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

Part 4: Network layer

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

Partie 4: Couche réseau

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 11783-4 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

ISO 11783 consists of the following parts, under the general title *Tractors and machinery for agriculture and forestry — Serial control and communications data network*:

— *Part 1: General standard for mobile data communication*

— *Part 2: Physical layer*

— *Part 3: Data link layer*

— *Part 4: Network layer*

— *Part 5: Network management*

— *Part 6: Virtual terminal*

— *Part 7: Implement messages application layer*

— *Part 8: Power train messages*

— *Part 9: Tractor ECU*

— *Part 10: Task controller and management information system data interchange*

— *Part 11: Data dictionary*

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Introduction

Parts 1 to 11 of ISO 11783 specify a communications system for agricultural equipment based on the CAN 2.0 B [1] protocol. SAE J 1939 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 J 1939 specifications to be used by agricultural and forestry equipment with minimal changes. This part of ISO 11783 is harmonized with SAE J 1939/31 [2]. General information on ISO 11783 is to be found in ISO 11783-1.

The purpose of ISO 11783 is to provide an open interconnected system for on-board electronic systems. It is intended to enable electronic control units (ECUs) to communicate with each other, providing a standardized system.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this part of ISO 11783 may involve the use of a patent concerning the controller area network (CAN) protocol referred to throughout the document.

ISO takes no position concerning the evidence, validity and scope of this patent.

The holder of this patent right has assured ISO that he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from:

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Attention is drawn to the possibility that some of the elements of this part of ISO 11783 may be the subject of patent rights other than those identified above. ISO shall not be held responsible for identifying any or all such patent rights.

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

Part 4: Network layer

1 Scope

This part of ISO 11783 specifies a serial data network for control and communications on forestry or agricultural tractors and mounted, semi-mounted, towed or self-propelled implements. Its purpose is to standardize the method and format of transfer of data between sensor, actuators, control elements, and information-storage and -display units, whether mounted on, or part of, the tractor or implement. This part of ISO 11783 describes the network layer, which defines the requirements and services needed for communication between electronic control units (ECUs) in different segments of the ISO 11783 network. The various types of network interconnection unit are defined in this part of ISO 11783.

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2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 11783. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 11783 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 11783-3:1998, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 3: Data link layer*

ISO 11783-5, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 5: Network management*

1) To be published.

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3 Description

3.1 Role of the network interconnection unit

3.1.1 Message transfer

3.1.1.1 General

When multiple segments exist in a network, the network interconnection unit provides the means of transferring messages from one segment to another. The unit transfers individual message frames between two or more nodes, of which there is one per segment.

3.1.1.2 Depending on its type (see 3.2 and clause 6), the interconnection unit can perform one or more of the following message-transfer tasks:

— forwarding (5.1)

— filtering (5.2)

— address translation (5.3)

— repackaging (5.4).

3.1.1.3 There are three main performance criteria for determining the suitability of a network interconnection unit for a given application.

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a) Maximum number of messages guaranteed to be forwarded per second: if exceeded due to average or peak bus loads, messages can be lost.

b) Maximum number of messages guaranteed to be filtered per second: if exceeded due to the number of entries in the database, messages can be excessively delayed.

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c) Maximum transit delay: used to determine the worst-case latency for a message transmitted by one ECU and received by another ECU in another bus segment.

3.1.2 Database management

The network interconnection unit can also support bridge and database management (5.5), enabling access to, and configuration of, internal databases within the interconnection unit itself.

EXAMPLE Although a bridge separates two media segments and the message traffic on each, the network will still be considered a single network in terms of its address space and identifiers, thanks to the communication made possible by the interconnection unit.

3.1.3 Other network layer functions

Network interconnection units can perform other functions beyond those defined in this part of ISO 11783, as provided by the supplier or as dictated by the network configuration. ISO 11783-1 gives examples of these other functions.

3.2 Role of the network layer

The main role of the network layer is management of the transfer of messages between segments. The network layer includes a number of different types of network interconnection unit, which, depending on the functions required, can provide these services:

— the repeater forwards the messages (6.1);

— the bridge (6.2) filters messages and manages the message-filter database;

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— the router (6.3) uses address translation to enable a network segment to appear as a single ECU to other parts of the network;

— the gateway (6.4) repackages parameters into different messages for easier transfer, reception and interpretation by ECUs;

— a special network interconnection unit, the tractor ECU, connects the implement and tractor buses on a tractor or self-propelled implement (see Figure 1, 4.1.3 and ISO 11783-9 [4]).

