INTERNATIONAL STANDARD

ISO 11992-1

Second edition
2003-04-15

Road vehicles — Interchange of digital information on electrical connections between towing and towed vehicles —

Part 1: Physical layer and data-link layer

Véhicules routiers — Échange d'informations numériques sur les connexions électriques entre véhicules tracteurs et véhicules tractés —

Partie 1: Couche physique et couche de liaison de données

Reference number
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Contents

Page

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 11992-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This second edition cancels and replaces the first edition (ISO 11992-1:1998), reviewed in the light of changing legislative requirements and which has been technically revised.

ISO 11992 consists of the following parts, under the general title *Road vehicles — Interchange of digital information on electrical connections between towing and towed vehicles*:

— *Part 1: Physical layer and data-link layer*

— *Part 2: Application layer for brakes and running gear*

— *Part 3: Application layer for equipment other than brakes and running gear*

Part 4, *Diagnostics*, is under preparation.

Road vehicles — Interchange of digital information on electrical connections between towing and towed vehicles —

Part 1: **Physical layer and data-link layer**

1 Scope

This part of ISO 11992 specifies the interchange of digital information between road vehicles with a maximum authorized total mass greater than 3 500 kg, and towed vehicles, including communication between towed vehicles in terms of parameters and requirements of the physical and data link layer of the electrical connection used to connect the electrical and electronic systems.

It also includes conformance tests of the physical layer.

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 4141-1, *Road vehicles — Multicore connecting cables — Part 1: Test methods and requirements for basic performance sheathed cables*

ISO 7637-1, *Road vehicles — Electrical disturbance by conduction and coupling — Part 1: Definitions and general considerations*

ISO 7637-2, *Road vehicles — Electrical disturbance by conduction and coupling — Part 2: Commercial vehicles with nominal 24 V supply voltage — Electrical transient conduction along supply lines only*

ISO 8092-2, *Road vehicles — Connections for on-board electrical wiring harnesses — Part 2: Definitions, test methods and general performance requirements*

ISO 11898:1993[1)], *Road vehicles — Interchange of digital information — Controller area network (CAN) for high-speed communication*

ISO 11992-2, *Road vehicles — Interchange of digital information on electrical connections between towing and towed vehicles — Part 2: Application layer for brakes and running gear*

ISO 11992-3, *Road vehicles — Interchange of digital information on electrical connections between towing and towed vehicles — Part 3: Application layer for equipment other than brakes and running gear*

1) Amended in 1995. Under revision.

3 Terms and definitions

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

3.1
commercial vehicle
motor vehicle which, on account of its design and appointments, is used mainly for conveying goods and which may also tow a trailer

[ISO 3833:1977, definition 3.1.3]

3.2
towed vehicle
non-power-driven road vehicle which, on account of its design and appointments, is used to transport persons or goods and is intended to be towed by a motor vehicle; semi-trailer is included in this category

[ISO 3833:1977, definition 3.2]

3.3
towing vehicle
motor vehicle or non-power-driven vehicle which tows a succeeding vehicle.

3.4
maximum authorized total mass
vehicle mass determined as a maximum by the administrative authority for operating conditions laid down by that authority

[ISO 1176:1990, definition 4.8]

3.5
point-to-point connection
electrical connection between two electronic nodes only

3.6
bus
one or more conductors used for transmitting signals

3.7
line conductor
conductive part of cables used for transmitting signals

3.8
CAN_H, CAN_L
particular cable and/or contact of the communication connection

3.9
differential transmission
transmission of digital information carried by voltage between the two conductors of the electrical connections (two-wire operation)

4 Abbreviations

a.c. alternating current

CAN Controller Area Network

d.c. direct current

ECU Electronic Control Unit

5 General specification

The data link layer and the fault confinement entity used for the data link layer shall be in accordance with ISO 11898.

6 Physical layer

6.1 General requirements

The physical layer shall be a point-to-point connection, in order to ensure satisfactory operation of both the coupled and the uncoupled trailer.

Stable electrical signals with a high signal-to-noise ratio are required even at extreme external operating conditions (salt, oil, moisture, etc.).

The contact resistance and leakage currents shall not become the weak points of the braking equipment during the lifetime of the vehicles.

For safety reasons the data transmission shall be monitored, and in the case of a failure, at least one emergency operation shall be provided.

The transmission shall be bi-directional and differential.

The nominal supply voltages of the physical layer circuits may be either 12 V or 24 V.

6.2 Physical media

6.2.1 General

The bus consists of an unscreened twisted pair, CAN_H and CAN_L, for the transmission of the differential signals. These cables may be part of a multi-core cable. For this physical layer the characteristic impedance has no significant influence, and is therefore left unspecified.

The total length of the cable is normally split into three parts, l_1, l_2 and l_3, as shown in Figure 1. If more connectors are used on each vehicle (ECU connectors, etc.) the total capacitance shall be less than $C_{\text{bus}x}$ for each length, as specified in Table 1.

