INTERNATIONAL STANDARD

ISO 11783-4

Second edition
2011-12-01

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

Part 4: Network layer

Tracteurs et matériels agricoles et forestiers — Réseaux de commande et de communication de données en série —
Partie 4: Couche réseau

Reference number
ISO 11783-4:2011(E)

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Published in Switzerland

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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 2.

The main task of technical committees is to prepare International Standards. 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.

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

This second edition cancels and replaces the first edition (ISO 11783-4:2001), which has been technically revised.

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: Mobile data element dictionary*
- *Part 12: Diagnostics services*
- *Part 13: File server*
- *Part 14: Sequence control*

Introduction

Parts 1 to 14 of ISO 11783 specify a communications system for agricultural equipment based on ISO 11898-1[1] and ISO 11898-2[2]. SAE J 1939[3] 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[4]. 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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Germany

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.

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

Part 4: Network layer

1 Scope

ISO 11783 as a whole 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 control functions (CFs) in different segments of the ISO 11783 network. The various types of network interconnection units are defined in this part of ISO 11783.

2 Normative references

The following referenced documents are indispensable for the application 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 11783-1, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 1: General standard for mobile data communication*

ISO 11783-2, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 2: Physical layer*

ISO 11783-3, *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*

ISO 11783-7, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 7: Implement messages application layer*

ISO 11783-9, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 9: Tractor ECU*

3 Terms and definitions

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

3.1
address space
allowable range of addresses on a particular subnetwork

NOTE When an NIU separates network segments, the same address can be used by CFs on each side of the NIU.

3.2
connection
establishment of dynamic virtual addresses in an NIU (network interconnection unit) for sending and receiving messages between CFs on different network segments that have different address spaces

3.3
network interconnection unit
NIU
electronic control unit (ECU) used for interconnecting networks or network segments

3.4
port
network segment interface to an NIU

NOTE An NIU has two or more ports connected to different network segments.

3.5
port pair
two ports of an NIU indicating the direction of data flow from one segment to another segment

3.6
transparent
CF which provides services to another CF without it being aware of the source of these services

NOTE The CFs need not be aware there is an NIU connecting the CFs together.

3.7
virtual CF
apparent CF established by an NIU on one network segment using the same NAME of the actual CF on a different network segment

3.8
actual CF
CF established directly by an ECU on the network segment

4 Description

4.1 Role of the network interconnection unit (NIU)

4.1.1 Message transfer

4.1.1.1 General

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

4.1.1.2 Message-transfer tasks

Depending on its type (see 4.2 and Clause 7), the NIU can perform one or more of the following message-transfer tasks:

— forwarding (6.1);

— filtering (6.2);

— address translation (6.3);

— repackaging (6.4).

4.1.1.3 Main performance criteria

There are three main performance criteria for determining the suitability of an NIU for a given application:

a) *maximum number of messages guaranteed to be forwarded per second*: if this number is exceeded due to average or peak bus loads, messages can be lost;

b) *maximum number of messages guaranteed to be filtered per second*: if this number is exceeded due to the number of entries in the database, messages can be excessively delayed;

c) *maximum transit delay*: this is used to determine the worst-case latency for a message transmitted by one CF and received by another CF on another bus segment.

4.1.2 Database management

The NIU can also support bridge and database management (6.6), 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, as a result of the communication made possible by the interconnection unit.

4.1.3 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 provides examples of these other functions.

4.2 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 units which, depending on the functions required, can provide these services:

— the repeater forwards the messages (7.1);

— the bridge (7.2) filters messages and manages the message-filter database;

— the router (7.3) uses address translation to enable a network segment to appear as a single CF to other parts of the network;

— the gateway (7.4) repackages parameters into different messages for easier transfer, reception and interpretation by CFs;

— a special network interconnection unit, the tractor ECU, connects the implement and tractor buses on a tractor or self-propelled implement (see Figure 1, 5.1.3 and ISO 11783-9).

