INTERNATIONAL STANDARD

ISO 11992-1

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

Part 1:
Physical layer and data link layer

Véhicules routiers — Connexions électriques entre véhicules tracteurs et véhicules tractés — Échange de données numériques —

Partie 1: Couche physique et couche liaison de données

Reference number
ISO 11992-1:1998(E)

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.

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.

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

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

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

— *Part 2: Application layer for braking equipment*

— *Part 3: Application layer for non-braking equipment*

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

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 authorised 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 standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 11992. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 11992 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1176:1990, *Road vehicles — Masses — Vocabulary and codes.*

ISO 7637-1:1990, *Road vehicles — Electrical disturbance by conduction and coupling — Part 1: Passenger cars and light commercial vehicles with nominal 12 V supply voltage — Electrical transient conduction along supply lines only.*

ISO 7637-2:1990, *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 8092-2:1996, *Road vehicles — Connections for on-board electrical wiring harnesses — Part 2: Definitions, test methods and general performance requirements.*

ISO 11898:1993, *Road vehicles — Interchange of digital information — Controller area network (CAN) for high speed communication,* and its Amendment 1:1995.

ISO 11992-2:1998, *Road vehicles — Electrical connections between towing and towed vehicles — Interchange of digital information — Part 2: Application layer for braking equipment.*

ISO 11992-3:1998, *Road vehicles — Electrical connections between towing and towed vehicles — Interchange of digital information — Part 3: Application layer for non-braking equipment.*

3 Definitions

For the purposes of this part of ISO 11992, the following definitions apply.

3.1 maximum authorised total mass
vehicle mass determined as a maximum by the administrative authority for operating conditions laid down by that authority [ISO 1176:1990]

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

3.3 bus
one or more conductors used for transmitting signals

3.4 line conductor
conductive part of cables used for transmitting signals

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

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

4 General specification

The data link layer and the fault confinement entity used for this data link shall be in accordance with ISO 11898 [Controller Area Network (CAN) for high speed communication].

5 Physical layer

5.1 General requirements

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

Stable electrical signals with 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 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.

5.2 Physical media

5.2.1 General

The bus consists of two unscreened twisted cables, 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 cable is split into at least three parts, as shown in figure 1. If more connectors are used on each vehicle (ECU connectors, etc.) the total capacitance shall be less than C_{busx} for each length, as specified in table 1.

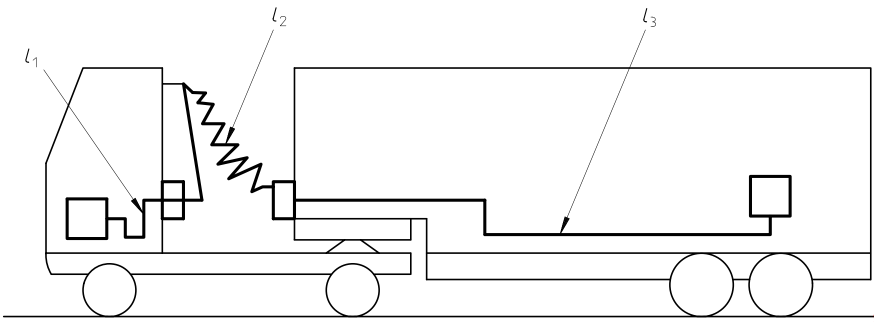


Figure 1 — Cable lengths

5.2.2 Parameters related to the cables CAN_H and CAN_L

The parameters shall be in accordance with table 1.

5.3 Contacts

5.3.1 General

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

5.3.2 Parameters related to the contacts CAN_H and CAN_L

The parameters shall be in accordance with table 2.

5.4 Physical medium attachment

5.4.1 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 5.4.2.

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

5.4.2.1 Transmission levels

CAN_H and CAN_L shall be operated with the voltage levels given in figure 3.

The logic state of the bus may be "dominant" or "recessive", as specified in figure 3.

