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Part 2: Physical layer.

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Introduction

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 11783-2

Tractors and machinery for agriculture and forestry — Serial control and communications data network —

Part 2: Physical layer

*Tracteurs et matériels agricoles et forestiers — Réseaux de
commande et de communication de données en série —*

Partie 2: Couche physique

ICS: 65.060.01; 35.240.68

ISO/TC 23/SC 19

Secretariat: DIN

Voting begins on:
2025-07-21

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2025-10-13

This document is circulated as received from the committee secretariat.

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. The different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

This third edition cancels and replaces the third edition (ISO 11783-2:2019), which has been technically revised. It also incorporates the Technical Corrigendum ISO 11783-2:2012/Cor 1:2012. The main changes compared to the previous edition are as follows:

- inclusion of physical layer aspects previously listed in other documents of the ISO 11783 series;
- addition of a twisted pair physical layer;
- updates to parameters of the physical layer components to reflect the current state of art;
- updates to test criteria to verify the conformance of implementations to this document.

A list of all the parts in the ISO 11783 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

ISO 11783-1 to ISO 11783-14 specify a communications system for agricultural equipment based on the ISO 11898^[1] protocol. SAE J1939 documents, on which parts of ISO 11783 are based, were developed jointly for use in truck and bus applications and for construction and agricultural applications. Joint documents were completed to allow electronic units that meet the truck and bus SAE J1939 specifications to be used by agricultural and forestry equipment with minimal changes. General information on the ISO 11783 series is to be found in ISO 11783-1.

Tractors and machinery for agriculture and forestry — Serial control and communications data network —

Part 2: Physical layer

1 Scope

This document specifies the physical layer of a network segment based on CAN classic as specified in ISO 11898-2 (high-speed physical medium attachment sublayer) and in ISO 11898-1 (physical coding sublayer). The bit rate is 250 kbit/s. This document covers two physical medium-dependent sublayer solutions: a) un-shielded, twisted quad-cable and b) un-shielded, twisted-pair cable.

NOTE Where not differently specified, requirements are valid for both twisted quad physical layer (TQPL) and twisted pair physical layer (TPPL).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1724, *Road vehicles — Connectors for the electrical connection of towing and towed vehicles — 7-pole connector type 12 N (normal) for vehicles with 12 V nominal supply voltage*

ISO 11783-1, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 1: General standard for mobile data communication*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11783-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

ECU Type I

electronic control unit without internal termination.

3.2

ECU Type I WEAK

electronic control unit with a weak split termination centrally coupled to ECU_GND with a capacitor and that is used for stubs only.

3.3

ECU Type II

electronic control unit with internal termination circuit.

3.4**internal delay time**

the sum of all asynchronous delays that occur along the transmission and reception path within the ECU, relative to the bit timing logic unit of the CAN implementation (see [A.2](#)).

3.5**twisted pair physical layer****TPPL**

250 kbit/s, unshielded, twisted pair cable-based network layer intended to be used as an alternate to the twisted quad physical layer and that is backward compatible with machines based on a twisted quad physical layer.

3.6**machine**

forestry or agricultural tractor or mounted, semi-mounted, towed or self-propelled implement.

3.7**network segment**

single CAN network using a linear topology configuration with short stubs.

3.8**twisted quad physical layer****TQPL**

250 kbit/s, unshielded, twisted quad cable-based network layer.

4 Abbreviated terms

IBBC Implement Bus Breakaway Connector

IBBP Implement Bus Breakaway Plug

5 General requirements**5.1 Network physical layer**

The physical coding sublayer shall comply with the CAN CC requirements as given in ISO 11898-1:2024 (Clause 7); it is implemented in CAN protocol controller units using a non-return-to-zero (NRZ) coding. The physical medium attachment (PMA) sublayer shall comply with the requirements for high-speed PMA entities supporting bit rates up to 1 Mbit/s as given in ISO 11898-2:2024 (see [Table 15](#) in particular); it is implemented in so-called high-speed (HS) CAN transceiver units.

The physical medium-dependent (PMD) sublayer is specified in the following subclauses. This includes requirements for the ECU designer: [5.5](#), [5.6](#), [7.1.2](#), [7.1.3.5](#), [7.1.3.5](#).

The requirements for network designers are given in: [5.2](#), [5.3](#), [5.4](#), [6](#), [7.1.3.1](#), [7.1.3.2](#), [7.1.3.3](#), [7.1.3.4](#), [7.1.4](#), [7.2](#), [7.3](#), [7.4](#), [7.5](#), [7.6](#), [7.7](#).

5.2 Physical media

This document defines two types of physical media.

