TECHNICAL SPECIFICATION

ISO/TS 21815-2

First edition
2021-07

Earth-moving machinery — Collision warning and avoidance —

Part 2: On-board J1939 communication interface

Engins de terrassement — Avertissement et évitement de collision — Partie 2: Interface de communication embarquée

Reference number
ISO/TS 21815-2:2021(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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. In particular, 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety, ergonomics and general requirements*.

A list of all parts in the ISO 21815 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

The increasing use of detection systems and avoidance technology has been supporting operators to safely operate machines in the field of mining and construction. At the same time, there are demands to set standards for machines and systems detecting, alerting and intervening to mitigate collision risk.

There are currently two existing standards in the field: ISO 16001 and ISO 17757. These standards provide guidance for visibility aids and object detection systems and for autonomous and semi-autonomous machines, however, there is currently no standard that describes collision risk awareness, warning signals and collision avoidance actions of the machinery operated by humans where there is a risk of collision.

Collision warning and avoidance systems are developing technologies; and the algorithms are not yet mature and well understood. This document is intended to foster innovation and accelerate the pace of improvements in new collision warning and avoidance technologies. The performance requirements of this document are technology neutral and do not specify technologies to meet the requirements.

The systems described in this document are intended to assist the operator of the machine. As current technologies are unable to achieve full collision warning/avoidance in every situation, the responsibility for safe operation of the machine remains with the operator of the machine.

This document defines a protocol for communication between a machine and a connected device to allow the connected device to command the machine to slow down, stop or to maintain a stationary state where the machine can move in a linear (i.e. forwards-backwards) direction along a travel path. Machines with rotational movements (e.g. excavators) and machines with compound movements (e.g. machines with booms) are only considered to the extent of the linear component of their travel.

The machine manufacturer may be flexible in deciding which method is most appropriate for their machine. Some applications can be delivered with basic functionality (e.g. without the use of registers). Regardless of which approach is selected, the connected device has a means to discover the capabilities of the machine.

Annex B outlines a mechanism for establishing trust between the machine and the connected device based on the exchange of certificates at the session layer as defined by the machine manufacturer. The message structure for the session layer can be different to the message structure defined in this document.

The specification of the J1939 protocol in this document does not preclude the development of other communication interfaces that can support collision warning and avoidance functionality. At the time of publishing this document, protocols have only been defined for SAE J1939 due to the general availability of CAN 2.0 interfaces on machinery and devices providing collision warning and avoidance functions.

Earth-moving machinery — Collision warning and avoidance —

Part 2: On-board J1939 communication interface

1 Scope

This document describes the on-board J1939 communication interface between a connected device and mobile machines for use in earth-moving, mining and road construction applications to enable interventional collision avoidance actions defined in ISO 21815-1 based on the SAE J1939 protocol. This interface is intended for use by a collision avoidance system (CAS) device integrated independently from the original machine providing intervention signals to slow down, stop or prevent motion of the machine. The protocol defined by this document can also be used to provide input information for a collision warning system (CWS).

This document is not intended for plug-and-play implementation of CAS or CWS on the machine. Additional details not fully described in this document can be negotiated by the CAS or CWS manufacturer and the machine manufacturer to enable functionality.

This document does not preclude the possibility of the machine manufacturer or the CxD manufacturer developing alternative on-board communication interfaces.

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 19014-3, *Earth-moving machinery — Functional safety — Part 3: Environmental performance and test requirements of electronic and electrical components used in safety-related parts of the control system*

SAE J1939-15, *Reduced Physical Layer, 250 kbits/sec, UN-Shielded Twisted Pair (UTP)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 http://www.electropedia.org/

3.1
collision warning system
CWS
system which detects intended objects in the collision risk area, evaluates the collision risk level and provides a warning to the operator

[SOURCE: ISO 21815-1:—, 3.8]

3.2
collision avoidance system
CAS
system which detects intended objects in the collision risk area, evaluates the collision risk level and provides interventional collision avoidance *action* (3.9)

[SOURCE: ISO 21815-1:—, 3.9]

3.3
CxS
CWS (3.1) or *CAS* (3.2) or both

[SOURCE: ISO 21815-1:—, 3.10]

3.4
CxS device
CxD
proximity detection system
device with sensors providing *CxS* (3.3) functions to detect objects in the proximity of the machine, assess the collision risk level, warn the operator of the presence of object(s) for *CWS* (3.1), and/or provide signals to the machine control system to initiate the appropriate interventional collision avoidance *action* (3.9) on the machine for *CAS* (3.2)

Note 1 to entry: Proximity detection system (PDS) is a colloquial industry term for a physical device providing CWS or CAS functionality.

