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Road vehicles — Controller area network (CAN) — Conformance test plan

Véhicules routiers — Gestionnaire de réseau de communication (CAN) — Plan d'essai de conformité

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Foreword

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ISO 16845 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

Road vehicles — Controller area network (CAN) — Conformance test plan

1 Scope

This International Standard provides the methodology and abstract test suite necessary for checking the conformance of any CAN implementation of the CAN specified in ISO 11898-1.

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/IEC 9646-1:1994, *Information technology — Open Systems interconnection — Conformance testing methodology and framework — Part 1: General concepts*

ISO 11898-1:2003, *Road vehicles — Controller area network (CAN) — Part 1: Data link layer and physical signalling*

ISO 11898-2:2003, *Road vehicles — Controller area network (CAN) — Part 2: High-speed medium access unit*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
ACK delimiter
second bit of the ACK field

3.2
ACK field
last field before the EOF, used for message validation

3.3
acknowledgement error
error condition of the transmitter when it does not detect a dominant bit on the ACK slot

3.4
ACK slot
first bit of the ACK field

3.5
active error flag
first field of an active error frame

3.6
active error frame
error frame that starts with an active (dominant) error flag

3.7
active state
state of a node when it can transmit an active error frame

3.8
arbitration field
field starting after the SOF bit and finished with the RTR bit

3.9
bit error
error condition encountered when the received bit does not correspond to the transmitted or expected bit

3.10
conformance testing
application of the test plan to an IUT

3.11
CRC delimiter
last bit of the CRC field

3.12
CRC error
error condition of a receiver when the received CRC code does not match the calculated CRC code

3.13
CRC field
field preceding the ACK field, consisting of the CRC code and the CRC delimiter

3.14
end of frame
last field of a data or remote frame before the intermission field

3.15
error delimiter
second field of an error frame

3.16
error flag
first field of an error frame

3.17
error frame
formatted sequence of bits indicating an error condition

3.18
form error
error condition encountered in a fixed form field

3.19
idle state
CAN bus state where no frame is started after intermission field

3.20
intermission field
field after EOF, error delimiter, or overload delimiter

3.21
lower tester
tester that supervises the test suite

3.22
overload delimiter
second field of an overload frame

3.23
overload flag
first field of an overload frame

3.24
overload frame
formatted sequence of bits indicating an overload condition

3.25
passive error flag
first part of a passive error frame

3.26
passive state
state of the device when the value of the REC or the TEC has reached the error passive limit

3.27
REC passive state
state of the device when the value of the REC has reached the error passive limit

3.28
recessive state
state of the CAN bus when no CAN node drives a dominant value on the line

3.29
stuff bit
bit inserted into the bit stream to increase the number of edges for synchronization purpose

3.30
stuff error
error condition encountered when an expected stuff bit is missing

3.31
suspend transmission field
waiting time added after the intermission field for an error passive transmitter, before it can start another transmission

3.32
TEC passive state
state of the device when the value of the TEC has reached the error passive limit

3.33
test case
specificly numbered and named test in the test suite

3.34
test frame
CAN frame containing the test pattern specified

3.35
test suite
check of the behaviour of the IUT for particular parameters of the CAN specification

3.36
test type
specification of the direction of the test frames

EXAMPLE Specification of the behaviour of the IUT receiving and/or transmitting messages.

3.37
time quantum
elementary time unit of the CAN bit time derived from the oscillator clock and the prescaler

3.38
upper tester
tester that acts as an user of the IUT

4 Abbreviated terms

ACK Acknowledgement

BRP Bit rate prescaler

CAN Controller area network

CRC Cyclic redundancy check

CTRL Control

DLC Data length code

EOF End of frame

DIE Identifier extension bit

IDEN CAN identifier

IPT Information processing time

IUT Implementation under test

LLC Logical link control

LME Layer management entity

LT Lower tester

MAC Medium access control

MDI Medium dependent interface

NDATA Network data

NTQ Number of Time Quanta

PCO Point of control and observation

PLS Physical layer signalling

PMA Physical medium attachment

REC Receive error counter

RTR Remote transmission request

RX Receiver signal

SJW Re-Synchronization jump width

SLIO Serial linked input/output

SOF Start of frame

SRR Substitute remote request

TEC Transmit error counter

TP Test plan

TQ Time quantum

TSYS System clock time (of the IUT)

UT Upper tester

5 General

5.1 Architecture of the test plan (TP)

The architecture of the TP plan is as shown in Figure 1.