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

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

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

Table 1 — Cable parameters

Parameter	Notation	Unit	Value		
			nominal	max.	min.
Overall cable length[1)]	l	m	—	40	—
Cable length in towing vehicle	l_1	m	—	15	
Differential capacitance between CAN_H and CAN_L in towing vehicle	C_{d1}	pF	750	—	—
Input capacitance between CAN_H and ground, CAN_L and ground in towing vehicle	C_{i1}	pF	750	—	—
Bus capacitance in towing vehicle[2)]	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[3)]	R_{i11}	MΩ	—	—	15
Insulation resistance between CAN_H and CAN_L in towing vehicle[3)]	R_{i21}	MΩ	—	—	15
Coiled cable length	l_2	m	—	7	—
Differential capacitance between CAN_H and CAN_L in coiled cable	C_{d2}	pF	560	—	—
Input capacitance between CAN_H and ground, CAN_L and ground in coiled cable	C_{i2}	pF	700	—	—
Bus capacitance in coiled cable[2)]	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[3)]	R_{i12}	MΩ	—	—	30
Insulation resistance between CAN_H and CAN_L in coiled cable[3)]	R_{i22}	MΩ	—	—	30
Cable length in towed vehicle	l_3	m	—	18	—
Differential capacitance between CAN_H and CAN_L in towed vehicle	C_{d3}	pF	900	—	—
Input capacitance between CAN_H and ground, CAN_L and ground in towed vehicle	C_{i3}	pF	900	—	—
Bus capacitance in towed vehicle[2)]	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[3)]	R_{i13}	MΩ	—	—	12
Insulation resistance between CAN_H and CAN_L in towed vehicle[3)]	R_{i23}	MΩ	—	—	12

1) $l = l_1 + l_2 + l_3$

2) 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}.

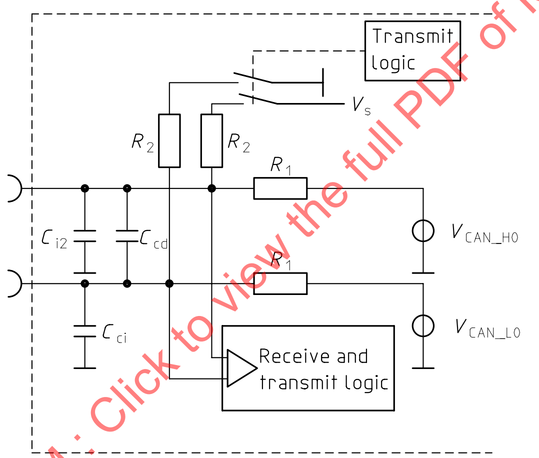
3) Test method similar to ISO 8092-2.

Table 2 — Contact parameters

Parameter	Notation	Unit	Value		
			nominal	max.	min.
Contact resistance	R_{con}	mΩ	—	10	—
Insulation resistance between CAN_H and CAN_L[2)]	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[2)]	R_{i2}	MΩ	—	—	50
Input capacitance between CAN_H/CAN_L and ground	C_{ci}	pF	5	—	—
Capacitive load of the connector[1)]	C_{con}	pF	—	20	—

1) The capacitive load for the driving circuit resulting from the connector is: $C_{con} = C_{ci} + 2\ C_{cd}$

2) According to ISO 8092-2.



NOTE — V_{CAN_H0} = Voltage source of CAN_H for recessive state, value (see 5.4.2.1).

V_{CAN_L0} = Voltage source of CAN_L for recessive state, value (see 5.4.2.1).

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

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.