As well as these message-transfer functions, the network layer provides access to, and allows configuration of databases within, the NIU (4.1.2, 6.6 and ISO 11783-1).

NOTE The NIU can also participate in the address-claim procedure on behalf of CFs in a subnetwork (ISO 11783-5). However, because the use of a router or gateway for interfacing with a proprietary subnetwork is application-dependent, these NIUs are not defined in ISO 11783. Specific implementations can 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 NIUs. The maximum number of nodes per implement is specified in ISO 11783-2 and the maximum apparent number of CFs on a segment is limited by addressing as specified in ISO 11783-5.

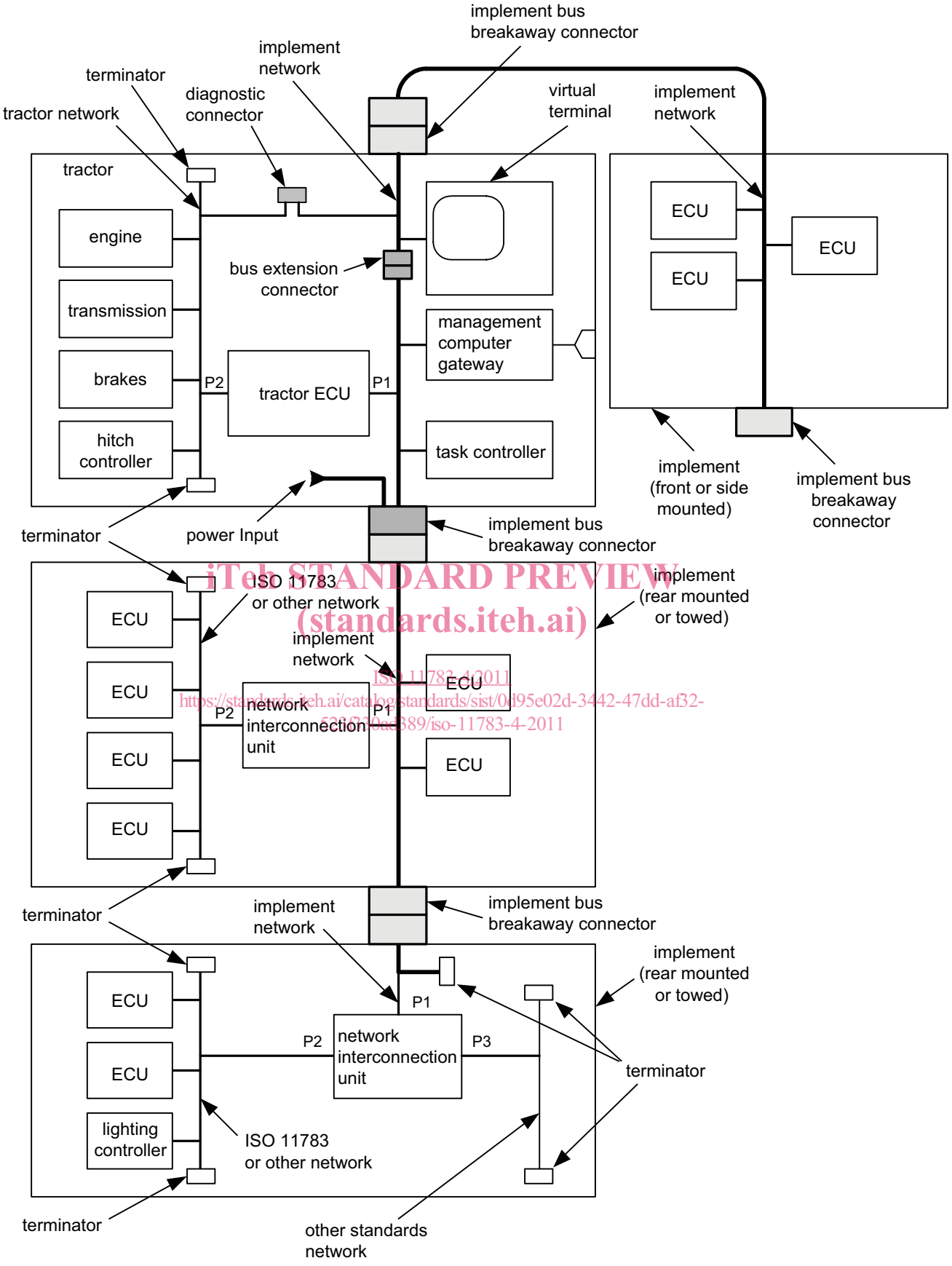

Figure 1 — Typical ISO 11783 network

5 Requirements

5.1 Network interconnection unit (NIU)

5.1.1 General requirements

The following apply.

a) The NIU shall provide guaranteed filtering and forwarding rates.

b) It shall not exceed the maximum transit-delay values.

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

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

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

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

5.1.2 General recommendations

The following apply.

a) The NIU should provide the capability to read and modify the filter database.

b) The NIU 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.

c) When in operation, the NIU should be transparent to any CF on the network.

5.1.3 Tractor ECU

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

5.2 Network topology

The system network topology (6.7) shall be constructed so that there is only one path between CFs.

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 NIU supplier.

5.3 Network addressing

The data link layer of the network (ISO 11783-3) provides for 256 source addresses. The theoretical number of CF addresses permitted on the network is 254 when the null and global addresses are not used. The electrical loading on the bus from each ECU can restrict the number of nodes connected to the network (ISO 11783-2).

6 Network interconnection unit functions

6.1 Forwarding

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

When an NIU forwards (7.1 Repeater and 7.2 Bridge) a message to another segment in the same address space, it uses an address identical to that of the originator of the message. Ordinarily, this does 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 CF is simultaneously claiming the same address. In such a low-probability situation, the NIU should stop the automatic retransmission sequence within the CAN protocol chip. Otherwise, the NIU will experience multiple collisions and go “bus off”, thereby preventing other messages from being forwarded until the NIU is able to recover from the bus off condition.