- a) TQPL: shall be composed by four conductors, two of them, designated CAN_H and CAN_L, are driven with the communication signals. The names of the ECU pins corresponding to these conductors are also designated CAN_H and CAN_L. The third and fourth conductors, designated TBC_PWR and TBC_RTN, provide power for the terminating bias circuits (TBCs) on the network segment.
- b) TPPL: shall be composed by a twisted pair cable as described in SAE J1939-15. The conductors, designated CAN_H and CAN_L, are driven with the MDI as specified in ISO 11898-2. The names of the ECU pins corresponding to these conductors are also designated CAN_H and CAN_L.

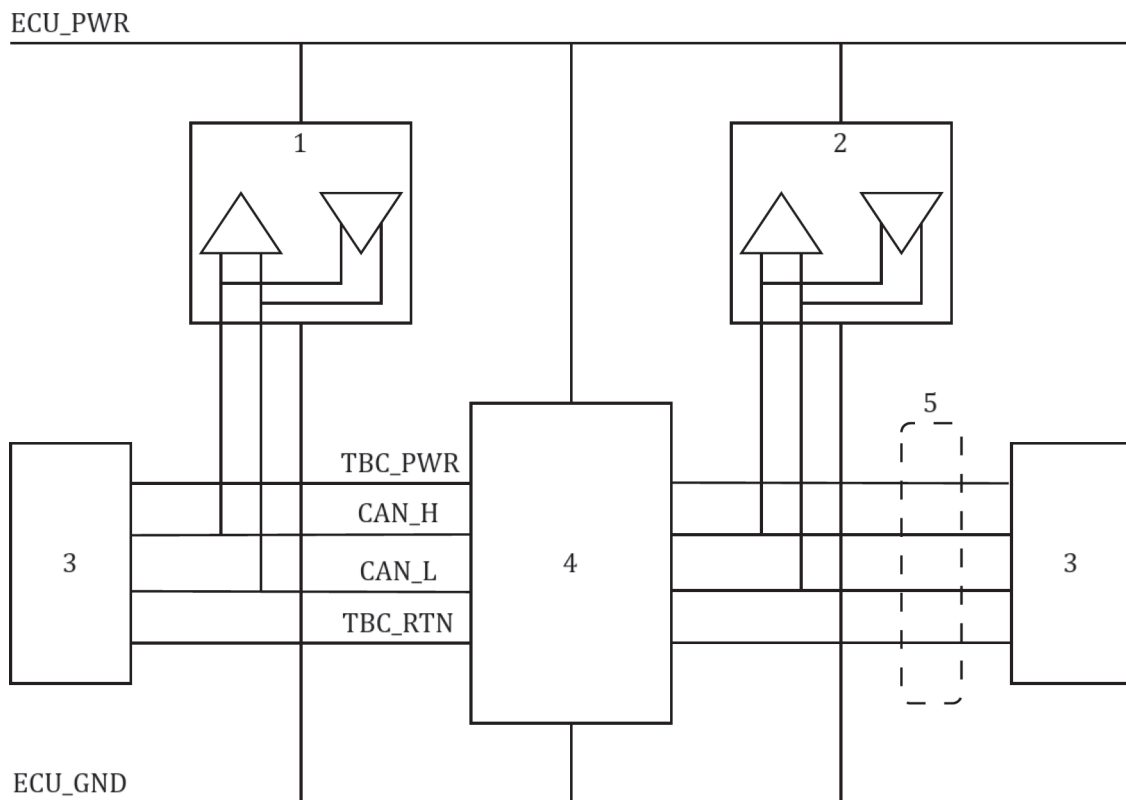
5.3 PMA sublayer requirements

The PMA sublayer, implemented in transceiver chips or system base chips, for example, shall comply with ISO 11898-2.

5.4 Termination circuit

5.4.1 Twisted quad network segment

The bus signal lines of a twisted quad network segment shall be electrically terminated at each end by a terminating bias circuit. When a node CAN driver is on, a current (I) flow is induced that is either sunk by the CAN_H termination or is sourced by the CAN_L termination. This TBC shall be located outside the ECU housing, to ensure bus bias and termination when the ECU is disconnected (see [Figure 1](#)).



Key

- 1 ECU no. 1
- 2 ECU no. n
- 3 terminating bias circuit (TBC)
- 4 power for TBC_PWR and TBC_RTN
- 5 twisted quad cable

