International Standard

ISO 23316-6

Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC —

Part 6: Communication signals

Tracteurs et matériels agricoles et forestiers — Interface électrique haute puissance 700VDC/480VAC —

Partie 6: Signaux de communication

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Foreword

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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 document 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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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 23, *Tractors and machinery for agriculture and forestry, Subcommittee SC 19, Agricultural electronics*.

The document is intended to be used in conjunction with the ISO 11783 series and the other parts of ISO 23316.

A list of all parts in the ISO 23316 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

Due to the requirements of modern agriculture, the precise control of implement functions is a key issue in agricultural technology. The required precision is difficult to achieve with mechanical or hydraulic devices; it is more efficient to provide control with electric and electronic means, i.e. electric power and ISOBUS. The use of electric power allows implement manufacturers to offer farmers improved implements that provide a higher degree of automation and navigation, resulting in greater precision, better power distribution, and better controllability.

The purpose of the ISO 23316 series is to provide a design and application standard covering implementation of electrical high-power interfaces operating with a nominal voltage of 700 V DC/480 V AC for manufacturers of agricultural machinery.

The ISO 23316 series specifies the physical and logical interface requirements that provide interoperability and cross compatibility for systems and equipment.

Conformance to the ISO 23316 series means all applicable requirements from ISO 23316-1 to ISO 23316-7 are met.

It is permitted for partial systems or components to conform to the ISO 23316 series by applying all applicable requirements, for example, for the plug, receptacle, or inverters, on a tractor or an implement.

NOTE 1 If a DC-mode only HPI is provided, it is not necessary to conform with ISO 23316-4 which describes AC-mode, as it is not applicable. If an AC-mode only HPI is provided, it is not necessary to conform with ISO 23316-5 which describes DC-mode, as it is not applicable.

The ISO 23316 series defines an interface between a power providing device (supply system) and a power consuming device (consumer system), used within an automated electrified system in the agricultural industry. This series deals with electrical, mechanical and bus communication objectives and is used in conjunction with ISO 11783, which defines the ISOBUS. Figure 1 portrays the elements of typical equipment that involve the high-power interface.

The following aspects are not within the scope of ISO 23316:

— service, maintenance, and related diagnostics;

— functional safety;

— control strategies for high-power supplies and loads;

— application-specific strategies and operational modes;

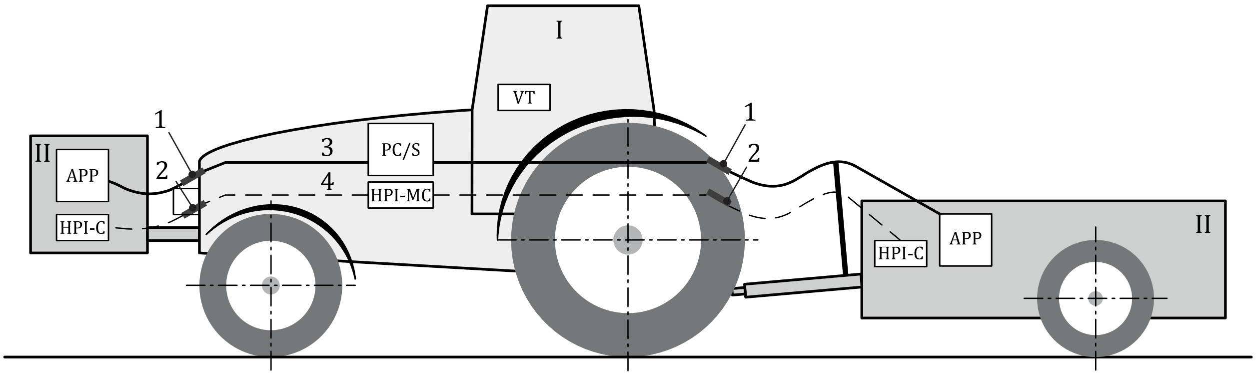
— component design;

— energy storage systems, e. g. supercapacitors or batteries;

— multiple electrical power supplies to a common DC link.