3.5
on-board communication interface
bi-directional connection between a *CxD* (3.4) and the machine in a *CWS* (3.1) or *CAS* (3.2)

Note 1 to entry: The *CxS* (3.3) may utilise information sent from the machine via the on-board communication interface to improve the estimation of the collision risk level. Only a CAS can initiate interventional collision avoidance *action* (3.9) over the on-board communication interface.

3.6
register
storage location on the machine side of the *on-board communication interface* (3.5) that may be read and optionally written to by the *CxD* (3.4)

Note 1 to entry: Changing the value of a register does not immediately initiate an interventional collision avoidance *action* (3.9).

3.7
parameter
type of *register* (3.6) that is used to store configuration information

EXAMPLE Software revision, timeout, max speed for emergency stop.

3.8
setpoint
type of *register* (3.6) that is used by the machine to respond to an interventional collision avoidance *action* (3.9)

EXAMPLE Minimum braking, maximum throttle, maximum speed.

3.9
action
message sent from the *CxD* (3.4) to the machine to change an internal *register* (3.6), or to initiate a machine function

EXAMPLE Reduce speed, apply brakes, inhibit motion.

3.10
enquiry
message sent from the *CxD* (3.4) to the machine to read an internal *register* (3.6), or request a machine capabilityEXAMPLE Slow down, emergency stop, controlled stop.

3.11
instruction
action (3.9) or *enquiry* (3.10) issued by the *CxD* (3.4)

3.12
reply
response (3.35) of the machine to an *instruction* (3.11) from the *CxD* (3.4)

3.13
logical group
grouping of related information or *instruction* (3.11) elements into a coherent message, sent from the *CxD* (3.4) to the machine or from the machine to the CxD over the *on-board communication interface* (3.5)

3.14
+bat
system voltage of the machine as defined by the machine manufacturer

Note 1 to entry: Typical voltages are 12 V or 24 V DC.

3.15
key switch
device used by the operator to turn on or turn off the machine

3.16
isolator switch
disconnect switch
device used by the operator to isolate the batteries or electrical supply to the machine

3.17
+bat(switched)
machine system level voltage that is turned on or off through the *key switch* (3.15)

3.18
+bat(un-switched)
voltage that is not affected by the state of the *key switch* (3.15), but is affected by the *isolator switch* (3.16)

3.19
CxD harness
auxiliary wiring between the machine connector and the *CxD* (3.4) connector

3.20
CxD bus
CAN-bus communication path between the machine and the *CxD* (3.4) terminated by 120 Ohm resistors at each end

3.21
CxD branch
machine-to-CxD bus or CxD-to-CxD bus wiring connection

3.22
PowerOn()
startup sequence for the machine that enables *CxD* (3.4) operation

3.23
doNegotiation()
automatic or semi-automatic process that verifies the credentials of the *CxD* (3.4) attached to the machine and returns permissions for the CxD to send commands to the machine and receive machine information

3.24
enableTimeout()
automatic process that enables an automatic timer that counts down to zero and sets a flag that there has been a communications error on the J1939 *on-board communication interface* (3.5)

3.25
resetTimeout()
automatic process that resets the automatic timer and clears the error flag indicating that the J1939 *on-board communication interface* (3.5) is functioning normally

3.26
doEmergencyStop()
automatic process that initiates an emergency stop on the machine

3.27
doControlledStop()
automatic process that initiates a controlled stop on the machine

3.28
doSlowDown()
automatic process that slows down the machine

3.29
doStandDown()
automatic process that brings the machine to a halted state

3.30
doBypassPropulsion()
instruction to bypass the propulsion system

3.31
doApplyPropulsionSetpoints()
activation of braking, throttle, speed *setpoint* (3.8) *registers* (3.6)

3.32
doMotionInhibit()
automatic process that prevents a machine from moving while stationary

3.33
doNormalOperation()
instruction (3.11) for the machine to continue with normal operation or return to normal operation

Note 1 to entry: This instruction has the effect of cancelling any other interventional collision avoidance *action* (3.9) that is already in progress.