The TP is a specific application of ISO 9646-1 and is restricted to the single party testing mode. Since the upper service boundary of a CAN implementation is not standardized and in some cases may not be observed and controlled, because of an application specific behaviour embedded in this implementation, (e.g. CAN SLIO), the TP shall rely either on the coordinated test method or the remote test method.

Depending on the test method applied, the TP shall involve up to three test functions:

— an LT operating in way similar to the CAN IUT, running test suite and granting test verdict;

— an UT acting as user of the IUT (IUT-dependant);

— a test management protocol between the IUT and the LT, consisting of test coordination procedures.

The last two functions are only applicable to the coordinated test procedure.

During testing, the LT may observe and control the standardized lower service boundary of the IUT (PCO) through the two service primitives provided by the PLS sub-layer, i.e. PLS Data.indicate and PLS Data.request, in most cases.

The environment that implements the TP is described in Figure 2.

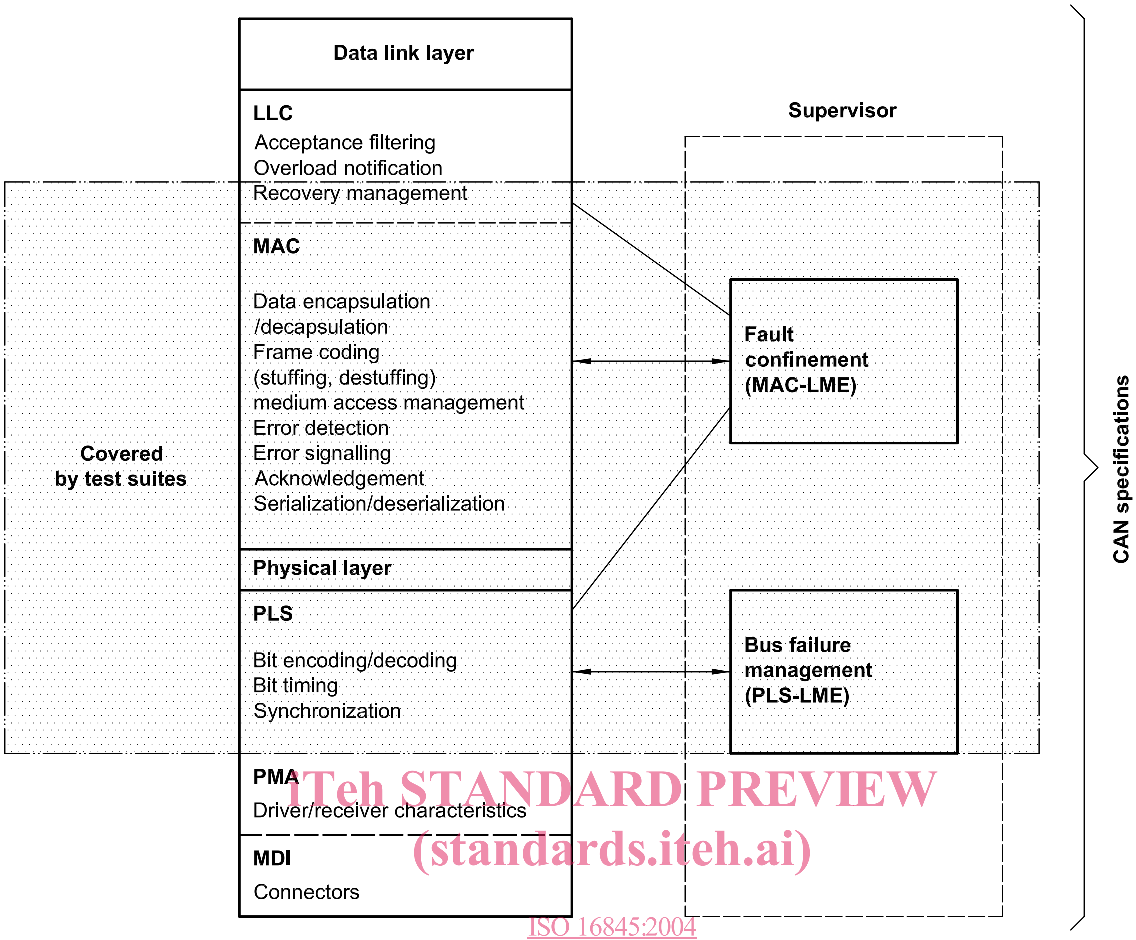

Figure 1 — Architecture of the test plan

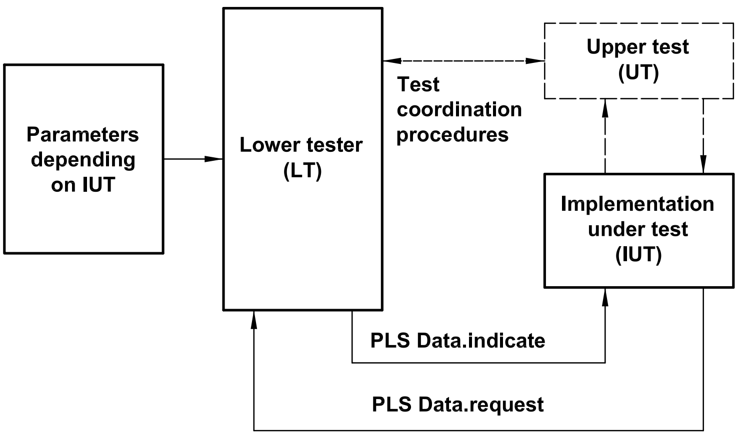

Figure 2 — CAN conformance TP environment

Using the network interface, the LT indicates to the UT the actions to be performed and the UT provides the LT with information concerning the internal behaviour of the IUT.

In order to allow the LT and the UT to communicate, it is necessary to specify some test coordination procedures between them. These procedures use the network to the exclusion of any other physical link. They are used to set up the UT and to verify the test results.