NOTE 2 Annex D lists some basic diagnostics by DTCs.

NOTE 3 For example, AEF guideline 007 handles some aspects of functional safety already.



Key

Symbol	Description	Symbol	Description
APP	application	1	high-power interface
PC/S	power converter/switch	2	ISOBUS connector
HPI-C	high-power interface - control	3	power lines
HPI-MC	high-power interface - master control	4	ISOBUS
VT	virtual terminal (user interface)	————	power connection
I	supply system	– – – –	signal connection
II	consumer system		

Figure 1 — Typical elements of system incorporating a high-power interface

Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC —

Part 6:
Communication signals

1 Scope

This document specifies the communication interface, so that the transmitted parameters, signals and objects between a supply system (SS), with power converter/switch (PC/S) and high power interface – master control (HPI-MC) including the tractor implement management (TIM) server, and a consumer system (CS), with application (APP) and high power interface – control (HPI-C) including the TIM client and the task controller, can be used is in the agricultural industry. The mentioned signals are used during identification, initialization, operation, and shutdown modes of operation.

This document does not cover the definitions of suspect parameter numbers (SPNs) for the signals, within the parameter group numbers (PGNs) for messages and the message setup. These definitions are given in ISO 11783 and SAE J1939.

NOTE For information on messages (PGNs) see also Annex B.

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 16230-1:2015, *Agricultural machinery and tractors — Safety of higher voltage electrical and electronic components and systems — Part 1: General requirements*

ISO 23316-1, *Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC — Part 1: General description*

ISO 23316-2, *Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC — Part 2: Physical layer*

ISO 23316-4:2023, *Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC — Part 4: AC operation mode*

ISO 23316-5:2023, *Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC — Part 5: DC operation mode*

ISO 23316-7, *Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC — Part 7: Mechanical integration*

ISO 11783 (all parts), *Tractors and machinery for agriculture and forestry — Serial control and communications data network*

IEC 60204:2016, *Safety of machinery — Electrical equipment of machines*

SAE J1939DA, *Serial Control and Communications Heavy Duty Vehicle Network — Digital Annex*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23316-1, ISO 23316-2, ISO 23316-4, ISO 23316-5, ISO 23316-7 and the following apply.

ISO and IEC maintain terminology 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
direction of rotation
positive values for frequency or speed related to powering the power converter phases in the sequence U V W positive torque means torque in the direction of positive speed

Note 1 to entry: If not stated otherwise (e.g. ground speed), the term ‘speed’ within this document refers always to rotational movement.

3.2
fieldbus maindevice
device integrated within inverter onboard supply system, controls actively the communication within the fieldbus network and requests/receives data to/from the *fieldbus subdevice* ((3.3), subordinated controller) in a cyclically and time-wise deterministic manner

3.3
fieldbus subdevice
device integrated within LLB on-board consumer system receives data (e.g. requests) from and provides data (e.g. feedback) to the *fieldbus maindevice* (3.2) passively

3.4
insulation monitor
IM
device monitoring the ungrounded system between an active phase conductor and the equipotential bonding

3.5
power converter/switch control
PC/S-C
control for AC mode, a power converter; for DC mode, a switch such as a contactor or solid-state switch, typically an integral part of the PC/S-C

3.6
minimum isolation resistance
MIR
value in failure free condition but at worst case ambient conditions (considering humidity, fluids, cooling type, etc. in operation)

3.7
multi consumer system
MCS
system of more than one consumer systems or consumer system trains, connected to the HPI in any combination of a series or parallel configuration

3.8
online insulation monitor
OIM
system to measure the overall system isolation resistance onboard of the initial supply system

3.9
parameter group number
PGN
3-byte CAN Message, 24 bit, representation of the extended data page, data page, protocol data unit (PDU) format, and group extension (GE) fields

[SOURCE: ISO 11783-1:2017, 3.44]

Note 1 to entry: The parameter group number uniquely identifies a particular parameter group.