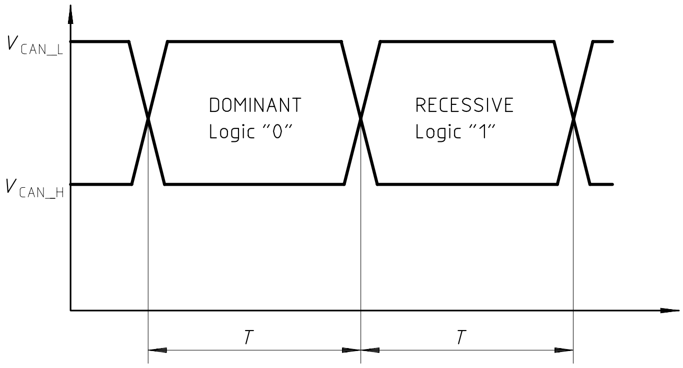


Figure 3 — Specification of "dominant" and "recessive" state of CAN_H and CAN_L

5.4.2.2 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 as in 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. If internal protection circuits (such as filters) are used, V_{CAN_H} and V_{CAN_L} shall fulfil the specified requirements of tables 6 and 7. 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, defined 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	Voltage		
			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	Voltage		
			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	Notation	Unit	Voltage	
			min.	max.
Ground offset between the two interfaces during two-wire operation[1)]	V_{os}	V	$-V_s/8$	$V_s/8$
Ground offset between the two interfaces during one-wire operation[1)]	V_{os}	V	$-V_s/16$	$V_s/16$
1) The ground offset V_{os} is related to the supply voltage of the interface of the towing vehicle.				

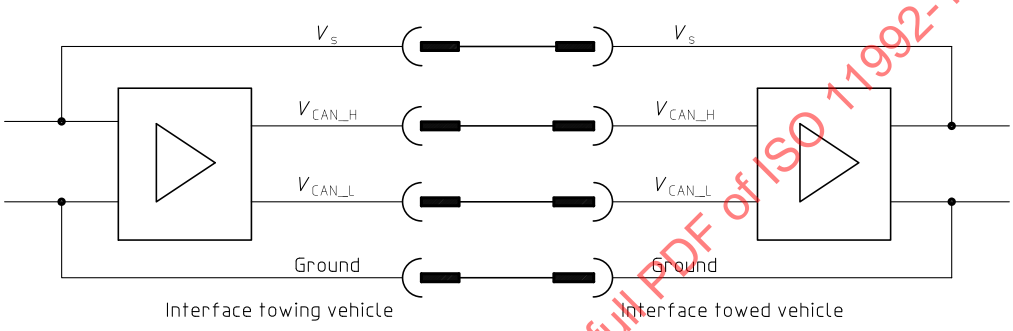


Figure 4 — Specification of V_s

5.4.2.3 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 at "recessive" state

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Voltage level (data link disconnected)	V_{CAN_H}	V	$0{,}32V_s$	$0{,}33V_s$	$0{,}35V_s$
	V_{CAN_L}	V	$0{,}65V_s$	$0{,}67V_s$	$0{,}68V_s$
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[1)]	I_{CAN_H}	mA	—	0	—
	I_{CAN_L}	mA	—	0	—
1) With the two connectors mated.					

Table 7 — d.c. parameters at "dominant" state

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Voltage level[1)]	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	$V_{diff\text{-}th}$		−0,65	—	0
Current through connector for the whole range of V_s[2)]	I_{CAN_H}	mA	—	13,3	—
	I_{CAN_L}			(6,6)	
Serial resistance[3)]	R_2	Ω	285	300	315

1) Two interfaces coupled with the connector, only one transmits.

2) Two interfaces coupled. The value within brackets applies to 12 V nominal voltage systems; those without brackets apply to 24 V nominal voltage systems.

3) Including the serial resistance of the switch (compare with figure 2).

5.4.2.4 a.c. parameters

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

5.4.3 Bus failure management

Transient errors (e.g. according to ISO 7637) are automatically handled by the CAN protocol as specified in ISO 11898.

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

Failure handling depends on the shortest nominal transmission repetition time t_r for all messages transmitted by the interface (as in ISO 11992-2 or 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.

Table 8 — a.c. parameters

Parameter	Notation	Unit	Value		
			min.	nominal	max.
Bit time without synchronisation (logical)	t	µs	7,9992	8,0	8,0008
Internal signal delay time [1]	t_{del}	µs	—	—	0,4
Sample point [2]	t	µs	6 + t_{sjw}	—	7
Input capacitance of one interface [3]	C_i		—	400	—
Differential input capacitance [4]	C_d	pF	—	100	—
Bus input capacitance [5]	C_{bus}		—	600	800
Time constant of supply filter [6]	t_F	ms	—	—	5

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

2) See 5.5.2.