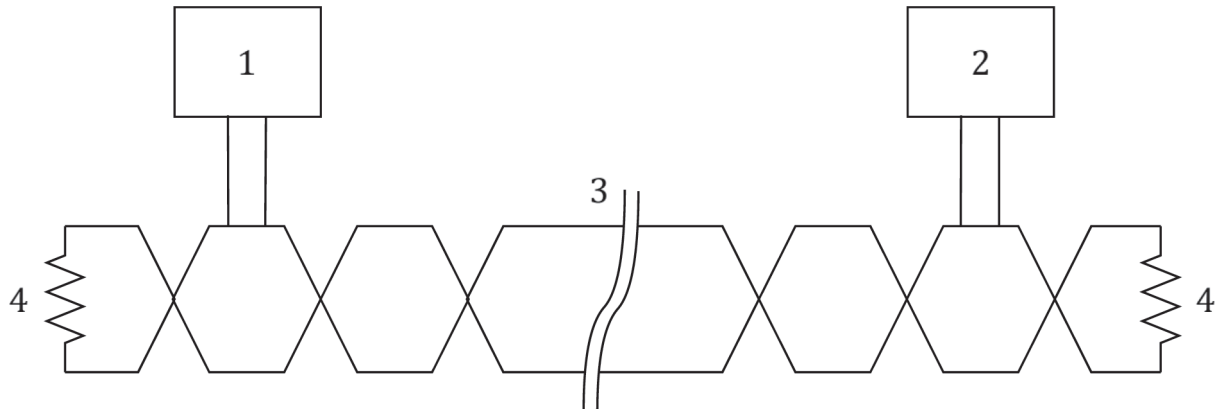
Figure 1 — Physical layer functional diagram

5.4.2 Twisted pair physical layer network segment

The bus signal lines of a TPPL network segment shall be electrically terminated at each end with a passive termination circuit (see [Table 18](#)).

If a Type II ECU is used for terminating the network segment, that ECU shall contain the bus termination circuit (see [Figure 3](#)).

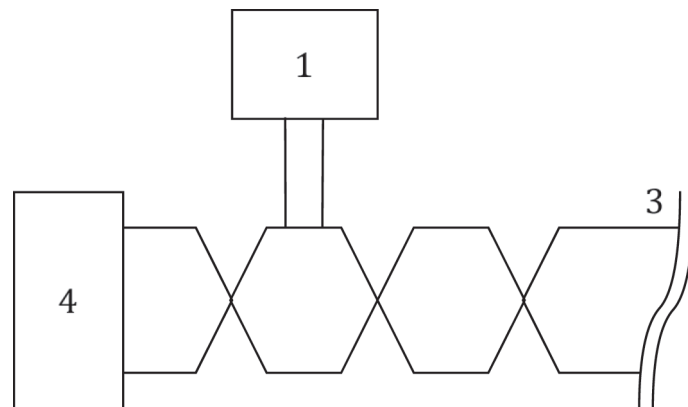
The system designer should take care that the network segment is terminated at one or both ends. Type II ECUs shall be marked. A Type II ECU shall only be used at one or both ends of a bus, even when the machine is attached to another machine by an IBBC. Type II ECUs shall only be powered by ECU_PWR/ECU_GND.



Key

- 1 ECU Type I No. 1
- 2 ECU Type I No. n
- 3 unshielded twisted pair
- 4 terminating resistors R_L

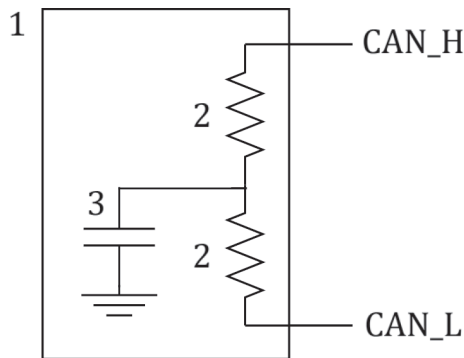
Figure 2 — TPPL passive termination circuitry by using single resistors at each end of the network segment



Key

- 1 ECU Type I
- 2 ECU Type II with internal R_L
- 3 unshielded twisted pair

Figure 3 — TPPL passive termination circuit (one side) by using an ECU Type II as a termination

**Key**

- 1 ECU Type II or passive bus termination
- 2 resistor $R_{L/2}$
- 3 coupling capacitor C_L

Figure 4 — TPPL passive termination circuit (one side) by using a split termination

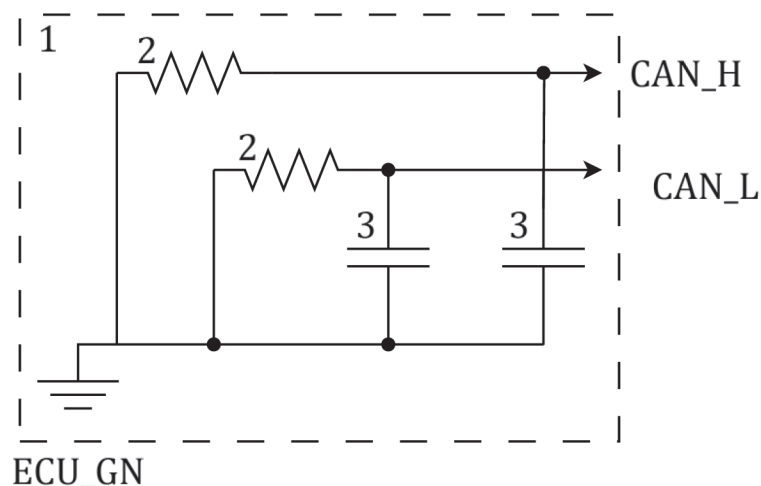
5.5 Resistance and capacitance

5.5.1 Internal resistance (R_{in}), internal capacitance (C_{in})

The internal resistance, R_{in} , of an ECU is defined as the resistance between CAN_H or CAN_L and ground (ECU_GND) in the recessive state, with the ECU disconnected from the bus signal line. The measurement shall be made with the ECU both powered and unpowered, and the minimum value used to confirm compliance.