3.10
pre-charge procedure
capacitor charging procedure to balance different DC link voltage levels

3.11
pre- and discharge unit
unit to pre- or discharge the DC link connected via HPI, typically an integral part of the PC/S-C

3.12
supply system master
SS-M
supply system that includes the initial power source, such as generator/rectifier unit or fuel cell, commonly the tractor, typically the HPI-MC also resides there.

3.13
suspect parameter number
SPN
19-bit number used to identify a particular element, component, or parameter associated with a control function

[SOURCE: ISO 11783-1:2017, 3.58]

Note 1 to entry: Suspect parameter numbers are assigned to each individual parameter in a parameter group, and to items that are relevant to diagnostics but are not presently a parameter in a parameter group.

Note 2 to entry: See SAE J1939 definitions for more details.

4 Voltage classes

Table 1 indicates the range of voltages (as defined in ISO 23285).

Table 1 — Voltage classes

Voltage class	Maximum working voltage	
	V DC	V AC RMS
VC-A	0 < U ≤ 60	0 < U ≤ 30
VC-A1	0 < U ≤ 32	0 < U ≤ 21
VC-A2	32 < U ≤ 60	21 < U ≤ 30
VC-B	60 < U ≤ 1 500	30 < U ≤ 1 000
VC-B1	60 < U ≤ 75	30 < U ≤ 50
VC-B2	75 < U ≤ 1 500	50 < U ≤ 1 000
U = nominal voltage		

NOTE 1 The definition of RMS values in Table 1 is related to a pure sine wave form or the fundamental frequency of a modulated signal. The RMS value of a modulated signal may differ from them.

NOTE 2 Unipolar PWM is DC. Bipolar PWM is AC.

5 General system overview

5.1 General

Initially, the basis for the communication between supply system (SS) and consumer systems (CSs), high power interface (HPI) controllers (shown in Figure 2 and Figure 3) shall use the ISOBUS as specified in the ISO 11783 series.

NOTE 1 High speed ISOBUS and other alternative communication media such as Automotive Ethernet and EtherCAT ™ [1] based technologies can be used but likely need an update to this document. For information, ISO technical committees TC 82, TC 23 and TC 127 are collaboratively working on high-speed secure communication interfaces.

NOTE 2 Topologies showed in this clause are only examples, implementations can differ from them (e.g. in number of interfaces).

If applicable, as basis for the communication between Power Converter/Switch Controller (PC/S-C) and application (APP)/load (shown in Figure 2), the fieldbus as defined in Clause 7 may be used.

The communication shall follow the TIM approach on ISOBUS.

NOTE 3 Advantage of this approach is using already defined measures like secure communication, usage of an existing automation state machine, etc. Refer to AEF guidelines 023 on automation and 040 on security for details.

NOTE 4 As diagnostics is not in scope, Annex D gives an informative overview of feasible DTCs.