5.2 TP organization

5.2.1 General organization

The LT verifies if the IUT complies with the MAC, LLC, and PLS sub-layers of the CAN specification. The LT points out differences between what is expected according to the specification and the actual behaviour of the IUT.

The test suites of the TP are independent of one another. Each test suite may be used to check the behaviour of the IUT for a particular parameter of the CAN specification. Tests may be performed in sequence or separately.

Tests requiring variations of individual parameters (identifier, number of data, etc.) shall be repeated for each value of the parameter, these repetitions being known as elementary tests. A test including different elementary tests is valid only if all tests are passed.

5.2.2 Test organization

5.2.2.1 Elementary tests

5.2.2.1.1 Description

Each elementary test shall consist of three states:

- set-up;
- test;
- verification.

At the PCO, these states involve interchanges of valid sequences of PLS service primitives [CAN frame(s)] or invalid sequences of PLS primitives (invalid CAN frames or noise).

Before the first elementary test is started the IUT shall be initialized into the default state.

5.2.2.1.2 Set-up state

The set-up state is the state the IUT shall be in before entering the test state.

5.2.2.1.3 Test state

The test state is the part of the elementary test in which the parameter or protocol feature is checked. This state needs one or several interchanges of frames, called test frames.

5.2.2.1.4 Verification state

The verification state is made up of the data-reading frames, which verify that the data have been handled in accordance with the CAN specification.