The internal capacitance, C_{in} , of an ECU is defined as the internal capacitance between CAN_H or CAN_L and ECU_GND during the recessive state, with the ECU disconnected from the bus signal line. The measurement shall be made with the ECU both powered and unpowered, and the maximum value used to confirm compliance.

[Figure 5](#) shows the equivalent circuit of internal resistance and internal capacitance of an ECU.

**Key**

- 1 ECU
- 2 internal resistance R_{in}
- 3 internal capacitance C_{in}

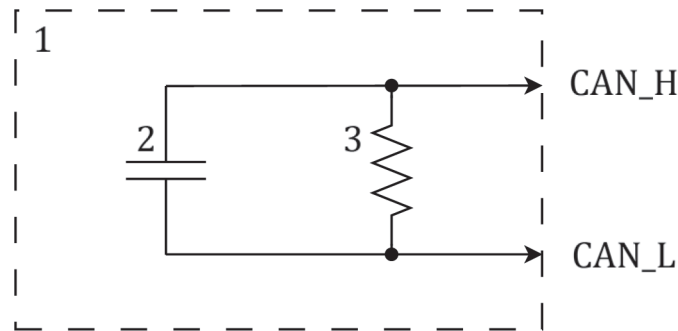
Figure 5 — Internal resistance and internal capacitance of ECU in recessive state

5.5.2 Differential internal resistance (R_{diff}), differential internal capacitance (C_{diff})

The differential internal resistance, R_{diff} , is defined as the resistance seen between CAN_H and CAN_L in the recessive state, with the ECU disconnected from the bus signal line. The measurement shall be made with the ECU both powered and unpowered, and the minimum value used to confirm compliance.

The differential internal capacitance, C_{diff} , of an ECU is defined as the capacitance seen between CAN_H and CAN_L during the recessive state, with the ECU disconnected from the bus signal lines (see [Figure 6](#)). The measurement shall be made with the ECU both powered and unpowered, and the maximum value used to confirm compliance.

[Figure 6](#) shows the equivalent circuit of differential internal resistance and differential internal capacitance of an ECU



Key

- | | |
|---|---|
| 1 | ECU |
| 2 | differential internal capacitance C_{diff} |
| 3 | differential internal resistance R_{diff} |

Figure 6 — Differential internal resistance and capacitance of ECU in recessive state

5.5.3 Weak termination for stubs

For higher immunity and better EMC performance, TPPL nodes which are connected to the bus may be realized by using ECU Type I WEAK equipped with a split-termination configuration. Where an ECU Type I WEAK is used, the termination should be realized by a split-termination of minimum $750\ \Omega + 750\ \Omega$ with a 47 nF capacitor coupled with ECU_GND. The total number of ECUs Type I WEAK used on a single network segment shall not exceed three units.

With reference to 7.6.3.7, where an ECU is powered by the PWR/GND circuit, the split termination of an ECU Type I WEAK shall be coupled with GND.

5.6 Bit time requirements

Bus management functions executed within this duration, such as protocol controller synchronization, network transmission delay compensation and sample point positioning, are defined by the programmable bit timing logic of the CAN protocol-controller integrated circuit (IC).

Bit rate shall be 250 kbit/s, resulting in a Bit time of 4 μs .

Additionally, the following settings shall be configured:

- single sample point method as defined in ISO 11898-1;
- sample point at 80 % $\pm$ 3 % of the bit time.

See [Annex A](#) for more information on protocol timing and naming, and a detailed description of bit timing.

5.7 AC parameters

[Table 1](#) defines the AC parameters for an ECU disconnected from the bus. The timing parameters also apply for an ECU connected to a network segment.

Table 1 — AC parameters of a node disconnected from the bus

Parameter	Symbol	Min.	Nom.	Max.	Unit	Condition
Bit time	t_B	3,998	4,000	4,002	μs	250 kbit/s
Transition time	t_T	—	—	500	ns	Measured from 10 % to 90 % of the voltage of the prevailing state
Internal delay time	t_{ECU}	0,0	—	0,9	μs	None
Internal capacitance single ended	C_{in}	0	—	200	pF	1 MHz
Differential internal capacitance	C_{diff}	0	—	100	pF	1 MHz
Common mode rejection	CMR	40	—	—	dB	DC to 50 kHz
	$\text{CMR}_{5\text{MHz}}$	10	—	—	dB	5 MHz may linearly decrease between 50 kHz and 5 MHz

6 Network segment requirements

6.1 Twisted quad network segment

A linear twisted quad network segment shall be terminated at each end by a TBC (see [Figure 1](#) and [7.5](#)). The TBC provides the electrical bias and common mode termination needed to suppress reflections.

