BAT}'

Table 23 lists the stress conditions of static low battery voltage inside the operational range.

Table 23 — Stress condition static low battery voltage inside operational range

Signal	Description	Min	Max	Unit
$uV1_{BATlow}$	Low battery voltage for evaluation of wakeup detection if V_{CC} is not implemented and non wakeup test cases are applied.	—	+5,5	V
$uV2_{BATlow}$	Low battery voltage for evaluation of wakeup detection if V_{CC} is implemented.	—	+7,0	V

7.3 Undervoltage

The behaviour of the IUT during this stress condition is very important regarding the low power operation modes and the wakeup mechanism, especially for the recovery functionality of the IUT. According to ISO 17458-4, the minimum allowed undervoltage detection thresholds are the following:

- In case of presence of a V_{BAT} pin: $V_{BATUndervoltage} = +4,0$ V.
- In case of presence of a V_{CC} pin: $V_{CCUndervoltage} = +4,0$ V.
- In case of presence of a V_{IO} pin: $V_{IOUndervoltage} = +2,0$ V.

In case the implemented minimum undervoltage detection threshold of the IUT for V_{BAT} , V_{CC} or V_{IO} is higher than specified in ISO 17458-4 then the undervoltage value in the conformance test shall be the specified minimum undervoltage value as given in the data sheet of the IUT.

EXAMPLE 1 for UV_{BAT} :

The undervoltage value of V_{BAT} is specified in ISO 17458-4 as +4,0 V.

If the minimum undervoltage threshold of V_{BAT} of the IUT in the data sheet is +4,5 V, then the undervoltage value for V_{BAT} in the conformance test shall be +4,5 V.

EXAMPLE 2 for $UV_{V_{CC}}$:

The undervoltage value of V_{CC} is specified in ISO 17458-4 as +4,0 V.

If the minimum undervoltage threshold of V_{CC} of the IUT in the data sheet is +4,2 V, then the undervoltage value for V_{CC} in the conformance test shall be +4,2 V.

EXAMPLE 3 for $UV_{V_{IO}}$:

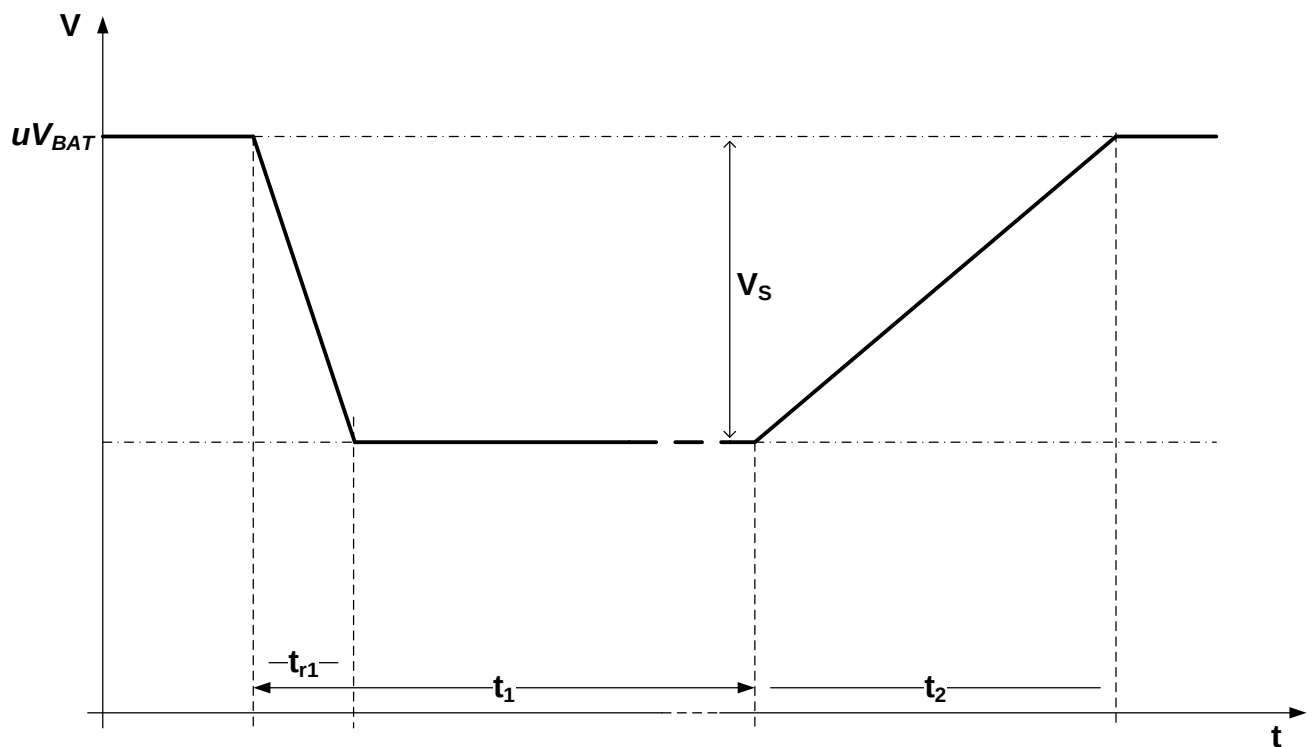
The undervoltage value of V_{IO} is specified in ISO 17458-4 as +2,0 V.