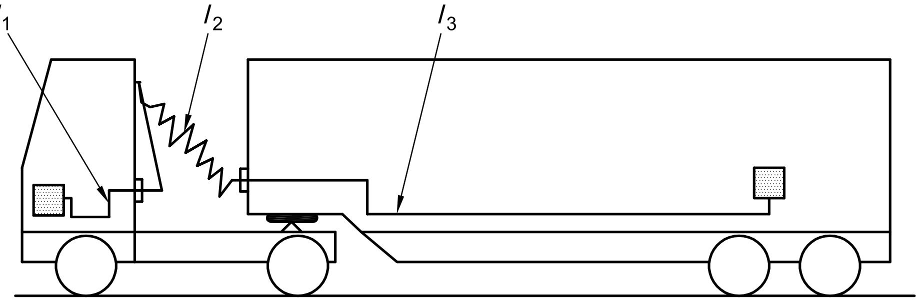


Figure 1 — Cable lengths

Table 1 — Cable parameters

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Overall cable length [a]	l	m	—	—	40
Cable length in towing vehicle	l_1	m	—	—	15
Differential capacitance between CAN_H and CAN_L in towing vehicle [b]	C_{d1}	pF	—	750	—
Input capacitance between CAN_H and ground, CAN_L and ground in towing vehicle [b]	C_{i1}	pF	—	750	—
Bus capacitance in towing vehicle [c]	C_{bus1}	nF	—	—	2,4
Resistance of CAN_H and CAN_L in towing vehicle	R_{l1}	mΩ	—	—	600
Insulation resistance of each CAN_H and CAN_L to ground and V_{bat} in towing vehicle [d]	R_{i11}	MΩ	15	—	—
Insulation resistance between CAN_H and CAN_L in towing vehicle [d]	R_{i21}	MΩ	15	—	—
Coiled cable length	l_2	m	—	—	7
Differential capacitance between CAN_H and CAN_L in coiled cable [b]	C_{d2}	pF	—	560	—
Input capacitance between CAN_H and ground, CAN_L and ground in coiled cable [b]	C_{i2}	pF	—	700	—
Bus capacitance in coiled cable [c]	C_{bus2}	nF	—	—	1,9
Resistance of each CAN_H and CAN_L in coiled cable	R_{l2}	mΩ	—	—	300
Insulation resistance of each CAN_H and CAN_L to ground and V_{bat} in coiled cable [d]	R_{i12}	MΩ	30	—	—
Insulation resistance between CAN_H and CAN_L in coiled cable [d]	R_{i22}	MΩ	30	—	—
Cable length in towed vehicle	l_3	m	—	—	18
Differential capacitance between CAN_H and CAN_L in towed vehicle [b]	C_{d3}	pF	—	900	—
Input capacitance between CAN_H and ground, CAN_L and ground in towed vehicle [b]	C_{i3}	pF	—	900	—
Bus capacitance in towed vehicle [c]	C_{bus3}	nF	—	—	2,9
Resistance of each CAN_H and CAN_L in towed vehicle	R_{l3}	mΩ	—	—	700
Insulation resistance of each CAN_H and CAN_L to ground and V_{bat} in towed vehicle [d]	R_{i13}	MΩ	12	—	—
Insulation resistance between CAN_H and CAN_L in towed vehicle [d]	R_{i23}	MΩ	12	—	—

[a] $l = l_1 + l_2 + l_3$

[b] Test method according to ISO 4141-1.

[c] The capacitive load for the driving circuit resulting from the cable is $C_{busx} = C_{ix} + 2\ C_{dx}$, where x = 1, 2, 3; including the connector capacitance, C_{con}.

[d] Test method similar to that given in ISO 8092-2.

6.2.2 Parameters related to the cables CAN_H and CAN_L

The parameters shall be in accordance with Table 1.

6.3 Contacts

6.3.1 General

The interface provides two contacts for the data transmission, CAN_H and CAN_L.

6.3.2 Parameters related to the contacts CAN_H and CAN_L

The parameters shall be in accordance with Table 2.

Table 2 — Contact parameters

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Contact resistance	R_{con}	mΩ	—	—	10
Insulation resistance between CAN_H and CAN_L [a]	R_{i1}	MΩ	50	—	—
Differential capacitance between CAN_H and CAN_L	C_{cd}	pF	—	5	—
Insulation resistance between CAN_H/CAN_L and ground [a]	R_{i2}	MΩ	50	—	—
Input capacitance between CAN_H/ CAN_L and ground	C_{ci}	pF	—	5	—
Capacitive load of the connector [b]	C_{con}	pF	—	—	20

[a] According to ISO 8092-2.

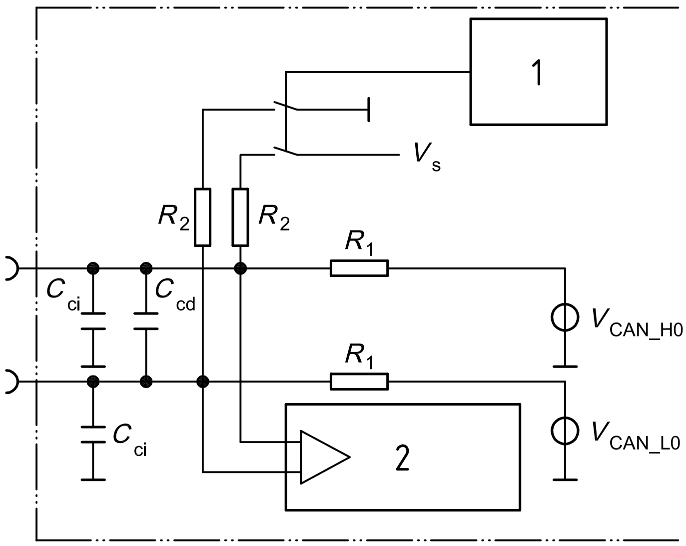
[b] The capacitive load for the driving circuit resulting from the connector is $C_{con} = C_{ci} + 2\ C_{cd}$.

6.4 Physical medium attachment

6.4.1 Electrical equivalent circuit diagram

Figure 2 shows the electrical equivalent circuit diagram of one unit of the data link.

CAN_H and CAN_L shall be connected to the resistances and voltage sources as specified. The data link shall fulfil the limiting values specified in 6.4.2.



Key

1 transmit logic

2 receive and transmit logic

V_{CAN_H0} Voltage source of CAN_H for recessive state (value see 6.4.2.1).

V_{CAN_L0} Voltage source of CAN_L for recessive state (value see 6.4.2.1).

Figure 2 — Electrical equivalent circuit diagram of one data link unit

6.4.2 "Dominant" and "recessive" status, electrical parameters

6.4.2.1 Transmission levels

CAN_H and CAN_L shall be operated with the voltage levels given by Figure 3.

The logic state of the bus may be "dominant" or "recessive", in accordance with Figure 3.

The logic "recessive" state is specified by the following voltage levels of CAN_H and CAN_L:

$V_{CAN\_H} = 1/3\ V_s$

$V_{CAN\_L} = 2/3\ V_s$

The logic "dominant" state is specified by the following voltage levels of CAN_H and CAN_L:

$V_{CAN\_H} = 2/3\ V_s$

$V_{CAN\_L} = 1/3\ V_s$

where V_s is the supply voltage of the data link units connected to the bus.

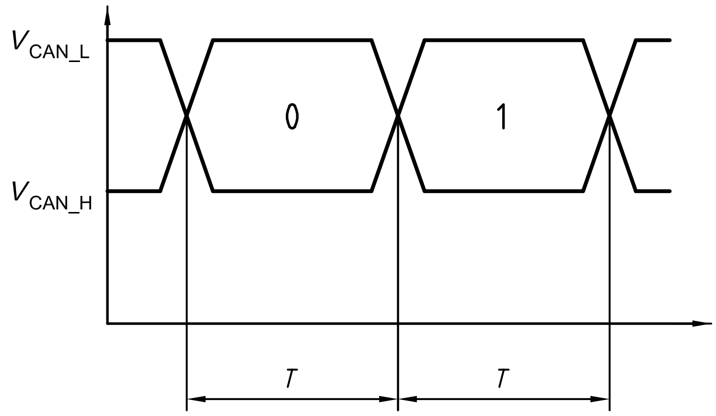
The differential voltage V_{diff} is

$V_{diff} = V_{CAN\_L} - V_{CAN\_H}$

This results in a value of

$V_{diff} = 1/3\ V_s$ at "recessive" state, and

$V_{diff} = -\ 1/3\ V_s$ at "dominant" state.