The network segment is in the recessive state if the transmitters of all nodes are switched off, with the mean voltage being generated by the TBCs. A dominant voltage level is sent to the bus signal lines if the transmitter of at least one of the nodes is switched on. This induces a current through each side of the TBCs, with the consequence that a differential voltage is produced between the CAN_H and CAN_L lines.

6.2 TPPL network segment

A linear TPPL network segment shall be terminated at each end by a passive termination circuit (see [5.4.2](#)) to suppress reflections.

The network segment is in the recessive state if the transmitters of all nodes are switched off. A dominant bit is sent to the bus signal lines if the transmitter of at least one of the nodes is switched on so that a differential voltage is produced between the CAN_H and CAN_L lines.

7 Electrical requirements

7.1 Electrical data

7.1.1 General requirements

ECUs shall comply with parameters specified in [Table 1](#), [Table 2](#), [Table 7](#), [Table 8](#), [Table 9](#) and [Table 10](#) throughout their operating temperature range.

7.1.2 ECU DC voltages

[Table 2](#) specifies the absolute maximum DC voltages which can be connected to the bus signal lines without damage to transceivers. Although the connection is not guaranteed to operate at these conditions, there is no time limit (operating CAN controllers go “error passive” after a period of time).

Table 2 — Limits of V_{CAN_H} and V_{CAN_L} of bus-disconnected ECU

Parameter	Symbol	Minimum	Maximum	Unit	Conditions
Maximum DC voltage	V_{CAN_H} V_{CAN_L}	-16,0	+16,0	V	12 V nominal supply voltage

7.1.3 Power supply DC parameters

7.1.3.1 Architecture power supply DC voltages

[Table 3](#) specifies limits of power supply operating ranges when the nominal supply voltage is 12 V when considering the entire architecture.

Table 3 — Limits of power supply operating ranges

Parameter	Symbol	Minimum	Maximum	Unit	Conditions
Voltage operating range	V_{PWR} V_{ECU_PWR}	+10,0	+16,0	V	12 V nominal supply voltage

7.1.3.2 Architecture power supply minimum currents

[Table 4](#) specifies the minimum current capacity available from the ECU_PWR and PWR lines when considering the entire architecture.

Table 4 — Power supply minimum currents

Parameter	Symbol	Minimum	Unit
Current capacity	I_{PWR}	50	A
	I_{ECU_PWR}	15	A

7.1.3.3 Requirements for DC voltage supplied by tractor through the IBBC

Electrical power on the tractor is supplied by the 12 V supply and alternator system to various electrical loads on the tractor and implement. While the system voltage is regulated at the alternator terminals, electrical loads that are connected through long electrical wires can experience a voltage drop due to resistance of the supply and return wires. If this voltage drop becomes excessive, the electrical load can function improperly. To ensure that the tractor can adequately supply electrical power to the implement, the following voltage requirements apply at the IBBC/TPPL-BC electrical supply terminals.

The minimum current available from the tractor implement bus ECU_PWR/ECU_GND circuit shall be 15A under conditions specified in [Table 5](#).

Table 5 — ECU_PWR limits at tractor IBBC/TPPL-BCs

Parameter	Symbol	Min	Max	Unit
ECU power line voltage	V_{ECU_DIFF}	10,5	16,0	V
Conditions for measurement: — $V_{ECU_DIFF} = V_{ECU_PWR} - V_{ECU_GND}$ — Measured at tractor IBBC/TPPL-BC terminals — 15A DC electrical load — Engine at normal operating min ⁻¹ range (as defined by manufacturer) — Tractor electrical loads on (lights, fans, etc.)				

The minimum current available from the tractor implement bus PWR/GND circuit shall be 50 A under the conditions specified in [Table 6](#).

Table 6 — PWR limits at tractor IBBC/TPPL-BCs

Power line voltage	Min	Max	Unit
$V_{\text{PWR}} - V_{\text{GND}}$	10,5	16,0	V
Conditions for measurement: — Measured at tractor IBBC/TPPL-BC terminals — 50A DC electrical load — Engine at normal operating min^{-1} range (as defined by manufacturer) — Tractor electrical loads on (lights, fans, etc.)			

Maximum simultaneous combined current shall not exceed 55 A (continuous current), in order to prolong component life-time and prevent damage.

7.1.3.4 Requirements for DC voltage drop on implements

Electrical power on an implement is supplied by the PWR and ECU_PWR circuits through the IBBC.

The implement may provide a rear IBBC receptacle to allow daisy chain connection of additional implements that acts like electrical loads.