3.34
challenge
unique message issued by the machine to the *CxD* (3.4) to which a valid *reply* (3.12) is expected

3.35
response
reply (3.12) by the *CxD* (3.4) to the *challenge* (3.34) issued by the machine to establish trust

4 Symbols and abbreviated terms

PGN	parameter group number (see SAE J1939)
SPN	suspect parameter number (see SAE J1939)
0xHH	8-bit hexadecimal value in the range 0x00 to 0xFF
0bB	1-bit binary value in the range 0b0 to 0b1
0bBB…	N-bit binary value

5 Logical interface

5.1 Logical groups

The logical connections for the on-board J1939 communication interface between the CxD and the machine are shown in Figure 1.

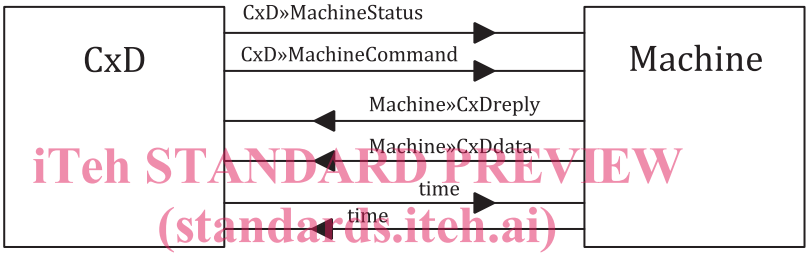

Figure 1 — Overview of logical CxD-machine interface

The logical groups defined for the on-board J1939 communication interface are:

— `CxD»MachineStatus` – this logical group of instructions allows the CxD to read or write to machine registers and detect the health of the communication interface.

NOTE 1 This logical group is used to provide machine status information to the CxD and allow the CxD to inspect and modify machine registers.

Information sent over this logical group may be sent at the maximum data rate supported by the machine.

— `CxD»MachineCommand` – instructions sent by CxD to machine to confirm or activate machine functions (e.g. slow down, stop, inhibit motion).

NOTE 2 This logical group is used to initiate interventional collision avoidance actions at the specified broadcast rate (see 7.3).

— `Machine»CxDreply` – response of machine to instructions sent by the CxD over `CxD»MachineStatus` or `CxD»MachineCommand`, which may include:

  — successful execution of the instruction;

  — an error was encountered while executing the instruction;

  — the instruction is not supported by the machine.

  The machine may limit the maximum data rate over the communication interface by delaying the response.

— `Machine»CxDdata` – data provided by machine to the CxD.

— `Time/Date` – information sent by machine to CxD or from CxD to machine to synchronise system clocks (see 7.10).

The enquiries and actions within each of these logical groups are described more fully in 5.2 to 5.4.

5.2 Negotiation

A higher level of sequence of negotiation and credentials may be used to protect the machine against access from an unauthorized CxD or connection of an unauthorised device to the interface. The negotiation sequence may be independently developed by the machine manufacturer and CxD supplier for exclusive use on a specific machine and may include:

— protocol version;

— machine model ID;

— machine generation / revision / series;

— other information defined by machine manufacturer and CxD manufacturer.

The CxD may pass credential information to the machine in a predefined sequence agreed between the CxD manufacturer and the machine manufacturer. Basic authentication methods are described in 7.2.3.1 (refer to NEGOTIATE_NOP description in Table 8).

A mechanism for establishing trust between the machine and the CxD is described in Annex B.