Key

0 dominant: Logic "0"

1 recessive: Logic "1"

Figure 3 — Specification of "dominant" and "recessive" state of CAN_H and CAN_L

6.4.2.2 Ratings

The voltage levels of V_s, V_{CAN_H} and V_{CAN_L} shall be within the voltage ranges specified in Tables 3 and 4, as appropriate, and in accordance with Table 5.

The interface operating voltage V_s is the on-board supply voltage for the commercial vehicle and the trailer interface as shown in Figure 4. V_{CAN_H} and V_{CAN_L} shall fulfil the specified requirements of Table 6 and 7, even if internal protection circuits (such as filters) are used. The time constant t_F shown in Figure 5 specifies the delay of voltage change between V_s and V_{CAN_H} or V_{CAN_L} in the case of any changes of V_s. Electrical interference along supply lines, as specified in ISO 7637-1 and ISO 7637-2, may interrupt the communication for less than 10 ms. No failure reaction shall occur during this time.

Table 3 — Voltage ranges for 24 V nominal voltage systems

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Interface operating voltage	V_s	V	16	—	32
Voltage at bus connection	V_{CAN_H} V_{CAN_L}	V	0	—	32
Interface supply current (nominal operation)	I_s	mA	—	—	60

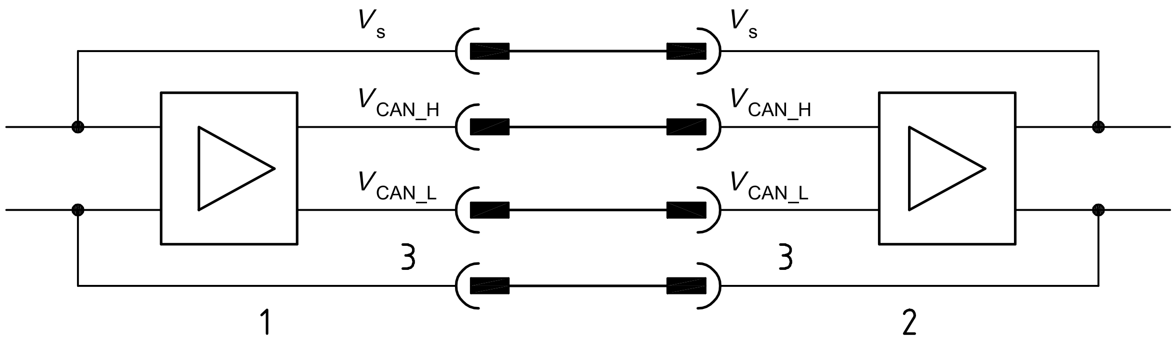
Table 4 — Voltage ranges for 12 V nominal voltage systems

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Interface operating voltage	V_s	V	9	—	16
Voltage at bus connection	V_{CAN_H} V_{CAN_L}	V	0	—	16
Interface supply current (nominal operation)	I_s	mA	—	—	30

Table 5 — Ground offset ranges

Parameter [a]	Notation	Unit	Value	
			min.	max.
Ground offset between the two interfaces during two-wire operation	V_{os}	V	$-V_s/8$	$V_s/8$
Ground offset between the two interfaces during one-wire operation	V_{os}	V	$-V_s/16$	$V_s/16$

[a] The ground offset V_{os} is related to the supply voltage of the interface of the towing vehicle.



Key

1 interface: towing vehicle

2 interface: towed vehicle

3 Ground

Figure 4 — Specification of V_s

6.4.2.3 d.c. parameters

The d.c. parameters of an interface shall be within the ranges specified in Tables 6 and 7, as appropriate.

The parameters are valid for two-wire operation, and for non-affected parts of the interface in the case of one-wire operation.

Table 6 — d.c. parameters — "Recessive" state

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Voltage level (data link disconnected)	V_{CAN_H}	V	0,32 V_s	0,33 V_s	0,35 V_s
	V_{CAN_L}	V	0,65 V_s	0,67 V_s	0,68 V_s
Differential voltage	V_{diff}	V	—	0,33 V_s	—
Threshold of differential voltage for receiving a recessive bit	$V_{diff\text{-}th}$	V	0	—	0,65
Input resistance	R_1	Ω	570	600	630
Current through connector [a]	I_{CAN_H}	mA	—	0	—
	I_{CAN_L}	mA	—	0	—

[a] With the two connectors mated.

Table 7 — d.c. parameters — “Dominant” state

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Voltage level [a]	V_{CAN_H}	V	0,64 V_s	0,67 V_s	0,70 V_s
	V_{CAN_L}		0,30 V_s	0,33 V_s	0,36 V_s
Differential voltage	V_{diff}		—	− 0,33 V_s	—
Threshold of differential voltage for receiving a dominant bit	$V_{diff\text{-}th}$	V	− 0,65	—	0
Current through connector for the whole range of V_s [b]	I_{CAN_H}	mA	—	13,3 (6,6)	—
	I_{CAN_L}				
Serial resistance [c]	R_2	Ω	285	300	315

[a] Two interfaces coupled with the connector, only one transmits.

[b] Two interfaces coupled. The value within brackets apply to 12 V nominal voltage systems; those without brackets apply to 24 V nominal voltage systems.

[c] Including the serial resistance of the switch (cf. Figure 2).

6.4.2.4 a.c. parameters

The requirements of the a.c. parameters shall be within the ranges specified in Table 8.

Table 8 — a.c. parameters

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Bit time without synchronisation (logical)	t	µs	7,999 2	8,0	8,000 8
Internal signal delay time [a]	t_{del}		—	—	0,4
Sample point [b]	t		6 + t_{sjw}	—	7
Input capacitance of one interface [c]	C_i	pF	—	400	—
Differential input capacitance [d]	C_d		—	100	—
Bus input capacitance [e]	C_{bus}		—	600	800
Time constant of supply filter [f]	t_F	ms	—	—	5

[a] Period of time between transmit logic input signal and receive logic output signal at state transition, bus length ≈ 0 m.

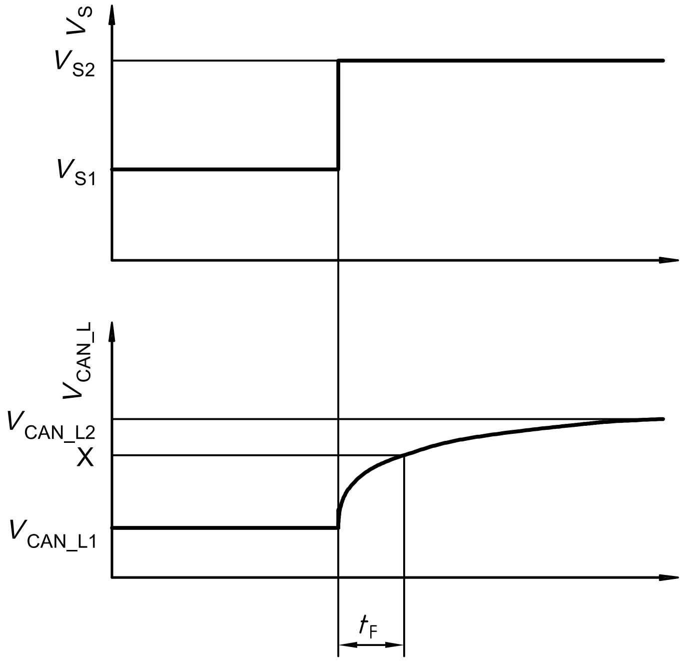
[b] See 6.5.2.