In case of a daisy chain connection, if the voltage drops due to the resistance of supply and return leads on an implement is too high, the following implement may experience an insufficient operating voltage for correct operation. To avoid such a situation, and to ensure that an implement can adequately supply electrical power to the following one, the maximum allowed voltage drop on an implement shall be in accordance to [Table 7](#) and the implement minimum supplied currents shall be in accordance to [7.1.3.2](#).

Table 7 — Maximum allowed voltage drop in an implement

Power lines voltage	Min	Max	Unit
Implement voltage drop on ECU_PWR/ECU_GND circuit ^a	—	1,5	V
Implement voltage drop on PWR/GND circuit ^b	—	1,5	V
^a 15 A provided at the implement rear IBBC. ^b 50 A provided at the implement rear IBBC. Conditions for measurement (see Figure 7): — Measured between implement plug and implement rear IBBC — Any load on the implement under test shall be disconnected — 1,5 V is the total drop of both power supply and return path			

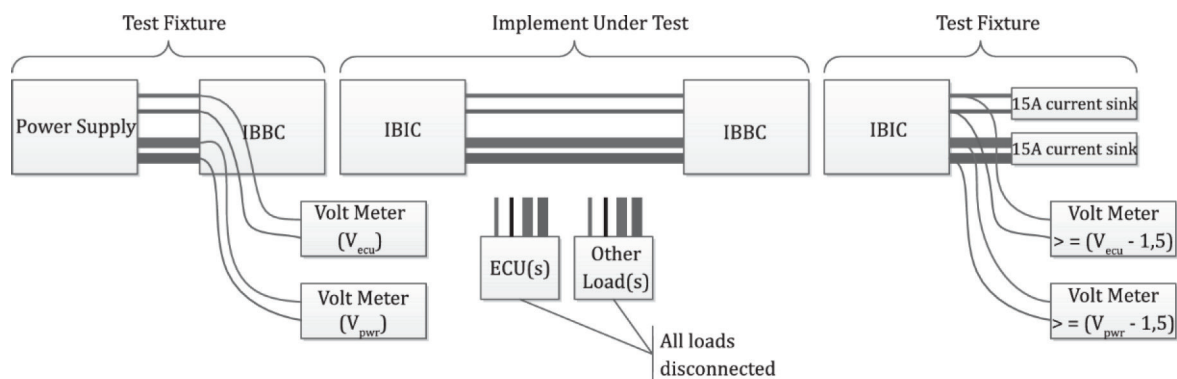


Figure 7 — Voltage-drop measurement

7.1.3.5 Bus-disconnected ECU

The DC parameters for the recessive state of the CAN interface of a powered ECU disconnected from the bus are specified in [Table 8](#).

Table 8 — DC parameters for recessive state of bus-disconnected ECUs

Parameter	Symbol	Min.	Nom.	Max.	Unit
Bus voltage output behaviour	V_{CAN_H} V_{CAN_L}	2,0	2,5	3,0	V
Differential output voltage behaviour	V_{diff}	−1 200	—	50	mV
Differential internal resistance (Type I ECU only) ^g	R_{diff}	2	—	100	kΩ
Internal resistance (Type I ECU only) ^g	R_{in}	5	—	50	kΩ
Internal resistance match	—	−5	—	5	%
Input differential voltage detected as recessive	V_{diff_IR}	−1,0	—	0,5	V

The DC parameters for the dominant state of the CAN interface of an ECU disconnected from the bus are specified in [Table 9](#).

Table 9 — DC parameters for dominant state of bus-disconnected ECUs

Parameter	Symbol	Min.	Max.	Unit
Bus voltage	V_{CAN_H}	2,75	5,0	V
	V_{CAN_L}	0,0	2,25	
Differential output voltage	V_{diff_OD}	1,5	3,0	
Differential voltage detected as dominant	V_{diff_ID}	1,0	5,0	

7.1.3.6 Bus-connected ECU

The DC parameters for the recessive state of the CAN interface of an ECU connected to a network segment and other ECUs is specified in [Table 10](#).

Table 10 — DC parameters (bus voltage) for bus-connected ECUs in recessive state, without faults

Parameter	Symbol	Min.	Max.	Unit	Conditions
Bus voltage	V_{CAN_H} V_{CAN_L}	0,1	4,5	V	Measured with respect to ground of each ECU
Differential bus voltage	V_{diff_R}	−1 200	50	mV	Measured at each ECU connected to bus signal lines

The DC parameters for the dominant state of the CAN interface of an ECU connected to a network segment and other ECUs is specified in [Table 11](#).