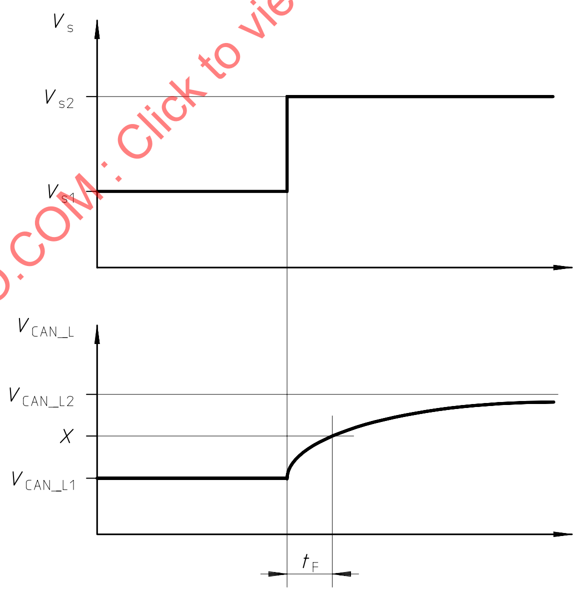
3) Capacitance between CAN_H and ground, CAN_L and ground, with the connector disconnected, see figure 2.

4) Capacitance between CAN_H and CAN_L with the connector disconnected.

5) The capacitive load for the driving circuit resulting from the electronic unit is $C_{bus} = C_i + 2\,C_d$.

measured with disconnected connector.

6) See figure 5.



$X = V_{CAN\_L1} + 0{,}63 \times (V_{CAN\_L2} - V_{CAN\_L1})$

Figure 5 — Example of time constant t_F

Several open and short failures can occur that may influence operation. These are shown in figure 6. An electrical circuit shall be provided to avoid a total breakdown of the data transmission during bus failures. This circuit shall allow to change from the two-wire-operation mode to a 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).

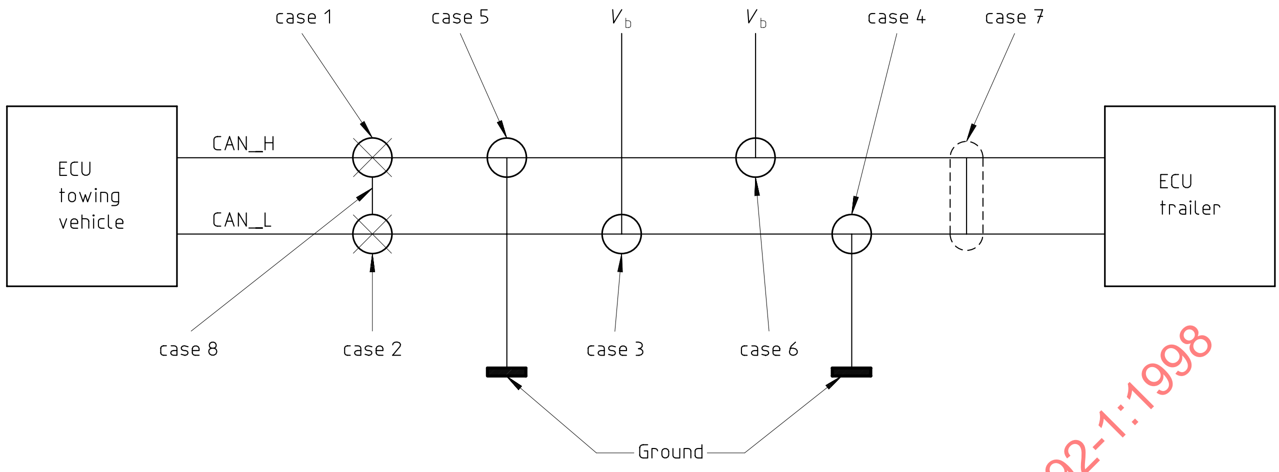


Figure 6 — Bus failures

5.4.3.1 Fault detection and handling

If correct data transmission is not possible for longer than 5t_r (data neither correctly received nor transmitted), then a fault logic shall indicate this and perform the fault handling procedure described below. The fault detection and the fault handling may be realised 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 the cases 1, 3 and 5 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 is 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 the cases 2, 4, 6 and 7 of figure 6.

Depending on the special fault, only one of the two modes allows successful data transmissions. This mode is called the "correct one-wire-operation mode". It might 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 is 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 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 the 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(s) used.

An example of the timing diagram for bus failure case 6 is shown in figure 7.