[c] Capacitance between CAN_H and ground, CAN_L and ground, with the connector disconnected, see Figure 2.

[d] Capacitance between CAN_H and CAN_L with the connector disconnected.

[e] The capacitive load for the driving circuit resulting from the electronic unit is $C_{bus} = C_i + 2\ C_d$ measured with disconnected connector.

[f] See Figure 5.



X = V_{CAN_L1} + 0,63 × (V_{CAN_L2} − V_{CAN_L1})

Figure 5 — Example of time constant t_F

6.4.3 Bus failure management

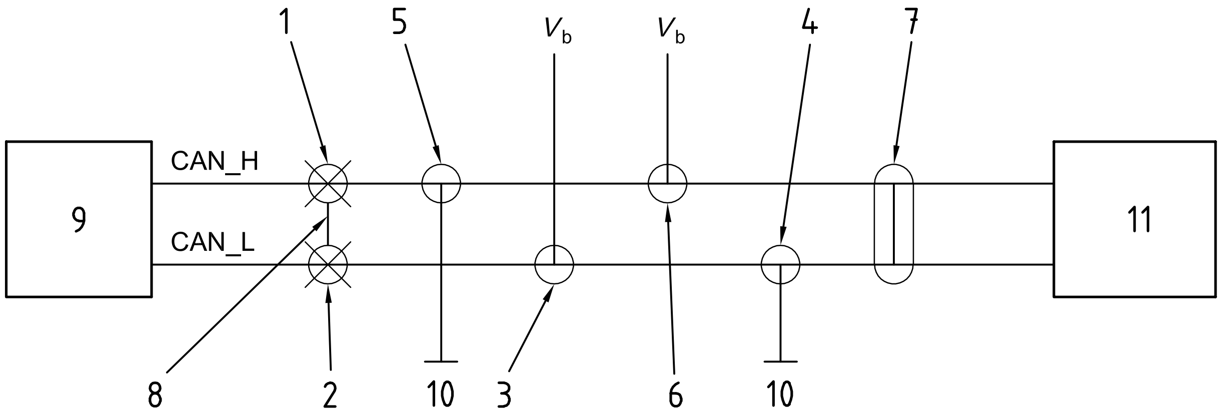
6.4.3.1 General

Transient errors (e.g. according ISO 7637) are automatically handled by the CAN protocol (see ISO 11898).

When a node is set into the bus-off state due to a more permanent failure, it shall immediately be reset to resume communication.

Failure handling depends on the repetition times, t_r, of the standard initialization messages as specified in ISO 11992-2 and ISO 11992-3. Failures in the data transmission that are only present for less than $5t_r$ shall not be indicated. In this case, the interface shall remain in the two-wire-operation mode.

Several open and short failures can occur that may influence operation (see Figure 6). An electrical circuit shall be provided to avoid a total breakdown of the data transmission during bus failures. This circuit shall allow a change from two-wire-operation mode to one-wire-operation mode using only one of the two cables CAN_H or CAN_L. This allows data transmission to be maintained in the case of an interruption of CAN_H or CAN_L, or a short circuit of one cable to ground or to supply voltage, or a short circuit between CAN_H and CAN_L (Cases 1, 2, 3, 4, 5, 6 and 7 in Figure 6). Data transmission is no longer possible if both cables are affected by a short circuit (except a short circuit between CAN_H and CAN_L) or interruption (Case 8).



Key

1 to 8 Cases 1 to 8

9 ECU towing vehicle

10 Ground

11 ECU trailer

Figure 6 — Bus failures

6.4.3.2 Fault detection and handling

If correct data transmission is not possible for longer than $5t_r$ (data neither correctly received nor transmitted), then the fault logic shall indicate this and perform the fault handling procedure described below. The fault detection and the fault handling may be realized either by hardware or software.

There are two one-wire-operation modes.

— In the CAN_L-operation mode the dominant driver of CAN_H shall be switched off and the voltage at the receive-comparator for CAN_H shall be replaced by a reference voltage. This mode shall be used to cover Cases 1, 5 and 6 of Figure 6.

— In the CAN_H-operation mode the dominant driver of CAN_L shall be switched off, the recessive source of CAN_L switched to a high impedance state, and the voltage at the receive-comparator for CAN_L shall be replaced by a reference voltage. This mode shall be used to cover Cases 2, 3, and 4 of Figure 6.

Case 7 of Figure 6 shall be covered by either CAN_L-operation mode or CAN_H-operation mode.

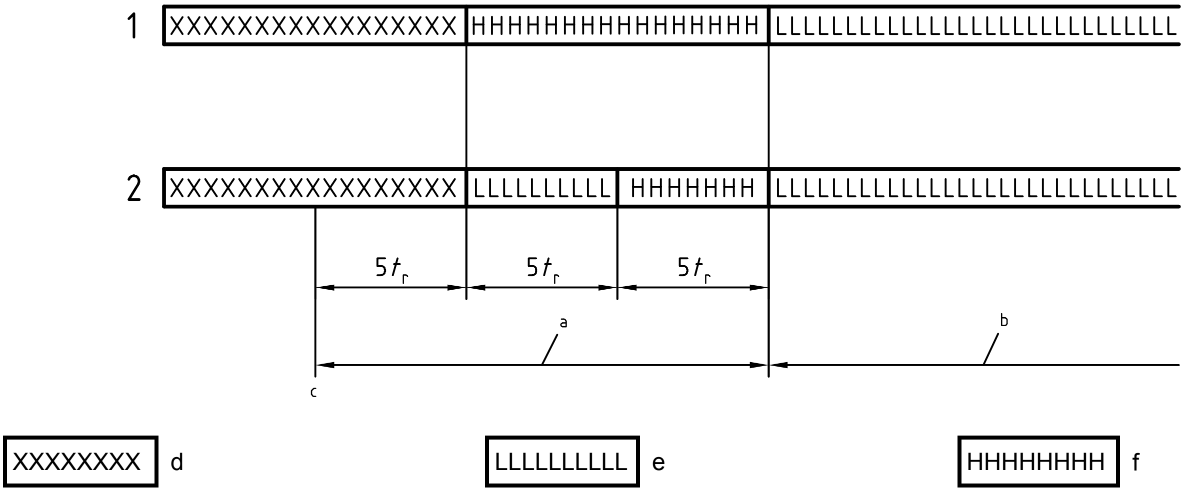
Depending on the special fault, one of the two modes allows successful data transmissions. This mode is called the “correct one-wire-operation mode”. It could be necessary to try both one-wire-operation modes before finding the correct one-wire-operation mode.