5.2 Basic AC-system topology

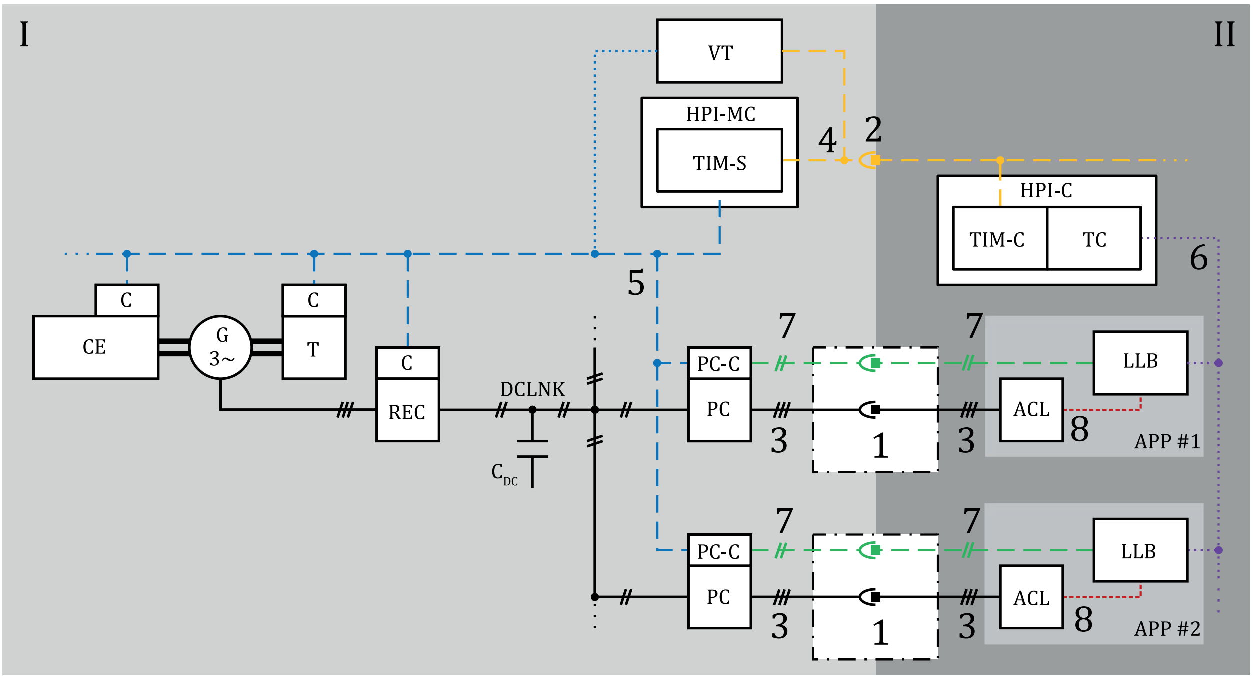
Typically, an electric AC drive system consists of one Power Converter (PC, e.g. a three-phase inverter) within the SS which is connected to at least one Application (APP), in particular an AC-load (ACL), on the side of a CS via one HPI. A SS provides at least one HPI.

Application specific communication shall use ISOBUS, e.g. for transmission of working process data from implement (as CS) to tractor (as SS).

Load specific communication shall use the fieldbus for ACL identification and transmission of feedback. The fieldbus shall be a 1:1 connection, enabling reliable and unambiguous communication between Power Converter (PC) and load logical box (LLB).

NOTE The load specific communication between SS and CS is functionally necessary since there is a split in the electric drive between Power Converter PC and ACL.

1) EtherCAT ™ is a Tradename of Beckhoff, used as an example of a suitable product 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.



Key

Symbol	Description	Symbol	Description
————	power connection		
– – – –	signal/bus connection	…………	optional signal connection
I	supply system	II	consumer system
1	high-power interface	5 – – –	supply system communication bus (e.g. tractor bus)
2	ISOBUS connector	6 …………	consumer system communication bus (e.g. implement bus)
3 ————	power lines	7 – – –	fieldbus (used also for interlock function)
4 – – –	ISOBUS	8 …………	feedback signal (e.g. sensor signal)
ACL	AC-load (e.g. electric motor)	PC	(DC/AC) power converter
APP	application	PC-C	power converter controller
C	controller of a device	REC	rectifier (AC/DC power converter)
C_{DC}	DC link capacitor	T	transmission
CE	combustion engine	TC	task controller
DCLNK	DC link	TIM-C	tractor implement management - Client
HPI-C	HPI - control	TIM-S	TIM - server
HPI-MC	HPI – master control	VT	virtual terminal (user interface, e.g. display)
LLB	load logical box		