If the minimum undervoltage threshold of V_{IO} of the IUT in the data sheet is +2,5 V, then the undervoltage value for V_{IO} in the conformance test shall be +2,5 V.

7.4 Dynamic low battery voltage

The IUT will also be affected by a test signal that emulates a low battery voltage that appears when turning on the starter circuit, so the generator is connected to V_{BAT} of the IUT.

Figure 16 depicts the stress signal of DynamicLowBattery.



NOTE The components are described in Table 24.

Figure 16 — Stress signal DynamicLowBattery

Table 24 defines the stress signal DynamicLowBattery.

Table 24 — Stress signal DynamicLowBattery

Signal	Description	Value	Unit
V_S	Battery voltage difference after t_r at the IUT	6,1	V
uV_{BAT}	Nominal battery voltage at the IUT	11,6	V
t_{r1}	Fall time of battery voltage	70	ms
t_1	Time of low battery voltage without t_2	10 000	ms
t_2	Rise time of battery voltage	100	ms
NOTE The slew rate of V_S/t_{r1} simulates a small capacitance in an ECU.			

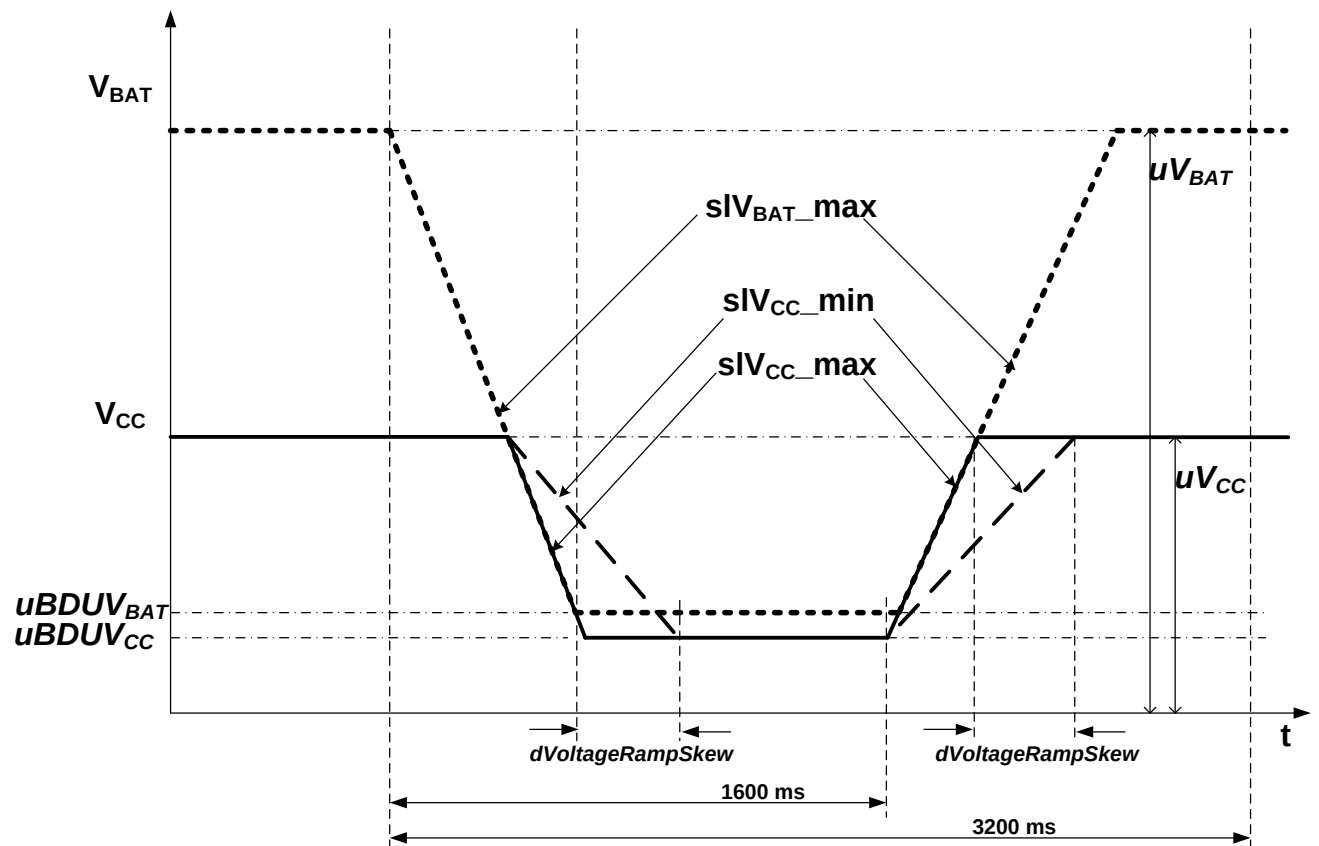
7.5 Dynamic low supply voltage