As well as these message-transfer functions, the network layer gives access to, and allows configuration of databases within, the network interconnection unit (3.1.2, 5.5, and ISO 11783-1).

NOTE The network interconnection unit can also participate in the address-claim procedure on behalf of ECUs in a subnetwork (ISO 11783-5). However, because the use of a router or gateway for interfacing with a proprietary subnetwork is application-dependent, it is not defined in ISO 11783. Specific implementations may be developed by the component manufacturer, subsystem supplier or the OEM (original equipment manufacturer).

Figure 1 illustrates the topology of a typical network in agriculture and forestry that uses serial control and communications data network interconnection units. The maximum number of nodes per implement is specified in ISO 11783-1.

4 Requirements

4.1 Network interconnection unit

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4.1.1 General requirements

4.1.1.1 The network interconnection unit shall provide guaranteed filtering and forwarding rates.

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4.1.1.2 It shall not exceed the maximum transit-delay values.

4.1.1.3 In order to avoid excessive delays, the order in which a frame is received on one node and transmitted to another shall follow its given priority.

4.1.1.4 The network interconnection unit shall forward messages having a higher priority before forwarding those of a lower priority.

4.1.1.5 It shall forward the messages, according to their given priority, in the same order as they are received.

4.1.1.6 A simple first-in-first-out (FIFO) message queue shall not be used.

4.1.1.7 The network interconnection unit shall not go “bus off” when forwarding an address-claimed message or when contention occurs.

4.1.2 General recommendations

4.1.2.1 The network interconnection unit should provide the capability to read and modify the filter database.

4.1.2.2 It should support database management by providing standard access for configuration of message forwarding, filtering, address translation and repackaging, as they pertain to bridge, router or gateway management, accordingly.

4.1.2.3 When in operation, the network interconnection unit should be transparent to any ECU on the network.

4.1.2.4 The transport protocol should be used whenever a message length is greater than 8 bytes.

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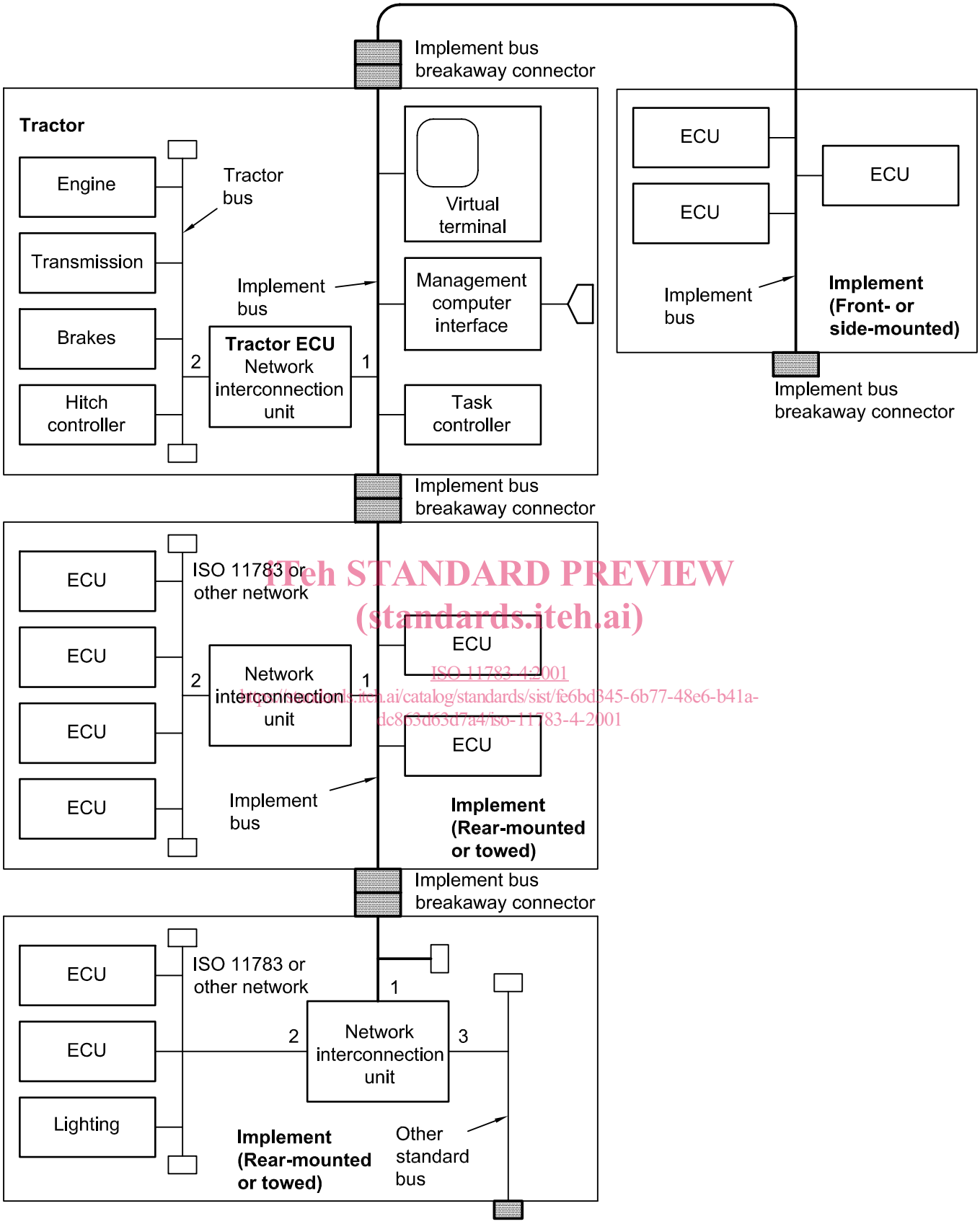

