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**Passenger Cars Physical Layer
Technical Specification of CAN Bus**

乘用车 CAN 总线物理层技术要求

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Passenger Cars Physical Layer Technical Specification of CAN Bus

1 Scope

This Standard specifies the terms and definitions of the physical layer of the high-speed CAN bus, the general requirements of the physical layer, technical requirements of physical layer signaling, high-speed media access unit, and bus failure management.

This Standard is applicable to high-speed CAN buses with communication rate from 125Kbit/s to 1Mbit/s.

2 Terms and Definitions

The following terms and definitions are applicable to this document.

2.1 Controller area network; CAN

A network communication technology for road vehicles.

2.2 Bus

A network communication topology that all nodes access to the network through a two-way transmission mode.

2.3 Bus state

One of two opposite logical states: explicit or implicit.

2.4 Physical layer

The electrical circuit (bus comparator and bus driver) that connects the CAN nodes to the bus; it consists of three parts, namely, analog circuit, digital circuit and analog signal on the CAN bus, and digital signal interface circuit inside the CAN node.

NOTE: The maximum number of nodes allowed to connect on the CAN bus depends on the electrical load of the CAN bus.

2.5 Physical media (of the bus)

A pair of shielded or unshielded twisted pair cables for signal transmission.

Differential voltage of CAN bus, $V_{\text{diff}} = V_{\text{CAN_H}} - V_{\text{CAN_L}}$.

2.16 Internal capacitance (of a CAN node), C_{in}

The capacitance measured under CAN_L (or CAN_H) in the implicit state, when the CAN node is disconnected from the bus.

2.17 Internal delay time (of a CAN node), T_{node}

The sum of all asynchronous delays that occur during the transmission or reception; it is related to the bit time logic unit of each node integrated circuit.

2.18 Internal resistance (of a CAN node), R_{in}

The resistance measured under CAN_L (or CAN_H) in the implicit state, when the CAN node is disconnected from the bus.

2.19 Supply voltage, V_{cc}

The voltage supplied to the bus transmitter, receiver, and optional split termination in the normal operating mode.

2.20 Split termination voltage, V_{split}

The output voltage of split termination of CAN node relative to the signal ground of the module.

2.21 Propagation time, t_{prop}

The time from a transmission data input edge of the medial access unit to a corresponding reception data output edge.

2.22 Wake-up frame

A CAN data frame used to wake-up one or more CAN nodes.

2.23 Wake-up filter time, t_{wake}

The explicit signal duration that can force the CAN node to wake up on the buses of CAN_H and CAN_L.

2.24 Activity filter time, t_{filter}

The duration of the explicit and implicit levels on the buses of CAN_H and CAN_L, which is used to monitor whether the activity on the CAN bus is effective.

2.25 Transceiver

The physical layer shall provide services for exchanging data bits between two peer media to access control sublayers; which include physical layer signaling data requests and physical layer signaling data indications.

The physical layer signaling data request service is sent from media access control sublayer to the physical layer, requesting the transmission of an explicit or implicit bit.

The physical layer signaling data indication service is sent from physical layer to the media access sublayer, indicating the arrival of an explicit or implicit bit.

3.3 Interface between physical layer signaling and physical media attachment

3.3.1 Message from physical layer signaling to the physical media attachment

When the physical layer signaling receives a signal from the physical media accessories, the physical layer signaling shall send an explicit or implicit output message to the physical media attachment.

When physical layer signaling receives a bus close request, the physical layer signaling shall send a bus close message to the physical media attachment.

When physical layer signaling receives the bus close and release request, the physical layer signaling shall send a bus close and release message to the physical media attachment.

3.3.2 Message from physical media attachment to physical layer signaling

When the media access unit receives a bit from the media; the physical media attachment shall send an input message to the physical layer signaling. Such input message represents the arrival of an explicit or implicit bit to the physical layer signaling.

4 Physical Layer Signaling

4.1 Bit encoding and decoding

4.1.1 Bit time

The bus management functions realized within one-bit time, including CAN node synchronization, network transmission delay compensation, sampling point positioning, all of which shall be performed in accordance with programmable bit timing logic; such logic is given by the CAN integrated circuit.

The nominal bit time is divided into 4 non-overlapping time segments, as shown in Figure 2:

- a) Only one synchronization (between two sampling points) is allowed in one bit time.
- b) Only when testing the bus state of the previous sampling point is different from the bus state behind the sampling point edge, the implicit to explicit trip edge can be used for synchronization.
- c) When the implicit to explicit trip edge occurs during the frame interval, the hard synchronization shall be performed (except for the first bit interval).
- d) All other implicit to explicit trip edge that satisfy the rules of a) and b) shall be applied to resynchronization. Except for the following cases, when the implicit to explicit trip edge has a positive phase error, the node sending explicit bit shall not perform resynchronization.

4.2.2 Phase error of synchronization edge

The phase error of synchronization edge, e , is related to the synchronization segment; which is measured with time slice as the unit. The sign definition of phase error is as follows:

- a) When the trip edge falls within the synchronization segment, $e = 0$;
- b) When the trip edge falls before the sampling point, $e > 0$;
- c) When the trip edge falls behind the sampling point, $e < 0$.