5.4.3.2 Fault recovery

When an interface works 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 transmission is successful during this test period data, 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.

5.4.4 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.

5.5 Physical signalling

5.5.1 Physical signalling/physical medium attachment interface

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

5.5.2 Physical signalling sublayer

The physical signalling sublayer 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 %.

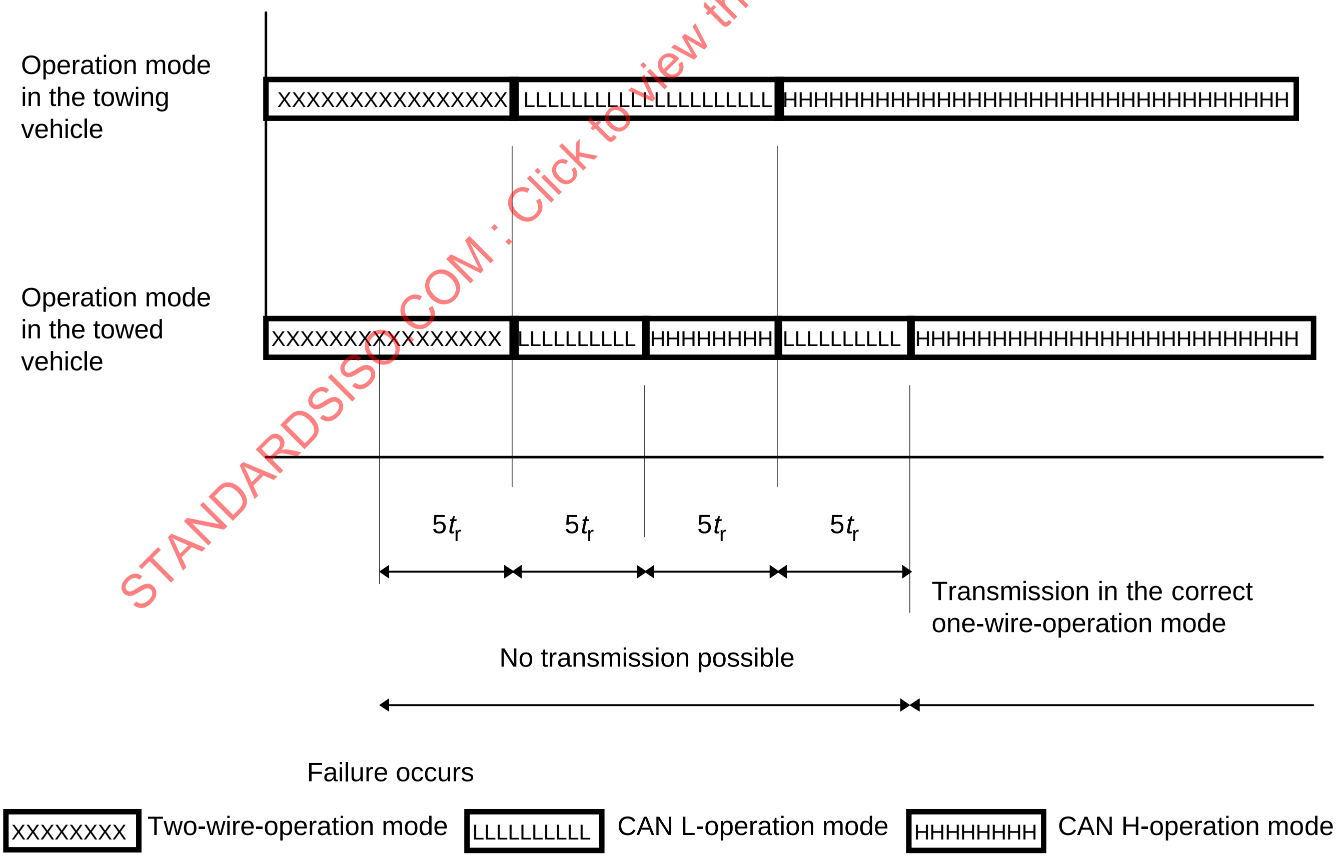


Figure 7 — Example of timing diagram for bus failure case 6

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 less than or equal to 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.