Table 11 — DC parameters (bus voltage) for bus-connected ECUs in dominant state, without faults

Parameter	Symbol	Min.	Max.	Unit	Conditions
Bus voltage	V_{CAN_H}	—	7,0	V	Measured with respect to ground of each ECU
	V_{CAN_L}	−2,0	—		
Differential bus voltage	V_{diff}	1,2	3,0	V	Measured at each ECU connected to bus signal lines
			5,0		During arbitration

7.1.4 Bus voltages (operational)

The bus voltage parameters specified in [Table 11](#) apply when all ECUs (from 2 to 30) are connected to a terminated network segment (see [5.4](#)). The maximum expected ground offset between ECUs or ECUs and TBCs on the bus is 2 V.

7.2 Physical media parameters

7.2.1 Unshielded twisted quad cable

[Table 12 Table 1](#) specifies the physical media parameters for the twisted quad cable (see [Figure 9](#))

Table 12 — Physical media parameters for twisted quad cable

Parameter	Symbol	Min.	Max.	Unit	Conditions
Impedance	Z_H Z_L	70	80	Ω	Measured at 1 MHz between either signal line and ground with TBC_PWR and TBC_RTN grounded
Specific resistance	R_b	0	50	m Ω /m	Measured at 20 °C
Specific line delay	T_p	—	—	ns/m	
Specific capacitance	C_b	0	75	pF/m	Between CAN_H and CAN_L
	C_a	0	110	pF/m	Between adjacent conductors
Conductor size	A_c	—	—	mm ²	Cross-section to be formed from 16 or greater strands of 32 AWG tinned or bare copper.
Conductor twist	—	48	52	mm/turn	
Temperature range	T	−40	+85	°C	Continuous operation without degradation

[Table 13](#) recommends colours for the insulation of the wires in the cable. A detailed description of the wires colour should be included in the manufacturer's instruction handbook.

Table 13 — Recommended colours for conductor insulation

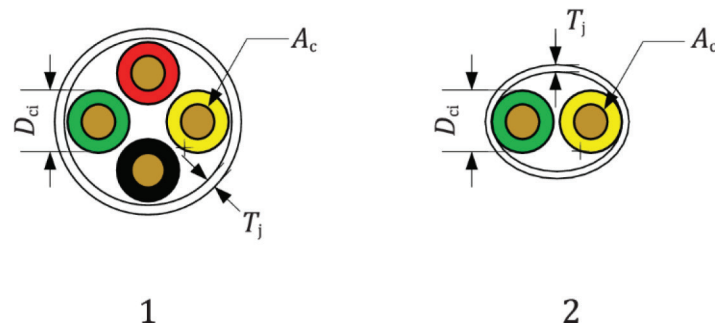
Colour	Conductor insulation
Red	TBC_PWR
Yellow	CAN_H
Black	TBC_RTN
Green	CAN_L

7.2.2 Unshielded twisted pair

[Table 14](#) specifies the physical media parameters for unshielded twisted pair cable (see [Figure 8](#))

Table 14 — Physical media parameters for twisted pair cable

Parameter	Symbol	Min.	Nom.	Max.	Unit	Conditions
Impedance	Z	108	120	132	Ω	Three-meter sample length measured at 1 MHz between the two signal wires, using open/short method.
Specific resistance	R_b	—	25	50	m Ω /m	Measured at 20 °C
Specific line delay	T_p	—	5,0	—	ns/m	
Specific capacitance	C_b	—	40	75	pF/m	Between CAN_H and CAN_L
Conductor size	A_c	—	0,5	—	mm ²	Cross-section to be formed from 7 or more strands of tinned or bare copper. Conductor construction depends on the use case.
Conductor insulation diameter	D_{ci}	2,0	2,11	3,05	mm	Depends on the environmental sealing application, the used connectors and its contact-sealing. Design engineers should ensure compatibility between cables/wires, connectors and contacts.
Conductor twist	—	24	—	52	mm/turn	—
Jacket size	T_j	—	—	—	mm	
Temperature range	T	-40	—	+85	°C	

**Key**

- 1 unshielded twisted quad
- 2 unshielded twisted pair
- A_c conductor size
- D_{ci} conductor insulation diameter
- T_j jacket size