In case the supply voltages V_{BAT} and V_{CC} of a BD ramp down to undervoltage thresholds and up again, the BD shall react on undervoltage conditions but do not enter *BD_Off* or hang up when V_{IO} is constantly supplied with the product specific minimum operating voltage according to the BD datasheet.

Four different cases have to be considered in case both V_{BAT} and V_{CC} supply inputs are implemented:

- Case1,1: Fast V_{BAT} voltage drop with $sIV_{BAT_max}=7,6\text{ V}/5\text{ ms}$, and the same voltage drop on V_{CC} ($sIV_{CC_max}=sIV_{BAT_max}$) see Figure 17.
- Case1,2: Fast V_{BAT} voltage drop with $sIV_{BAT_max}=7,6\text{ V}/5\text{ ms}$, combined with slower voltage drop on V_{CC} than V_{BAT} with $sIV_{CC_min}=6,1\text{ V}/(5\text{ ms}+65\text{ ms})$ see Figure 17.
- Case2,1: Slow V_{BAT} voltage drop with $sIV_{BAT_min}=6,1\text{ V}/300\text{ ms}$, and the same voltage drop on V_{CC} ($sIV_{CC_max}=sIV_{BAT_min}$) see Figure 18.
- Case2,2: Slow V_{BAT} voltage drop with $sIV_{BAT_min}=6,1\text{ V}/300\text{ ms}$, combined with slower voltage drop on V_{CC} than V_{BAT} with $sIV_{CC_min}=6,1\text{ V}/(300\text{ ms}+65\text{ ms})$ see Figure 18.