Figure 2 — AC-system topology example with two loads

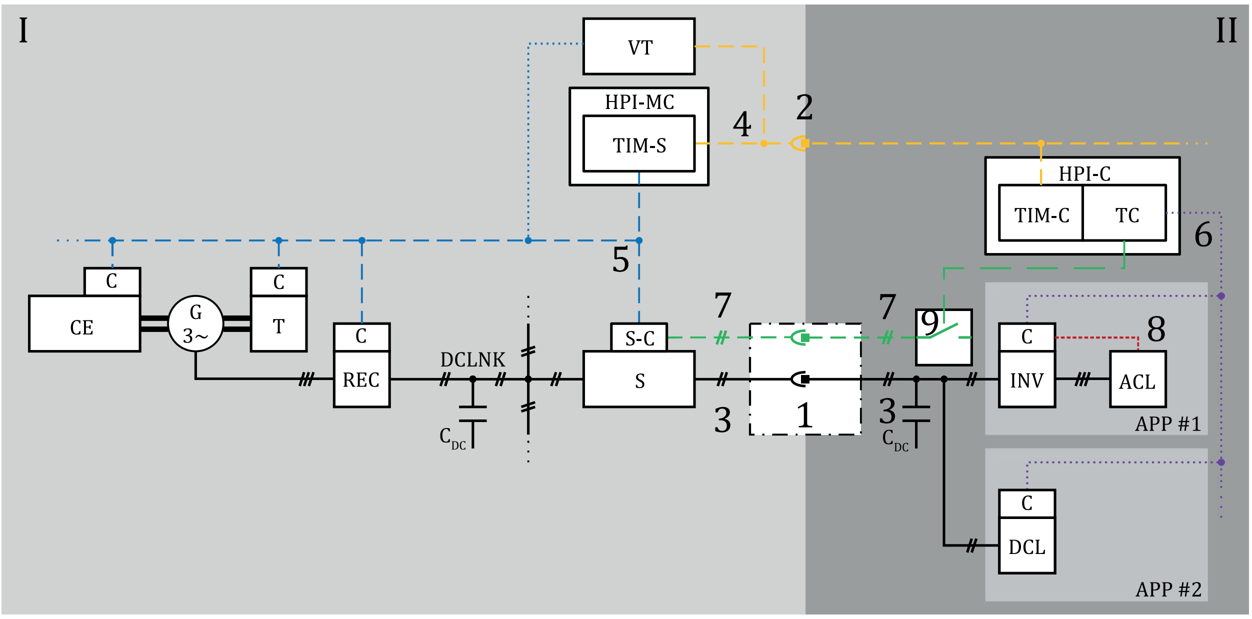
The SS and CSs may include additional communication bus systems (as shown in Figure 2), these are not within the scope of this document.

The interaction (sequences for identification, initialization, operation and shutdown) between SS [including the Tractor Implement Management (TIM) server [2] on-board, e.g. a tractor] and CS [including TIM client and Task Controller (TC) on-board e.g. an implement] is described in Clauses 6, 7 and 9 for fieldbus-based systems.

2) Depending on specific topologies, an implement can also be a server.

The total number of TCs of a CS is not specified by the example in Figure 2, it is permitted to use a dedicated TC per APP.

5.3 Basic DC-system topology



Key

Symbol	Description	Symbol	Description
	power connection		
	signal/bus connection		optional signal connection
I	supply system	II	consumer system
1	high-power interface (HPI)	6	consumer system communication bus (e.g. implement bus)
2	ISOBUS connector	7	interlock loop
3	power lines	8	feedback signal (e.g. sensor signal)
4	ISOBUS	9	interlock signal line breaker
5	supply system communication bus (e.g. tractor bus)		
ACL	AC-load (e.g. electric motor)	REC	rectifier (AC/DC power converter)
APP	application	S	switch (contactor or solid-state switch, including pre- and discharge unit)
C	controller of a device	S-C	switch controller
CDC	DC link capacitor	T	transmission
CE	combustion Engine	TC	task controller
DCLNK	DC link	TIM-C	tractor implement management–client
HPI-C	high-power interface–control	TIM-S	tractor implement management–server
HPI-MC	high-power interface–master control	VT	virtual terminal (user interface, e.g. display)
INV	inverter (DC/AC power converter)		

Figure 3 — DC-system topology example with two loads

Typically, an electric DC drive consists of a switch (this includes a contactor or a solid-state switch and as well as a pre-/discharge device) that is connected with at least one APP (e.g. a three-phase inverter for