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Figure 1 — Typical ISO 11783 network

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4.1.3 Tractor ECU

There shall be a special type of network interconnection unit, the tractor ECU, located between the tractor's power-train and implement segments, which shall provide isolation and protect the power-train segment. Similar to a gateway, the tractor ECU represents the tractor to any other ECU on the implement network (see Figure 1).

4.2 Network topology

The system network topology (5.5.5) shall be constructed so that there is only one path between ECUs.

NOTE Although this part of ISO 11783 does not require that network loops be detected or duplicate messages be prevented from being generated or replicated indefinitely, it is the responsibility of the OEM to ensure there are no loops in the network. Redundant bus segments for fault tolerance can be used, but the provision of mechanisms for detecting, selecting and automatically reconfiguring the message routing path is the responsibility of the network interconnection unit supplier.

4.3 Network addressing

The data link layer of the network (ISO 11783-3) provides for 255 source addresses. The theoretical number of controllers permitted on the network is 254 when the null and global addresses are not used. Where there is no network interconnection unit, the electrical loading on the bus from each ECU can restrict this number.

4.4 Proprietary messages

The network shall allow for proprietary messages to reside directly on the tractor-implement segment. If bus traffic and latency pose a problem, a separate segment should be used to handle these messages. The supplier of this segment and its related ECUs shall provide the router function within one of the ECUs.

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All ECUs on the tractor-implement segment shall support CAN 2.0B [1], which defines 29-bit identifiers.

Subnetworks may support either CAN 2.0B or CAN 2.0A [1] with 11-bit identifiers. However, in these cases, a router or gateway shall exist to selectively permit the transfer of messages between the two segments, and, because ISO 11783 does not utilize 11-bit identifiers, to perform any needed diagnostics on the subnetwork.

OEMs and suppliers are responsible for using such identifiers, as there are no means of assuring the assignment of unique identifiers. A CAN 2.0B 11-bit subnetwork can reside on the same segment as the ISO 11783 network. Nevertheless, bus loading and reliability issues will have to be considered.

5 Network interconnection unit functions

5.1 Forwarding

A network interconnection unit transfers individual message frames between two or more nodes (one node for each network segment). The order of frames received on one node and transmitted on another shall be preserved for a given priority level. A network interconnection unit shall forward all queued messages of a higher priority before those of a lower priority. Otherwise, all messages being forwarded to a specific node could be excessively delayed. A simple FIFO queue shall not be used to meet this requirement.

When a network interconnection unit forwards (6.1 and 6.2) a message to another segment, it uses an address identical to that of the originator of the message. Ordinarily, this will not cause arbitration problems, as the unit will not retransmit the message to the segment it originally came from and, moreover, the addresses are unique on a given ISO 11783 network.

The sole exception is when an address-claim message is forwarded to a segment in which another ECU is simultaneously claiming the same address. In such a low-probability situation, the network interconnection unit shall be able to detect a bus error when transmitting the message and stop the automatic retransmission sequence within the CAN controller chip. Otherwise, the network interconnection unit will experience multiple collisions and go "bus off", thereby preventing other messages from being forwarded until the network interconnection unit is able to recover from the bus off condition.

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