The machine may refuse to reply to or acknowledge all other instructions until after the negotiation sequence has been completed successfully.

Once negotiation has been successfully completed, the CxD shall send a PROTOCOL_NOP instruction within the specified maximum interval to avoid a timeout of the communication link.

5.3 Initialisation

After successful completion of the negotiation sequence, the CxD should read the contents of all registers defined on the machine and discover the capabilities of the machine using the mechanisms described in 7.2.

The CxD may read or write to registers after startup of the machine or at any time while the machine is running.

5.4 Operation

After negotiation and initialisation have been completed, the CxD may initiate interventional collision avoidance actions which are supported by the machine, including:

— motion inhibit;

— emergency stop;

— controlled stop;

— slow down;

— stand down;

— bypass propulsion;

— apply propulsion setpoints;

— no operation (NOP) – do nothing.

The machine may not support all interventional collision avoidance actions listed here. The CxD should discover the capabilities of the machine during initialisation.

Some interventional collision avoidance actions may require pre-conditions to be met, e.g. the machine is stationary before motion inhibit is applied, maximum machine speed for emergency stop, valid setpoint values provided by CxD.

Examples are shown for the PROPULSION subsystem only. Additional interventional collision avoidance actions may be defined in other subsystems.

6 Physical interface

6.1 General

The connection between the machine and the CxD is defined in 6.2 to 6.5.

The connectors specified in 6.2 to 6.5 can be unsuitable for the specific requirements of machines working in hazardous atmospheres. Alternative connector and connection arrangements may be used in these cases.

6.2 Machine connector

The physical connector on the machine shall be Deutsch DT-Series 12-pin plug part DT06-12SC-EP06 (Key C) shown in Figure 2 or equivalent[1]. The pin connections and pin definitions are shown in Table 1.

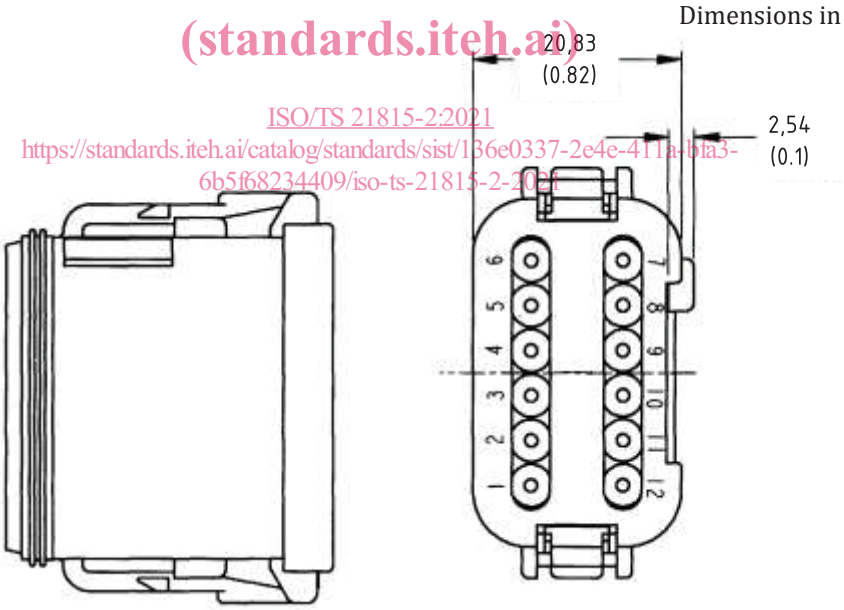

Figure 2 — Machine physical connector - Deutsch DT-series 12 pin, part DT06-12SC-EP06 (Key C)

1) Deutsch DT-Series 12-pin plug part DT06-12SC-EP06 (Key C) is an example of a suitable connector that is available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Table 1 — Machine pin connections

Pin	Machine	Comment
1	n/a	Reserved for future use by the ISO 21815 series
2	+bat(un-switched)	10A (maximum)
3	-bat 0V/GND	Common ground, 0V from battery supply
4	+bat(switched)	10 A (maximum) switched from ignition key
5	CAN HI	SAE J1939 CAN-bus (High)
6	CAN LO	SAE J1939 CAN-bus (Low)
7	n/a	Reserved for future use by the ISO 21815 series
8	n/a	Reserved for future use by the ISO 21815 series
9	n/a	Reserved for future use by the ISO 21815 series
10	n/a	Reserved for future use by the ISO 21815 series
11	Override A	Override switch (see Table 2)
12	Override B	Override switch (see Table 2)

The maximum combined load from pin 2 and pin 4 shall not exceed 10 A. An alternative source of power should be obtained from the machine for CxS devices that exceed the combined requirements of pin 2 and pin 4.