5.5.3 Data link layer/physical layer interface

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

6 Conformance tests

6.1 General

The conformance tests specify measurement methods, including the appropriate test circuits, to check 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 at 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 the measuring equipment.

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

6.2 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.

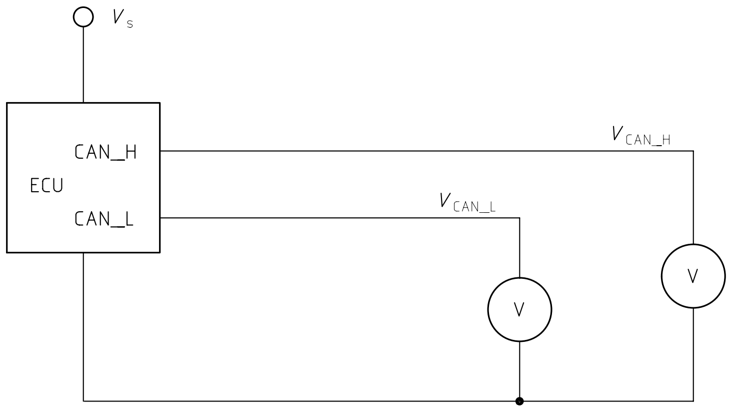


Figure 8 — Measurements of the output voltage in recessive state

6.3 Input resistance R_1

The input resistance 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 using following equation.

$$R_1 = \frac{R_{test}(V_{CAN\_L,H} - V)}{V - V_{test}}$$

where V_{CAN_L} and V_{CAN_H} are the recessive output voltage in 6.2.

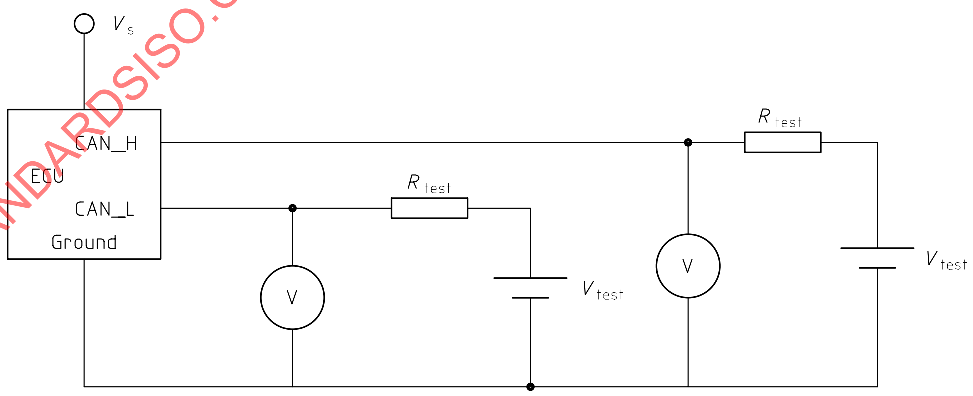


Figure 9 — Measurements of the input resistance during recessive state

6.4 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 value and to the test supply voltage.

When the dominant voltages, the recessive voltages of 6.2 and the input resistances of 6.3 are within the range specified, the value of the serial resistance R_2 is correct.