The fault handling procedure in the towing vehicle starts when data transmission is not possible for $5t_r$. It shall then switch to a one-wire-operation mode and try to work in this mode for $10t_r$. If during this time no data transmission is successful, the interface shall switch to the other one-wire operation mode and try to work in this mode for $10t_r$. If during this time data transmission is still not successful, the interface shall switch to the two-wire-operation mode and start the fault detection and handling procedure again with a $5t_r$ observation period.

The fault handling procedure in the towed vehicles starts when data transmission was not possible for $5t_r$. It shall then perform a procedure that guarantees that the towed vehicle switches to the correct one-wire-operation mode within $6t_r$, after the interface of the towing vehicle switched to the correct one-wire-operation mode and that it then remains in that mode. If no data transmission is successful for $20t_r$, the interface shall switch to the two-wire-operation mode and start that fault detection and handling procedure again with a $6t_r$ observation period.

As soon as data transmission is successful again, the current operation mode shall be continued and the fault detection and handling procedure shall be restarted with a $5t_r$ observation period of the line or lines used.

An example of the timing diagram for bus failure, Case 6, is shown in Figure 7.



Key

1 operation mode in the towing vehicle

2 operation mode in the towed vehicle

a No transmission possible

b Transmission in the correct one-wire operation mode

c Failure occurs

d Two-wire operation mode

e CAN_L operation mode

f CAN_H operation mode

Figure 7 — Example of timing diagram for bus failure — Case 6

6.4.3.3 Fault recovery

When an interface has worked in a one-wire-operation mode for $100t_r$ since the first correct data transmission in this mode, it shall switch back to the two-wire-operation mode for a test period of $5t_r$. If data transmission is successful during this test period, it shall remain in the two-wire-operation mode and restart the normal fault detection and handling procedure with another $5t_r$ observation period. If during the test period data transmission is not successful, the interface shall switch back to the one-wire-operation mode that was in use before the test period.

6.4.3.4 Power-on procedure

An interface shall start with transmission not later than 0,2 s after power is switched on for the interface. When transmission is started, the interface shall try to work in the two-wire-operation mode for at least $30t_r$.

6.5 Physical signalling

6.5.1 Physical signalling/physical medium attachment interface

The physical signalling/physical medium attachment interface shall be in accordance with ISO 11898:1993, 10.4.

6.5.2 Physical signalling sub layer

The physical signalling sub layer shall be in accordance with ISO 11898:1993, 10.3.

The nominal data rate shall be 125 kbit/s. The oscillator frequency from which the data rate is derived shall have a maximum relative tolerance of ± 0,01 %.

The programming of the bit time depends on the internal signal delay time and the capacitive load. To ensure proper operation under worst case conditions, the following requirements shall be fulfilled.

— Only signal edges from “recessive” to “dominant” shall be used for synchronization.

— The synchronization jump width shall have the duration of one time quantum, which shall be $\leqslant$ 500 ns.

— The sample point shall be located between minimal 6 µs plus the value for the synchronization jump width (t_{sjw}) and maximal 7 µs, counted from the beginning of the bit time.

— Single sampling shall be used.

6.5.3 Data link layer/physical layer interface

The data link layer/physical layer interface shall be in accordance with ISO 11898:1993, 10.2.

7 Conformance test circuits

7.1 General

The conformance tests specify measurement methods, including the appropriate test circuits, for checking the parameters of the physical layer. All measuring results shall be within the tolerance range of the corresponding parameter to make the systems compatible.

Those parameters which may have an influence on the compatibility are specified in the conformance tests.

The conformance tests shall be performed under the following conditions, unless otherwise specified:

— test temperature: (23 ± 5) °C (ambient);

— test supply voltage (V_s): 27 V (13,5 V) ± 2 %;

— power supply capability: $>$ 60 mA;

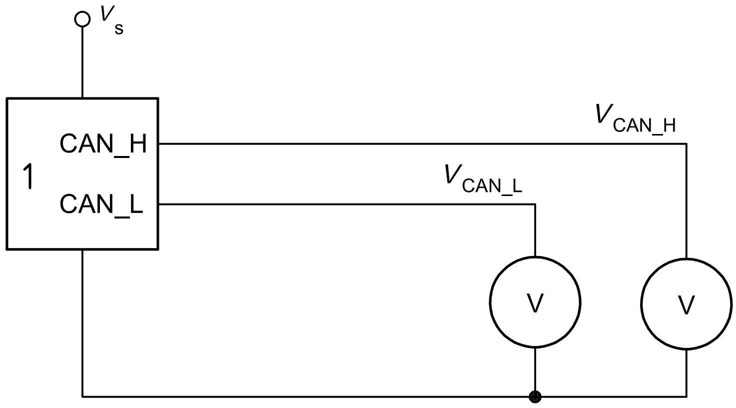
— test resistor accuracy: ± 1 %.

It shall be taken into account that measurements could contain inaccuracies due to the measuring equipment.

As a test device, an ECU may be used for data communication in accordance with these standard specifications.

7.2 Recessive output of the ECU

The output voltages V_{CAN_L} and V_{CAN_H} of the ECU shall be measured unloaded when the bus has been in the recessive state for 6,5 µs minimum and 7,5 µs maximum (see Figure 8). The measurements shall be made with minimum, nominal and maximum interface operating voltage V_s.



Key

1 ECU

Figure 8 — Measurements of output voltage in recessive state

7.3 Input resistance R_1

The input resistances at CAN_L and CAN_H shall be measured when the bus has been in the recessive state for 6,5 µs minimum and 7,5 µs maximum (see Figure 9).

The interface operating voltage V_s shall be set to the nominal value specified.

The test voltage V_{test} shall be

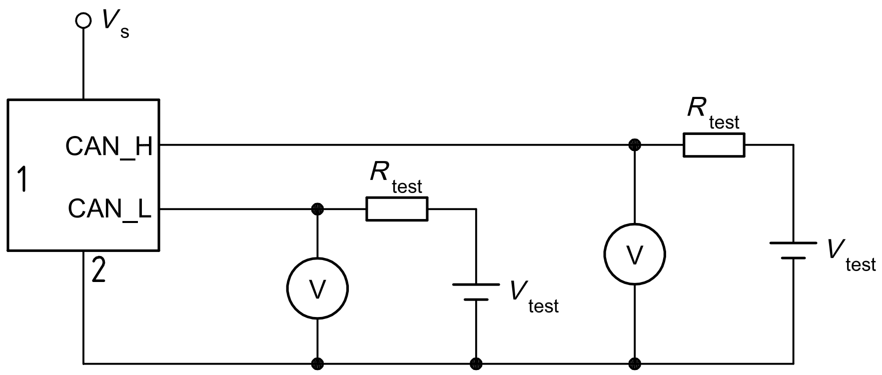
V_{test1} = 0 V, and

$V_{test2} = V_s$; R_{test} = 600 Ω.

