CAN in AUTOMATION

CiA Draft Standard 102 Version 2.0

CAN Physical Layer for Industrial Applications

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Two-Wire Differential Transmission

1. Scope

The scope of this document is, to define the content of the physical layer and the basic characteristics of the physical medium, for communication according to the Controller Area Network protocol specification (CAN) between different types of electronic modules in general industrial applications. CAN is a serial communication protocol supporting distributed real-time control and multiplexing. This part refers to using a differentially driven two-wire bus line with common return as physical medium.

2. References

/1/ Controller Area Network protocol specification, Version 2.0
Robert Bosch GmbH 1991

/2/ ISO 7498: 1984, Information processing systems - Open systems interconnection - Basic reference model

/3/ ISO 11898: 1992, Road vehicles - Interchange of digital information - Controller area network (CAN) for high-speed communication

/4/ D-Sub connector specification (DIN 41652 or corresponding international standard)

/5/ CAN in Automation, Working Group Physical Layer,
Protocol of the 2nd Meeting on 16.Jun.1992

3. Definitions

See /3/.

4. Basic Concepts of CAN

See /3/.

5. Layered Architecture of CAN

See /2/, /3/.

6. Description of the Medium Access Unit

6.1 Physical Medium Attachment Sublayer Specification (Transceiver)

See /3/. The maximum rating for V_{CAN_H} and V_{CAN_L} is +16V.
Galvanic isolation between the bus nodes is optional.

6.2 Medium Dependent Interface Specification (Bus connector)

6.2.1 Electrical Parameters

See /3/.
The output voltage at pin 9 (external positive supply) shall be +7 V < V+ < +13 V at an output current of up to 100 mA (current consumption of module). Modules are not allowed to source current into this pin.
Note: The electrical parameters for pin 9 (V+) refer to the proposal of the working group "Physical Layer". They are not yet agreed upon by the General Assembly of CAN in Automation.

6.2.2 Mechanical Parameters

The connector used to plug electronic modules to the bus line is a 9-pin D-Sub connector according to /4/. Its pinning is fixed as follows

Pin	Signal	Description
1	-	Reserved
2	CAN_L	CAN_L bus line (dominant low)
3	CAN_GND	CAN Ground
4	-	Reserved
5	(CAN_SHLD)	Optional CAN Shield
6	(GND)	Optional CAN Ground
7	CAN_H	CAN_H bus line (dominant high)
8	-	Reserved (error line)
9	(CAN_V+)	Optional CAN external positive supply (dedicated for supply of transceiver and optocouplers, if galvanic isolation of the bus nodes applies)

Each bus node has to provide a male connector, meeting the above-mentioned specification.
Within the modules, pin 3 and pin 6 have to be interconnected.
Inside of such electronic modules providing two bus connections, and inside the T-connectors, all the pins (including the reserved ones) have to be connected. The intention is, that there shall be no interruption of any of the wires in the bus cable, assuming a possible future specification of the use of the reserved pins.
By using the pin V+ for supplying transceivers in case of galvanical isolation, the necessity of an extra local power isolation (e.g. DC/DC-converter) is avoided.
If an error line is needed within a system, then pin 8 shall be used for this purpose.

6.3 Physical Medium Specification (Bus line)

The physical medium is a two-wire bus line with common return being terminated at both ends by resistors representing the characteristic impedance of the line. Its maximum length is 1 km. It is allowed to use bridge-devices or repeaters to increase the number of bus nodes which may be connected, or to increase the allowed distance between the bus nodes (to e.g. more than 1 km), or to provide galvanic isolation (a bridge-device contains at least two CAN-controllers and two transceivers). The bus wires may be routed parallel, twisted and/or shielded, depending on EMC requirements. The wiring topology should be as close as possible to a single line structure, in order to minimize reflections. The cable stubs for connection of the bus nodes should be as short as possible, especially at high bit rates. At 1Mbit/s, the length of the cable stubs should not exceed 0.3 m (see /3/).
The ground inputs of all transceivers are interconnected. The parameters

- Specific resistance per length unit
- Length
- Current
- Location of the power supply input

should be chosen in a way, that the difference between the ground potentials of the transceivers does not exceed 2V. If necessary, galvanic isolation has to be applied, to reduce the current through the ground line. In general, it is advantageous to locate the power supply input in the center of the bus line.

6.3.1 Electrical Specification

See /3/. At bus line length greater than 40 m, the specific resistance of the bus cable should be lower than the value given in /3/. The recommendations included in /5/ should be taken into account.

6.3.2 Implementation Concepts

There are two basic concepts how to implement the bus line.

6.3.2.1 Interconnected Bus Line Sections

The bus line consists of a number of sections which are interconnected. Two options are allowed.

Option A: A T-connector (1) is used to interconnect the bus line sections and the bus node.
Option B: Electronic modules provide two bus connectors, interconnecting the bus line sections.

Option	A	B
Bus node	1x male	1x male, 1x female
T-connector (1)	1x male, 2x female	not required
Bus line section	1x male, 1x female	1x male, 1x female

Note (1): A T-connector is a passive device for connecting three different connectors. This has to be distinguished from the "T-CANnector" concept of the CAN Textile Users Group.

6.3.2.2 Undivided Bus Line

The bus line consists of a single cable without interconnecting devices.

Bus node 1x male
Bus line: one female connector per bus node, plus 1x female, 1x male for termination

6.3.3 Bus Line Termination Networks

The bus line is terminated at both ends using extra connectors containing the termination resistors. For mechanical parameters see paragraph 'Medium Dependent Interface Specification'.

Termination network 1 1x male124 Ω typ. between pin 2 and pin 7
Termination network 2 1x female 124 Ω typ. between pin 2 and pin 7

6.4 Bit Rates

Every module has to support a bit rate of 20 kbit/s (50 μs per bit).
Recommended bit rates are:

Bit Rate	Nominal Bit Time	Remarks
1 Mbit/s	1 μs	max. 40 m
800 kBit/s	1.25 μs	
500 kbit/s	2 μs	
250 kbit/s	4 μs	
125 kbit/s	8 μs	
(100 kbit/s)	(10 μs)	(1)
50 kbit/s	20 μs	max. 1 km
20 kbit/s	50 μs	has to be supported by all modules
10 kbit/s	100 μs	min. bit rate

(1) Not recommend for new developments.

A module shall support as many of the recommended bit rates as possible. It is not required, that a module has to support all recommended bit rates.