NOTE For some machines the additional power requirement of the CxD can require modification to the machine electrical system (e.g. larger alternator, reduction in electrical loads, changes to wiring harness).

The +bat(switched) or +bat(un-switched) battery lines should not be routed around the isolator switch to connect directly to the battery.

The machine should provide protection for short circuit or overcurrent fault conditions on pin 2 and pin 4, e.g. circuit breaker, resettable fuse, fuseable link.

Alternate compatible connector body styles may be used depending on the preferred method of connection, e.g. bulkhead / chassis, in-line connection.

All unused cable entries and cavities should be plugged to preserve the IP rating of the connector.

6.3 CxD connector

The physical connector on the CxD shall be Deutsch DT-series 12-pin receptacle part DT04-12PC-BE02 (Key C) shown in Figure 3 or equivalent[2]. The pin connections are identical to the machine connector (see Table 1).

2) Deutsch DT-series 12-pin receptacle part DT04-12PC-BE02 (Key C) is an example of a suitable connector that is available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

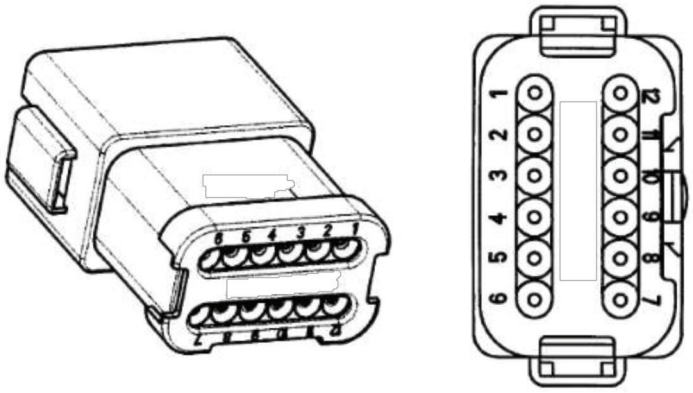

Figure 3 — CxD physical connector - Deutsch DT-series 12 pin, part DT04-12PC-BE02 (Key C)

The maximum combined load from pin 2 and pin 4 shall not exceed 10 A.

Alternate compatible connector body styles may be used depending on the preferred method of connection, e.g. bulkhead / chassis, in-line connection.

6.4 Override switch

An override signal may be implemented on the machine to notify the CxD that the operator has determined that the collision avoidance action may be overridden.

If provided by the machine, the override signal shall be implemented by parity switches connected to override A (pin 11) and override B (pin 12) with the states defined in Table 2.

Table 2 — CxD Override switch

Override A Pin 11	Override B Pin 12	Value
Open	Open	Connection fault
Open	Closed	Override enabled
Closed	Open	Override disabled
Closed	Closed	External fault
Key Closed short to 0V/GND Open machine voltage (e.g. +bat)		

If provided by the machine, the maximum sinking load on either override A or override B shall be 1 A at the system voltage of the machine as defined by the machine manufacturer.

NOTE Typical voltages for +bat (un-switched) and +bat (switched) are 12 V or 24 V DC.

If provided by the machine, the override A and override B contacts shall be maintained in the closed state when the override signal is indeterminate (e.g. during the startup sequence).

The override signal can be provided by a momentary action change-over switch, relay contacts, low impedance electronic switch with de-bounce provisions, or other means. Refer to Annex C for example implementations of the override functionality.

Transient states lasting less than 100 ms shall be ignored by the CxD.