An NIU may begin to forward messages from one segment to another before the NIU has claimed an address (i.e. it does not perform address translations) if it is simply acting as a repeater or bridge.

NOTE Until an NIU has completed a power up sequence and connected it to the network, the subnetwork and the CFs connected to it cannot receive other messages.

6.2 Filtering

6.2.1 General

For the filtering function, messages sent with Transport Protocol, Extended Transport Protocol, Fast Packet, or other message packeting mechanism, shall be handled according to the parameter group number (PGN) of the contained message. If the PGN of the contained message is defined for the filter, the protocol handling messages shall be processed according to the defined filter.

6.2.2 Block mode

In block filter mode (0), the NIU shall default to forwarding all messages (7.2). Bus utilization (traffic) can be higher on each bus segment, but if it is within acceptable limits, the message filtering algorithm will be non-existent. The filter database within the NIU can contain identifier entries (PGN values) for messages which shall not be forwarded (blocked). This can be used to reduce the overall bus traffic on a given segment, and is the preferred mode of operation for bridges conforming to ISO 11783. Filter database entries are typically made during assembly or initial configuration and retained in non-volatile memory.

6.2.3 Pass mode

In pass filter mode (1), the NIU shall default to not forwarding messages (7.2). Then, in order for a message to be forwarded, an entry shall exist with a specific identifier (PGN value) for that particular message. This mode is best for ports on NIUs that link subnetworks performing specific functions. It requires prior knowledge of the CFs and the functions of the whole network, or that the CFs be able to add entries to the filter database, in which case the NIU can require more memory and processing power if it is to accommodate a large filter database. Moreover, some entries within the database need to be permanent (i.e. configured to be always present), so that corresponding messages are always forwarded across the whole network. Typical applications are network management, diagnostics and global requests.