For tests belonging to Classes 1 to 6 according to 5.3.3, the LT shall be able to detect the correct value of the bit.

For bit timing tests (Class 7 according to 5.3.3), the LT shall be able to detect a faulty synchronization of one time quantum.

5.2.2.2 Default state

The default state is characterized by the following default values:

- both REC and TEC shall be equal to 0;
- no pending transmission shall be present;

— IUT shall be in idle state;

— PLS data.indicate and PLS data.request shall be recessive.

After the end of each elementary test, the default state shall be applied.

5.3 Hierarchical structure of tests

5.3.1 Overview

The tests are grouped in categories in order to aid planning, development, understanding or execution of each test. Three levels of categories are specified test types, test classes and test cases.

5.3.2 Test types

Test types specify the direction of the frames. There are three types:

— **Type 1, received frame,** includes all tests evaluating the behaviour of the IUT for data frames and remote frames received by the IUT;

— **Type 2, transmitted frame,** includes all tests evaluating the behaviour of the IUT for data frames and remote frames transmitted by the IUT;

— **Type 3, bi-directional frame,** includes all tests with data frames or remote frames both received and transmitted by the IUT.

5.3.3 Test classes

Each of the three test types given in 5.3.2 is divided into seven classes, grouping tests:

— **Class 1, valid frame format,** includes the tests involving only error free data or remote frames;

— **Class 2, error detection,** includes the tests that corrupt data or remote frames, which are used to check correct error detection by the IUT;

— **Class 3, active error frame management,** includes the tests verifying the IUT correct management of error-free and of corrupted active error frames;

— **Class 4, overload frame management,** includes the tests verifying the IUT correct management of error-free and of corrupted overload frames;

— **Class 5, passive error state and bus-off,** includes the tests verifying the IUT behaviour during passive error state and bus-off state;

— **Class 6, error counter management,** includes the tests verifying the correct management of the TEC and REC by the IUT in both active and passive error state;

— **Class 7, bit timing,** includes the tests verifying the correct management of bit timing by the IUT, and shall be applied only to those components performing recessive to dominant edge synchronization — if the dominant to recessive edge synchronization exists, it shall be disabled.

5.3.4 Test cases

Each and every basic entry of the test list is intended for checking a particular parameter of the harmonized CAN specification in the IUT.

Each test case is specified by a number and a particular name in order to differentiate the test cases and to easily summarize the goal of the test case. Some test cases may be subdivided into elementary tests that are repetitions of the test case for several values of the parameter tested.

6 LT parameters

6.1 Overview

The CAN specification allows several IUT implementations. Consequently, the LT shall be provided with parameters in order to indicate which kind of IUT is to be tested. These parameters are classified in two categories:

— **communication parameters,** specifying which tests can be executed for the IUT, and which test method shall be applied;

— **application parameters,** which specifies the features of the frames used for each test case selected according to the previous parameters.

NOTE LT applies to IUT performing only recessive to dominant edge synchronization and operating in single sampling mode.

6.2 Description of parameters

6.2.1 Communication parameters

6.2.1.1 Categories of communication parameter

Communication parameters are subdivided in three categories: implementation, timing and NDATA parameters.

6.2.1.2 Implementation parameters

Implementation parameters dependant on the IUT shall be specified in order to allow the LT to fit on the IUT. These implementation parameters are as follows.

a) **CAN_VERSION** indicates the version implemented in the IUT and may take three values.

A: IUT handes 11 bit identifiers.

B: IUT handles 11 and 29 bit identifiers.

BP: IUT handes 11 identifiers and tolerates 29 bit identifiers.

b) **Open/specific,** which indicates whether the IUT is open regarding the application layers or includes a specific application, and may be of two types.

OPEN: open IUT allowing the test coordination procedure to be implemented in an UT.

These IUT shall be tested with the coordinated test method according to ISO 9646-1.

SPECIFIC: IUT that can be tested only with the help of a specific configuration procedure.

These IUT shall be tested with the remote test method according to ISO 9646-1.