Figure 8 — Cable cross-section

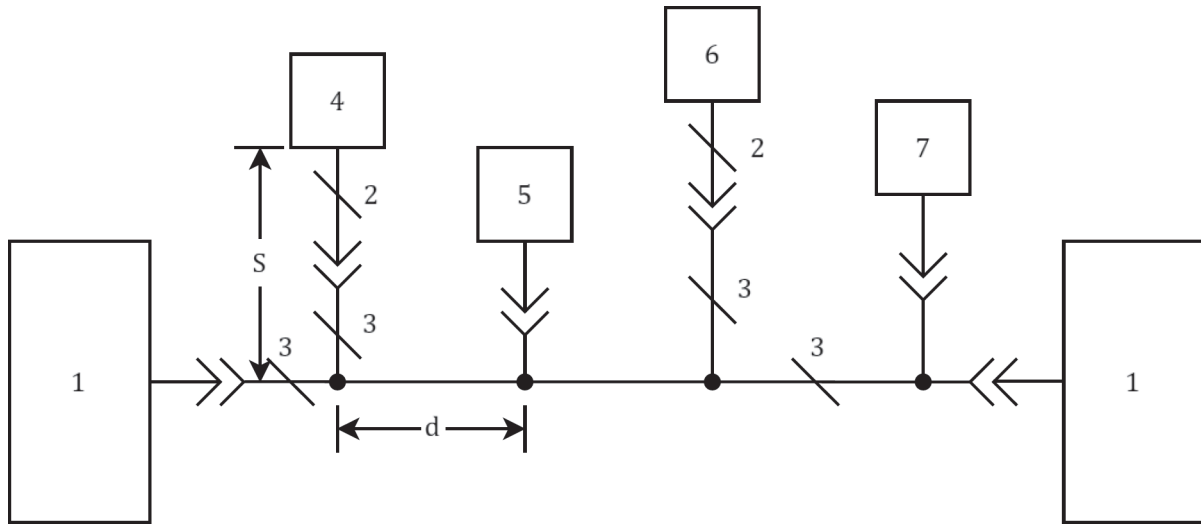
The bus line consists of CAN_H and CAN_L conductors. CAN_H conductor wire jacket should be yellow while the CAN_L conductor wire jacket should be green (see [Figure 8](#) — Cable cross-section and [Table 15](#)).

Table 15 — Recommended colours for conductor insulation

Colour	Conductor insulation
Yellow	CAN_H
Green	CAN_L

7.3 Topology of twisted quad physical layers

To avoid cable reflections, the wiring of a network segment should have a bus line topology with short stubs (see [Figure 10](#)). To minimize standing waves, nodes should have different distances (d) on the network segment and stub lengths should have different lengths (S). The dimensional parameters of this topology as shown in [Figure 10](#) are specified in [Table 16](#).



Key

- 1 terminating bias circuit (TBC)
- 2 2 wires, CAN_H and CAN_L
- 3 twisted quad cable
- 4 ECU 1
- 5 ECU 2
- 6 ECU $n-1$
- 7 ECU n
- d distance between two nodes (see [Table 16](#))
- S^b stub length (see [Table 16](#))

Figure 9 — Topology of bus-segment wiring

Table 16 — Topology dimensional parameters

Parameter	Symbol	Min.	Max	Unit	Conditions
Bus length	l_{bus}	-	40	m	Not including stubs
Stub length	S	0	1	m	—
Node distance	d	0,1	-	m	Random

NOTE Consider not to cluster nodes.

7.3.1 ECU connection to TBC_PWR and TBC_RTN

To sense the status of the network, each ECU on the bus may provide a pin for TBC_PWR and TBC_RTN. Loading limits are specified in [Table 17](#).

Table 17 — ECU loading of TBC_PWR and TBC_RTN

Parameter	Symbol	Min.	Max.	Unit	Conditions
DC resistance	R_{TBC_PWR}	30	—	k Ω	Measured between TBC_PWR and any other signal in ECU
	R_{TBC_RTN}	30	—	k Ω	Measured between TBC_RTN and any other signal in ECU
Capacitance	C_{TBC_PWR}	—	200	nF	Measured at 1 MHz between TBC_PWR and any other signal in ECU
	C_{TBC_RTN}	—	200	nF	Measured at 1 MHz between TBC_RTN and any other signal in ECU

7.3.2 Power for TBC_PWR and TBC_RTN

TBC_PWR and TBC_RTN for a given network segment shall be supplied at a single point. This single connection point shall comply with the requirements specified in [Table 17](#). Filtering and regulation can be provided within the module providing this interconnection (see [Annex B](#)).

7.4 Topology of twisted pair physical layer

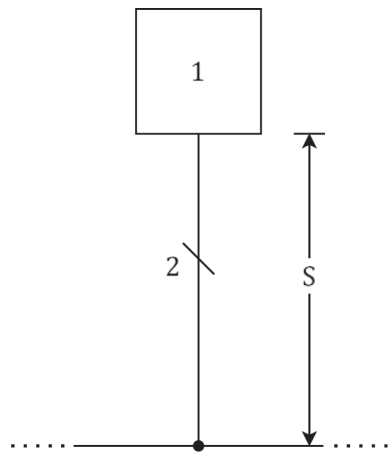
7.4.1 General specifications

The main topology shall be the same as the TQPL (see [7.3](#)). The ECUs may be connected to the network segment by the following subclauses.

The minimum distance between two stubs/splices shall be 50 cm.

7.4.2 Single stub

The single stub is intended to connect one single ECU to the network segment. The maximum stub length shall be 3,0 m, see [Figure 10](#).



Key

- 1 ECU
- 2 2 wires, CAN_H and CAN_L
- S stub length

Figure 10 — Single stub