After measurements of V, calculate R_1 at CAN_L and CAN_H using following equation.

$$R_{1,CAN\_L,H} = \frac{R_{test}\left(V_{CAN\_L,H} - V\right)}{V - V_{test}}$$

where V_{CAN_L} and V_{CAN_H} are the recessive output voltages specified in 7.2, measured with nominal interface operating voltage V_s.



Key

1 ECU

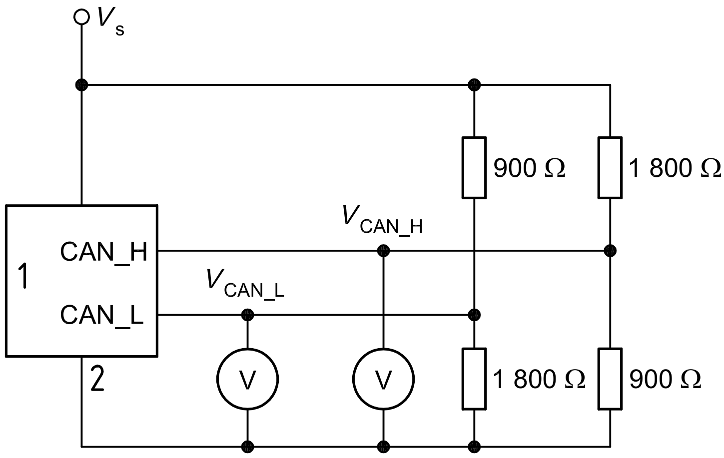
2 Ground

Figure 9 — Measurements of input resistance — "Recessive" state

7.4 Dominant output of the ECU and serial resistance R_2

The output voltage shall be measured as shown in Figure 10 when the ECU has been in the dominant state for 6,5 µs minimum and 7,5 µs maximum. V_s shall be set to the minimum and maximum values and to the test supply voltage.

When the dominant voltages, the recessive voltages of 7.2 and the input resistances of 7.3 are within the range specified, the value of the serial resistance R_2 is correct.



Key

1 ECU

2 Ground

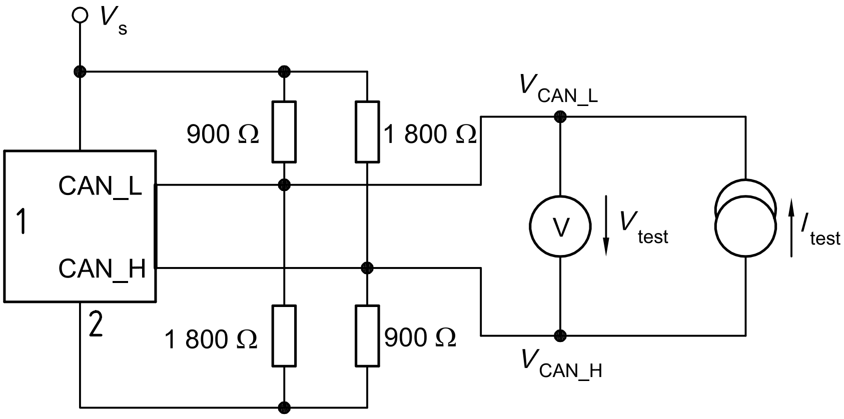
Figure 10 — Measurements of the output voltage — "Dominant" state

7.5 Receive threshold of recessive bits

A constant current source is applied to the bus (see Figure 11). If the resulting differential voltage, V_{test}, measured in the recessive state is ⩾ 0,65 V, a transmitted recessive bit shall be received as recessive. No error shall occur during this test.

This may be monitored by a standard network analyser. If the current is adjusted such that a negative voltage is produced for V_{test} during recessive state, the ECU shall stop transmitting.

This test procedure can only be applied during two-wire operation.



$V_{test} \geqslant 0{,}65$ V

Key

1 ECU

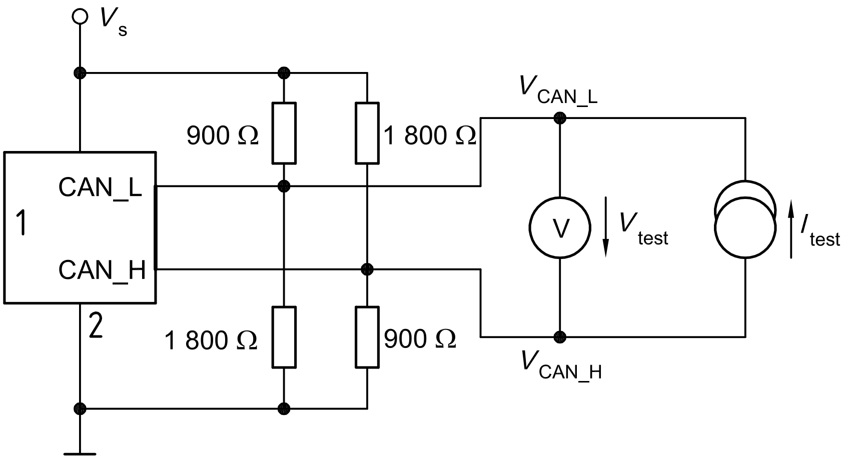
2 Ground

Figure 11 — Measurement of receive threshold for recessive bits

7.6 Receive threshold for dominant bit

A constant current source shall be applied to the bus (see Figure 12). If the resulting differential voltage V_{test}, measured in the recessive state, is less than (i.e. more negative) or equal to – 0,65 V, a transmitted recessive bit shall be received as dominant. The ECU shall stop transmitting the frame. No error shall occur if the current is adjusted such that a positive voltage of V_{test} is produced during the recessive state. This can be monitored by a standard network analyser.

This test procedure can only be applied during two-wire operation.



$V_{test} \leqslant -0{,}65$ V

Key

1 ECU

2 Ground

Figure 12 — Measurement of receive threshold for dominant bits

7.7 Offset voltage

The supply voltage, V_s, shall be set to maximum.