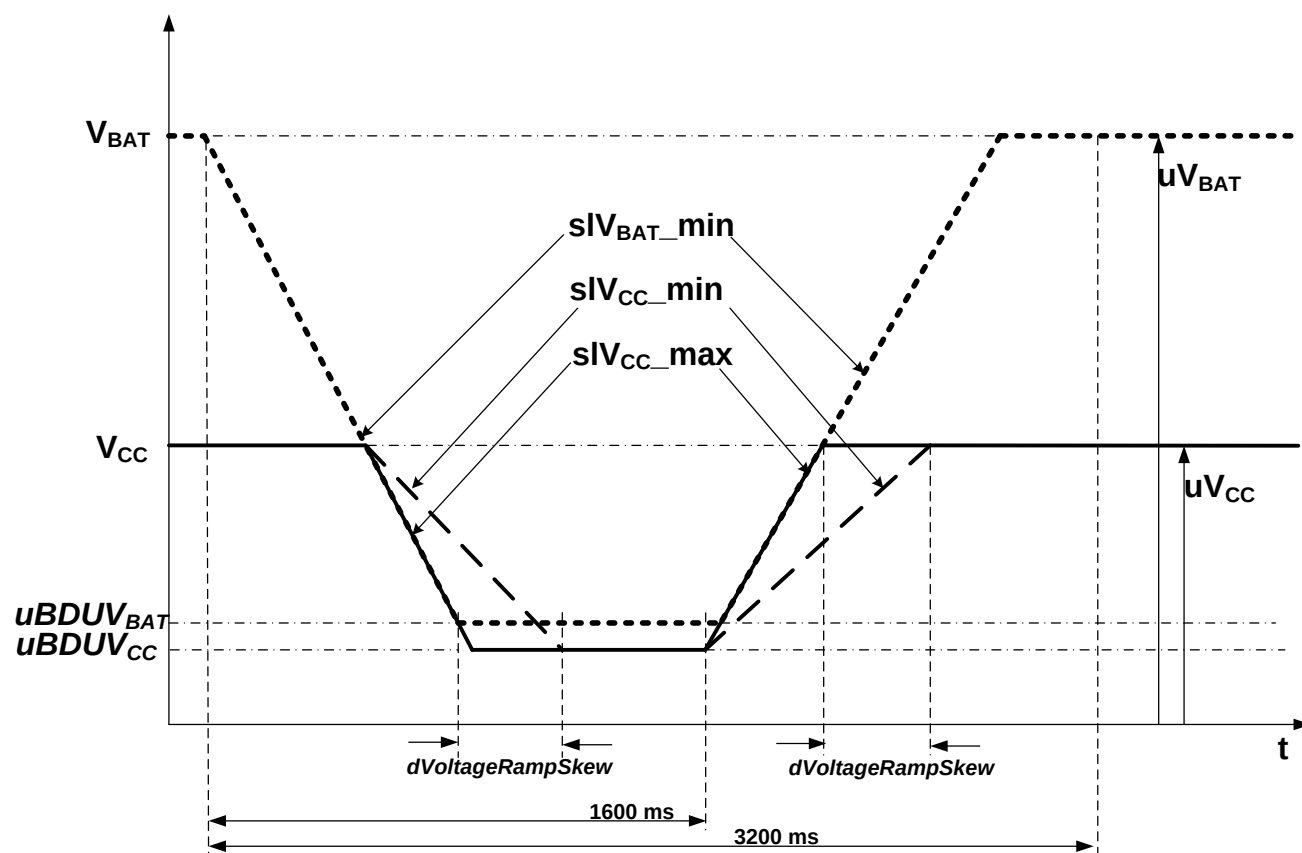
Figure 17 depicts the stress signal of the dynamic low supply case 1.



NOTE The components are described in Table 25.

Figure 17 — Stress signal dynamic low supply (case 1)

Figure 18 depicts the stress signal dynamic low supply case 2.



NOTE The components are described in Table 25.

Figure 18 — Stress signal dynamic low supply (case 2)

Table 25 lists the values of the dynamic low supply stress signal.

Table 25 — Stress signal dynamic low supply

Signal	Description	Min	Typ	Max	Unit
uV_{BAT}	Voltage value of V_{BAT} voltage supply at the IUT	—	11,6	—	V
uV_{CC}	Voltage value of V_{CC} voltage supply at the IUT	—	5	—	V
sIV_{BAT}	Absolute slope of V_{BAT} voltage	0,02	—	1,52	V/ms
sIV_{CC}	Absolute slope of V_{CC} voltage	see b	—	sIV_{BAT}	V/ms
$uBDUV_{BAT}$	Undervoltage detection threshold on V_{BAT}	4 ^a	—	5,5 ^a	V
$uBDUV_{CC}$	Undervoltage detection threshold on V_{CC}	4 ^a	—	— ^a	V
$dVoltageRampSkew$	<i>Time skew in reaching end of dynamic low supply voltage slope</i>	0	—	65	ms

^a See also 7.3.

^b Minimum value results from sIV_{bat} and $dVoltageRamp$, as depicted in Figure 18.