6.2.1.3 Timing parameters

The LT also requires that some timing parameters be in accordance with the IUT and the UT characteristics. These parameters are as follows.

a) Timeout indicates the minimum duration time for which the LT shall wait in order to respect the following three conditions.

— The UT shall have enough time to put the IUT into the set-up state.

— The IUT shall have enough time to transmit a response frame after a remote frame.

— The LT shall consider an optional additional waiting time after the end of the minimum bus-off recovery sequence before the IUT enters error active state again.

b) **TSYS** indicates the duration of the IUT system clock (clock used as input of the prescaler).

c) **BRP** indicates the value of the prescaler (the duration of a TQ is T_Q = TSYS × BRP).

d) **NTQ** indicates the number of time quanta per bit.

e) **Phase_Seg2** indicates the number of time quanta for the phase buffer segment 2.

f) **SJW** indicates the number of time quanta for the re-synchronization jump width. In all tests, the re-synchronization jump width shall be programmed to its full range, up to its maximum value which is the minimum of Phase_Seg1 and 4 TQ.

g) **IPT** indicates the information processing time.

h) **IUT delay time** shall be considered for bit timing class tests. It indicates the time difference between the response of the IUT and the response of an ideal IUT (without internal delays) to an edge causing synchronization. The IUT delay time is the sum of the IUT input and output delay time periods, measured according to ISO 11898-2.

6.2.1.4 NDATA parameter, a set of DLC values which an IUT accepts for data exchange with higher layers.

6.2.2 Application parameters

Except for tests for which a particular profile of application parameters is specified by the TP, the content of the application parameters used during the test shall be chosen by the user.

7 Test type 1, received frame type

7.1 Test class 1, valid frame format

7.1.1 Identifier and number of data in standard format

7.1.1.1 Purpose and limits of test case

This test case is applicable to CAN_VERSION ∈ {A, B, BP}.

It is used to verify the behaviour of the IUT when receiving a correct data frame with different identifiers and different numbers of data bytes in a standard format frame.

Tested identifiers: ∈ [000h, 7EFh] ∪ [7F0h, 7FFh],

Tested number of data bytes: ∈ [0, 8]

7.1.1.2 Test case organization

Test case organization shall be in accordance with Table 1.

Table 1 — Identifier and number of data in standard format — Test case organization

State	Description
Set-up	No action required, the IUT is left in the default state.
Test	A single test frame is used for each elementary test.
Verification	The IUT shall not generate any error flag during the test. The IUT shall acknowledge the test frame. The data received by the IUT during the test state shall match the data sent in the test frame.

7.1.2 Identifier and number of data in extended format — Test case 1

7.1.2.1 Purpose and limits of this test case

This test case is applicable to CAN_VERSION ∈ {B}.

It is used to verify the behaviour of the IUT when receiving a correct data frame with different identifiers and different numbers of data bytes in a extended format frame.

Tested identifiers: ∈ [00000000, 1FFFFFFFh]

Tested number of data bytes: ∈ [0, 8]

7.1.2.2 Test case organization

Test case organization shall be as shown in Table 2.

Table 2 — Identifier and number of data in extended format — Test case 1 organization

State	Description
Set-up	No action required, the IUT is left in the default state.
Test	A single test frame is used for each elementary test.
Verification	The IUT shall not generate any error flag during the test. The IUT shall acknowledge the test frame. The data received by the IUT during the test state shall match the data sent in the test frame.

7.1.3 Identifier and number of data in extended format — Test case 2

7.1.3.1 Purpose and limits of this test case

This test is applicable to CAN_VERSION ∈ {BP}.

It is used to verify the behaviour of the IUT when receiving a correct data frame with different identifiers and different numbers of data bytes in a extended format frame.

Tested identifiers: ∈ [00000000, 1FFFFFFFh]

Tested number of data bytes: ∈ [0, 8]

7.1.3.2 Test case organization

Test case organization shall be in accordance with Table 3.