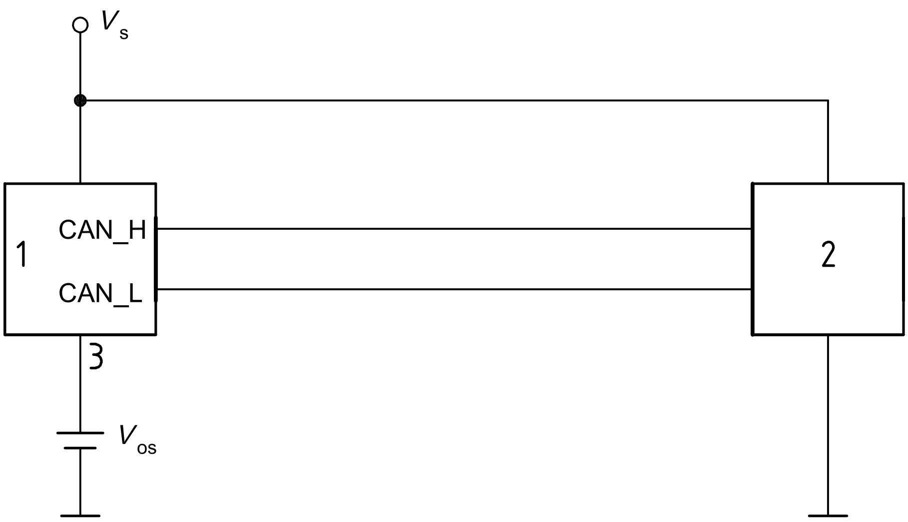
The offset voltage, V_{os}, shall be set to maximum ($V_{os} = V_s/8$).

The bus capacitance shall be simulated as a maximum.

The ECU and the test device shall transmit messages.

a) Case a: Offset voltage V_{os} at the ECU

See Figure 13.



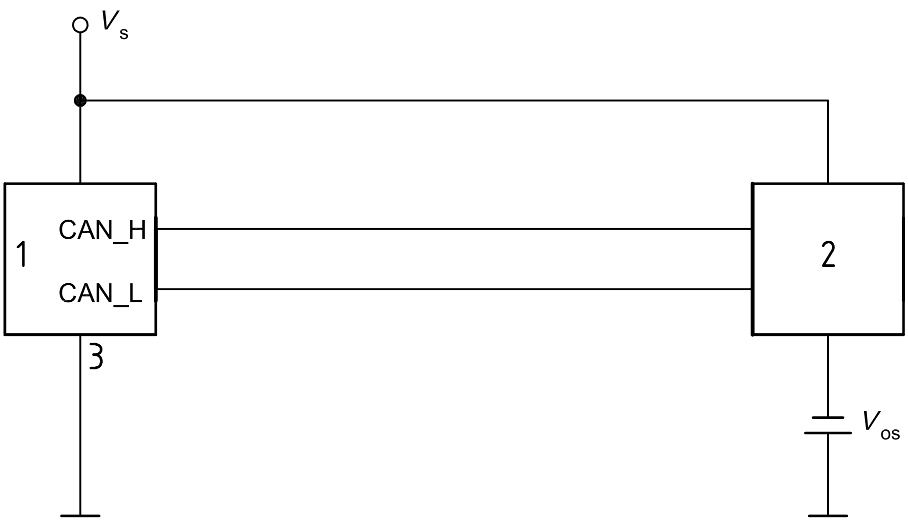
Key

1 ECU
2 test device
3 Ground

Figure 13 — Measurement of the offset voltage — Case a

b) Case b: Offset voltage V_{os} at the test device

See Figure 14.



Key

1 ECU
2 test device
3 Ground

Figure 14 — Measurement of the offset voltage — Case b

The required offset voltage range is met if the ECU and the test device answer the messages with ACK (acknowledge) in both Cases a and b. This can be monitored by a standard network analyser.

NOTE The input capacitance of the ECU is a part of the whole capacitive load during this measurement. An additional conformance test of the input capacitance is not necessary. This test also confirms the correct timing of the sample point, specified in 6.5.2, when the conformance test from 7.8 also gives a positive result.

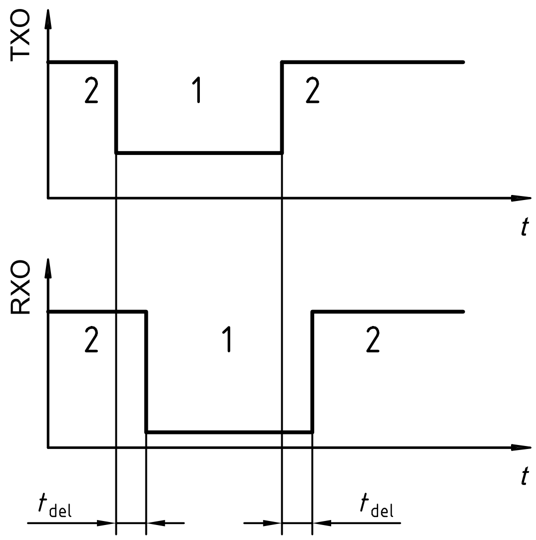
7.8 Internal signal delay

7.8.1 General

Use one of the following test methods.

7.8.2 Measurement inside the ECU

Measure the internal signal delay time within the ECU. Connect the bus output pins to the same resistor network as is shown in Figure 10. The delay period starts when a change of the actual bus state is required, indicated by a change of the logical value at the input of the transmit logic of the transceiver. It then takes some time until the corresponding bus voltages have been established. The delay period ends after the receive logic has recognized and indicated the new level at its output (see Figure 15).



Key

1 dominant

2 recessive

TXO is the transmit logic input signal

RXO is the receive logic output signal

Figure 15 — Measurement of internal signal delay time

7.8.3 Measurement outside the ECU

The internal signal delay time measurement with an external device shall be as shown in Figure 16. The test device shall have the physical layer of the ECU according to 6.4. The ECU and the test device shall be directly connected, i.e. the bus length shall be approximately zero.

Measurement shall be made by partly overwriting the first recessive identifier bit of an ECU message with a dominant level of the test unit (see hatched area in Figure 16) until the arbitration has been lost.

The test unit synchronises itself to the start of frame bit transmitted by the ECU. Upon detection of the first recessive identifier bit, the test unit partly overwrites this recessive bit for a duration of t_{overw} with a dominant bit (see hatched area shown in Figure 16). The duration of overwriting is increased from message to message until the ECU has lost arbitration and stops transmission. When this occurs, the part of the bit time available for delay time compensation, t_{avail}, is exhausted.