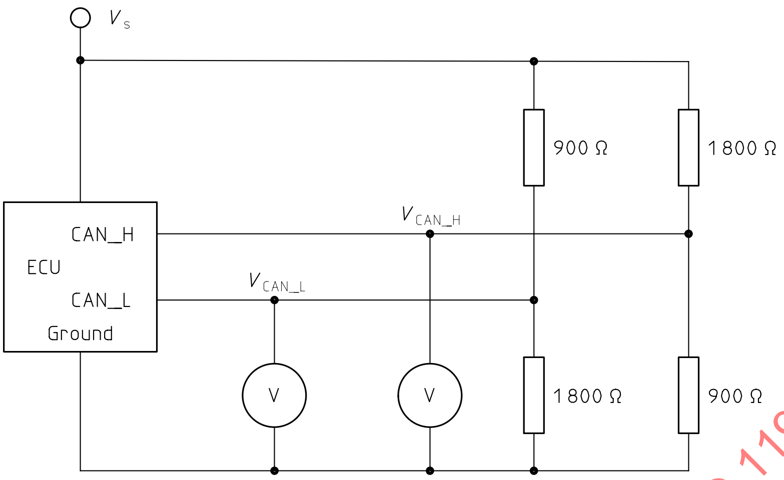


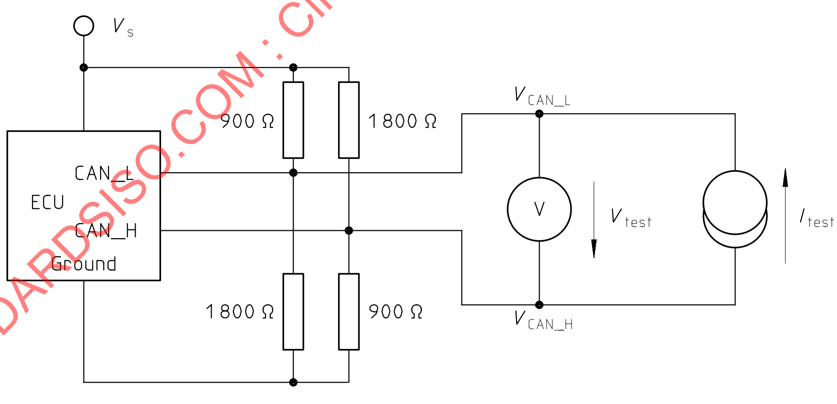
Figure 10 — Measurements of the output voltage in the dominant state

6.5 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 greater than or equal to 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.



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

Figure 11 — Measurement of the receive threshold for recessive bits

6.6 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 (i.e. more negative) than 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.

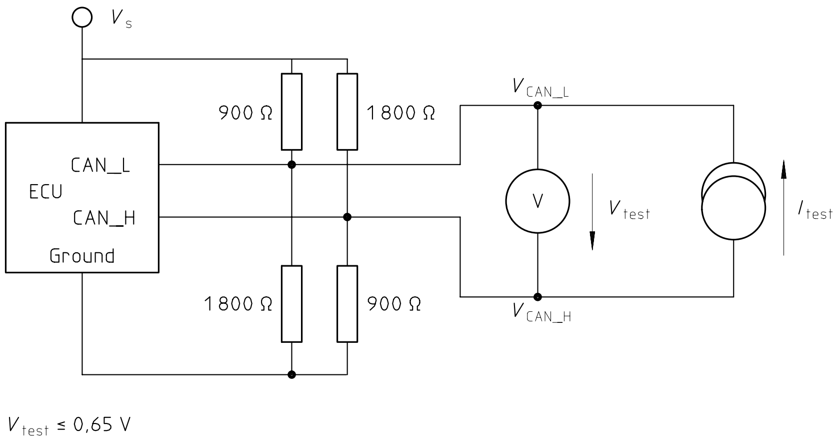


Figure 12 — Measurement of the receive threshold for dominant bits

6.7 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 are transmitting messages.

Case a: offset voltage V_{os} at the ECU

See figure 13.

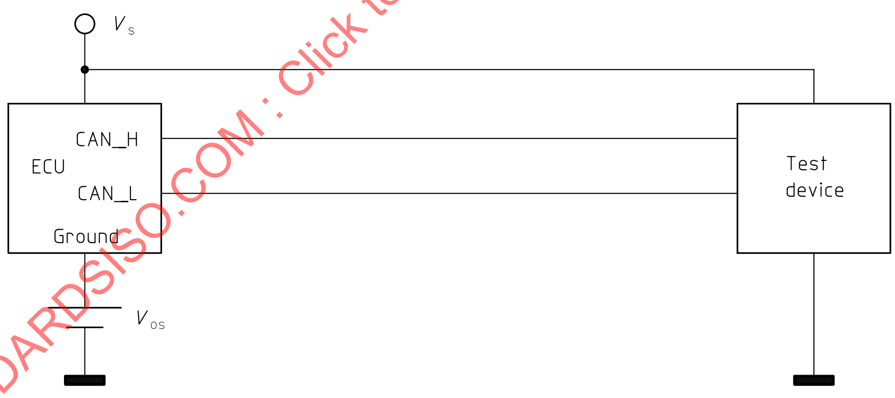


Figure 13 — Measurement of the offset voltage, case a

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

See figure 14.