4.2.3 Hard synchronization

After hard synchronization, the bit timing logic unit shall restart the bit time from the synchronization segment. Therefore, the hard synchronization shall force the trip edge that caused the hard synchronization to be within the synchronization segment that starts to restart the bit time.

4.2.4 Resynchronization

When the phase error amplitude of the trip edge that causes the resynchronization is less than or equal to the setting value of the resynchronization jump width, the resynchronization shall lengthen or shorten the bit time to ensure the correct sampling point position. When the phase error amplitude is greater than the resynchronization jump width:

- If the phaser error, e , is positive, then phase buffer segment 1 shall be increased the value equal to the resynchronization jump width;
- If the phaser error, e , is negative, then the phase buffer segment 2 shall be shortened the value equal to the resynchronization jump width.

6.1.3 Wake-up to exit the low power mode

When it is in the low power mode, physical layer shall monitor the CAN_H and CAN_L of the CAN bus for wakeup. When the bus appears one or more consecutive explicate bus level that can last for at least t_{wake} time; and when separated by an implicate bus level, then the bus wakeup shall be performed.

6.1.4 Power-off node system

In order not to affect the CAN communication system, for the actively powered off node (e.g.: ignition key control module), the power-off node shall not affect the bus level as much as possible, when other nodes remain the normal communication. The transceiver shall produce the lowest leakage current to the bus that is still communicating.

Based on the application objectives, the node that is continuously powered shall allow the maximum leakage current parameter defined in Table 13; and the node that is temporarily unpowered shall minimize the leakage current as much as possible.

6.2 Electrical technical requirements

6.2.1 Physical media attachment

In the operating condition of each CAN node, it shall satisfy the parameters specified in Table 12 ~ Table 15.

Table 12 – Bus Voltage Parameters in Low Power Mode

Parameter	Sign	Unit	Value			Condition
			Min.	Nominal	Max.	
Bus common mode voltage	$V_{\text{CAN,H}}$	V	—	0	12.0	Measured at each CAN node
	$V_{\text{CAN,L}}$	V	−12.0	0	—	
Bus differential voltage ^a	V_{diff}	mV	−120	0	12	Measured at the CAN node connected with bus

^a Bus differential voltage shall be jointly determined by the output characteristics of all CAN nodes in the implicate state; thus, V_{diff} is close to 0, see Table 17.

Table 13 – Bus Input Leakage Current

Parameter	Sign	Unit	Value			Condition
			Min.	Nominal	Max.	
Input leakage current	$I_{\text{CAN,H}}$	μA	0	—	250 ^a	$U_{\text{BUS}} = 5 \text{ V}, U_{\text{Supply}} = 0 \text{ V}$
	$I_{\text{CAN,L}}$	μA	0	—	250 ^a	

^a In the case of power off, when other devices in the same network continue to maintain the communication, the maximum leakage current of the power-off device shall be as low as possible; see 6.1.4; the recommended leakage current is less than 25 μA .

Table 20 – AC Parameters of CAN Node Disconnected from Bus

Parameter	Sign	Unit	Value			Condition
			Min.	Nominal	Max.	
Bit time	t_B	μ	1	—	—	*
Propagation time ^b	t_{prop}	ns	—	—	255	Load in normal operating mode $R_L = 120\ \Omega, C_L = 100\ \text{PF}$ $C_{RSD} = 15\text{PF}, F_{TXD} = 250\ \text{KHZ}$
In the explicate bus, wake-up filter time	t_{wake}	μ	0.5	—	5 ^c	In low power mode, load $R_L = 120\ \Omega$, Common mould voltage U see Table 12
Internal capacitance	C_{in}	pF	—	20	—	1 Mbit/s ^d

Table 20 – Continued

Parameter	Sign	Unit	Value			Condition
			Min.	Nominal	Max.	
Internal differential capacitance	C_{diff} ^e	pF	—	10	—	1 Mbit/s

^a The maximum bit rate corresponding to the minimum bit time is 1Mbit/s.
^b When there is sender/receiver read interface, such parameter can be measured directly. In the integrated CAN nodes, such parameter shall be measured indirectly.
^c The maximum filter time shall affect wake-up message length, especially in the high baud rates.
^d CAN_H and CAN_L are measured to ground.
^e In addition to the internal capacitance limit, the inductance of the bus connection shall be as small as possible. The minimum C_{in} and C_{diff} can be 0. The maximum value of capacitance shall be determined by the bit time and network topology parameter of L and d , see Table 10 in details. When the harness reflection wave generated by the CAN node doesn't cause the explicate differential level lower than $V_{diff} = 0.9V$; and doesn't cause the explicate differential level greater than $V_{diff} = 0.5V$ (see Table 17 and Table 19); can the normal function be realized.

6.2.3 Technical requirements of medial attachment interface and connector

The Parameters of connector that connect the CAN node to the node on the bus shall be the same as that of Table 7.

6.2.4 Physical media

The technical requirements of physical media attachments are as specified in 5.2.5.

7 High-Speed Media Access Unit with Selective Wake-up Function

7.1 Electrical technical requirements

7.1.1 Physical media attachment

The technical requirements of physical media attachment are as specified in 5.2.2 and 6.2.1.

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