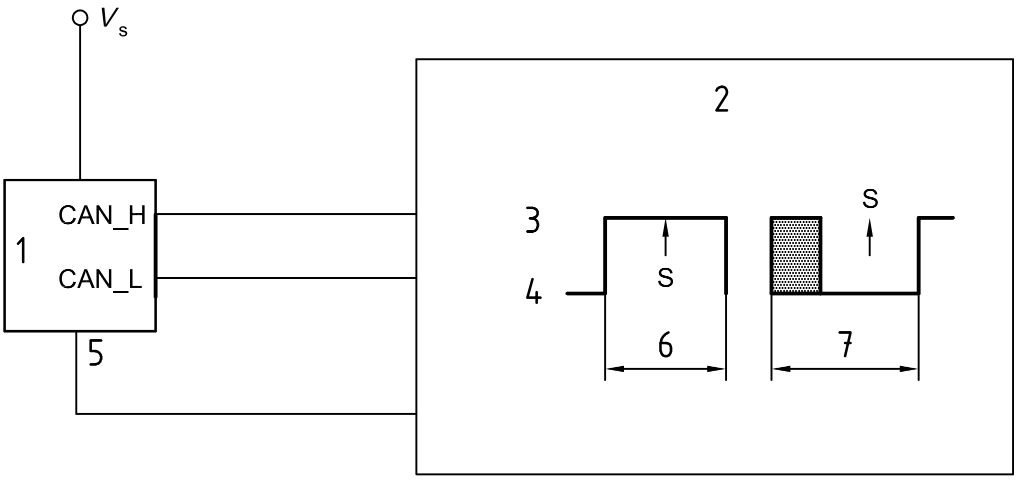
The internal delay time, t_{del}, is calculated as follows:

$$t_{del} = t_{avail} - t_{overw}$$

where

t_{avail} is the time counted from the beginning of the bit until the sample point;

t_{overw} is known from the test unit.



Key

1 ECU
2 test device
3 dominant
4 recessive
5 Ground
6 start of frame
7 first recessive ID bit
S sample point

Figure 16 — Measurement of the internal delay time

7.9 Bus failure management and power-on procedure

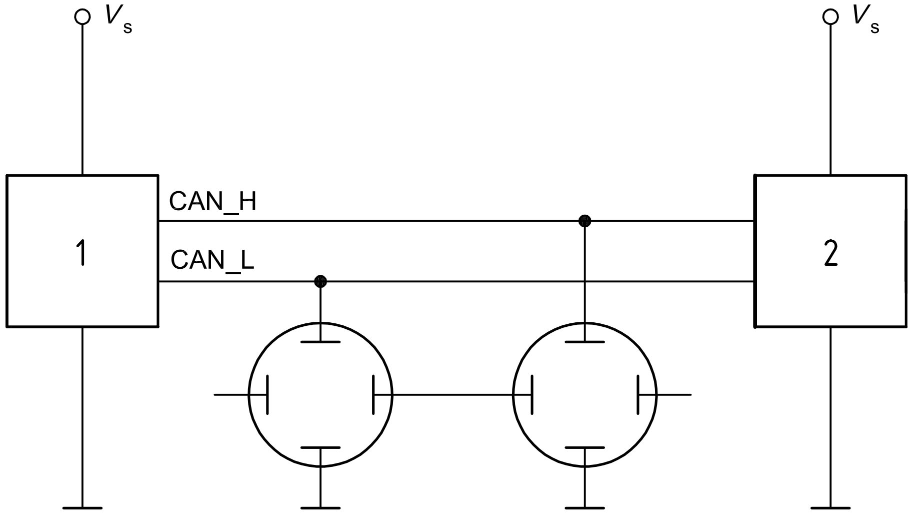
Correct fault detection and handling shall be tested as shown in Figure 17.

For testing a towing/towed vehicle, the ECU of the towing/towed vehicle may be replaced by an appropriate test device.

One-wire operation shall be initiated 20 t_r after one of the Cases 1 to 6 (see 6.4.3 and Figure 6), and CAN transmission shall work on the line not affected. In Case 7, transmission shall work either in the CAN_H or in the CAN_L operation mode. After 100 t_r, when the failure has been removed, two-wire operation mode shall start again.

Start of transmission shall be measured using the test circuits as shown in Figure 17.

CAN signals shall be present on both line conductors 0,2 s after ECU power-on.



Key

1 ECU

2 test device

Figure 17 — Measurements of fault handling

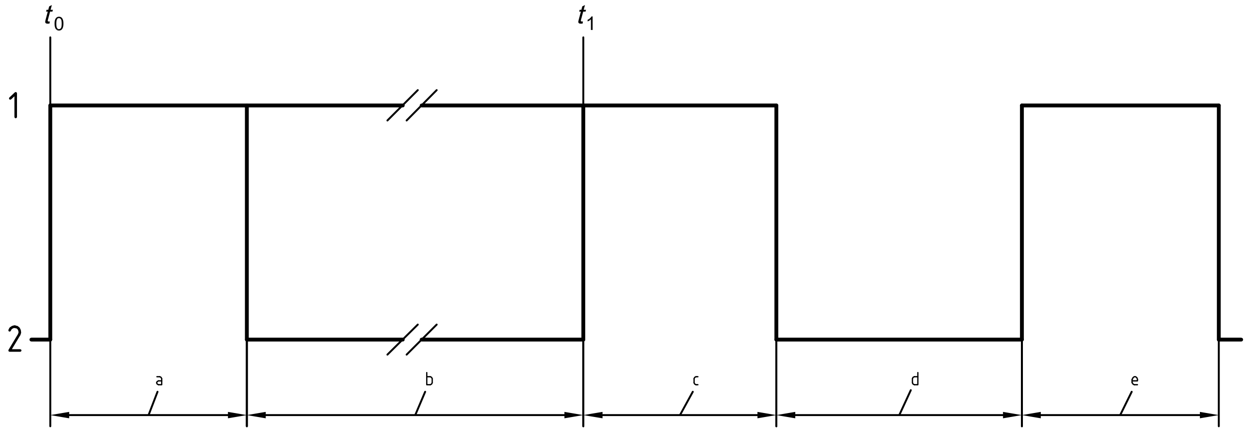
7.10 Bit timing

An external test device monitors the messages transmitted by the ECU. The test device calculates the bit time, t, of the ECU by measuring the duration of a message, and dividing this duration by the number of bits of this message. The duration starts at t_0 with the recessive to dominant edge of the start-of-frame bit, and ends at t_1 with the recessive to dominant edge of the last dominant bit transmitted by the ECU before the acknowledge bit is received (see Figure 18). Care shall be taken that the thresholds for start and end of measurement are the same.

The bit time is then calculated by

$$t = \frac{(t_1 - t_0)}{n}$$

where n is the number of bits transmitted between t_0 and t_1, including stuff bits.



Key

1 dominant

2 recessive

a Start of frame

b Dominant or recessive

c Last dominant

d 1 … 5 recessive bits, including CRC delimiter

e ACK

Figure 18 — Measurement of bit time

8 Data link layer

The data link layer shall be in accordance with ISO 11898:1993, Clauses 5, 6, 7 and 8.

9 Fault confinement

Fault confinement shall be in accordance with ISO 11898:1993, 11.1.

Bibliography

[1] ISO 1176, *Road vehicles — Masses — Vocabulary and codes*

[2] ISO 3833, *Road vehicles — Types — Terms and definitions*

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