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

Part 1: General

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Foreword

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

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.

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Introduction

0.1 General

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 at up to 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 ISO23316 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 implement.

NOTE 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 the relevant part of ISO 11783, which defines the ISOBUS. Figure 1 portrays the elements of typical equipment that involve the high-power interface.

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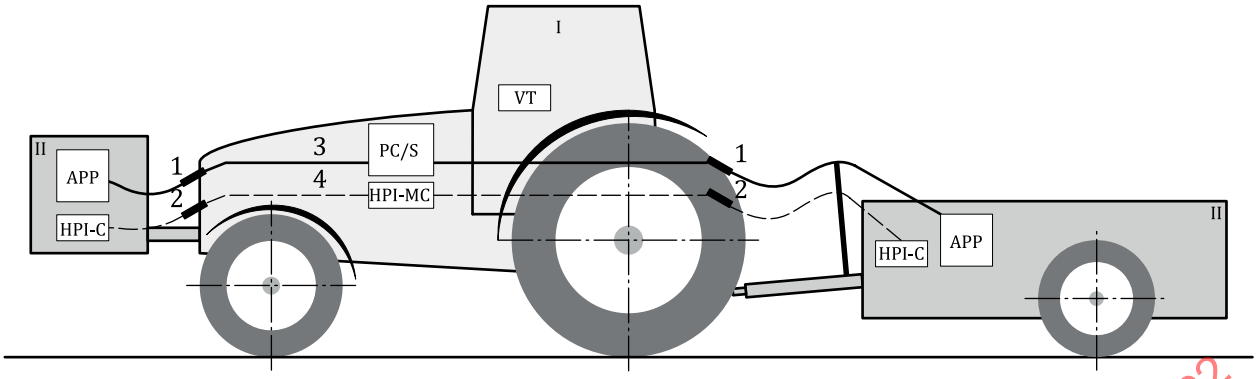

Key

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

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

0.2 Patent

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent.

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

Part 1: General

1 Scope

This document describes the general purpose and structure of the ISO 23316 series and common elements of the ISO 23316 series.

The following topics are not within the scope of this document:

— 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.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
alternating current
AC
alternating electric quantities such as voltage or current, to devices operated with these, or to quantities associated with these devices

[SOURCE: IEC 60050-151:2001, 151-15-01]

3.2
application
APP
system of load and optional load logical box located on a consumer system

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3.3
controller area network
CAN
protocol originally defined for use as a communication network for control application in vehicles

[SOURCE: ISO 17356-1:2005, 2.17]

3.4
connector
receptacle or plug assembly containing socket, plug, pins or contact sockets

3.5
consumer system
CS
physical unit consisting of one or more applications and its control instances (e.g. implement) to be connected via HPI to a supply system

3.6
electric energy converter
CNV
device for changing one or more characteristics associated with electric energy

Note 1 to entry: Characteristics associated with energy are for example voltage, number of phases and frequency including zero frequency.

[SOURCE: IEC 60050-151-13-36]

3.7
direct current
DC
time-independent electric quantities such as voltage or current, to devices operated with direct voltage and current, or to quantities associated with these devices

[SOURCE: IEC 60050-151:2001, 151-15]

3.8
DC link
DCLNK
DC connection between devices (e.g. power converter) to distribute electric power

Note 1 to entry: Refers to tractors, implements, or both.

3.9
electronic control unit
ECU
electronic item consisting of a combination of basic parts, subassemblies and assemblies packaged together as a physically independent entity (e.g. ISOBUS job controller)

3.10
electrical high-power interface
HPI
logical and power gateway between a power providing supply system and a power consumer system used within an electrified system in the agricultural industry

3.11
electromagnetic compatibility
EMC
ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161-01-07/-01-06]

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3.12
fieldbus
industrial computer network protocol used for real-time distributed control (e.g. EtherCAT ™ [1]) using Ethernet – combined with optimized communication functions between a main fieldbus controller and a segment of fieldbus sub devices)

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.1593]

3.13
HPI control
HPI-C
control instance of a consumer system, unambiguously assigned to one HPI connected to a PS of the VC-B2 network providing communication client function to a supply system and, optionally, communication server function, if it is possible to connect another consumer system

3.14
HPI master control
HPI-MC
control instance, assigned to at least one but not more than 15 HPIs of the VC-B2 network of one supply system, providing communication server functionality for the communication to the related HPIs, managing the interlock loop, and providing the network management functions (e.g. topology determination) to all consumer systems connected to the supply system

3.15
interlock loop
IL
means to detect the status of each socket/plug-combination

3.16
inverter/switch control
PC/SC
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/SC

3.17
inverter
INV
electric energy converter that changes direct electric current to single-phase or polyphase *alternating currents* (3.1)

[SOURCE: IEC 60050-151-13-46]

3.18
ISOBUS
CAN bus system according to ISO 11783

Note 1 to entry: ISOBUS is a SAE J1939 based CAN communication bus system, usually used in agriculture and forestry between, such as a tractor, as power supply and at least one implement as load. The communication bus system consists at least of one tractor ECU and one implement ECU. One tractor ECU shall fulfil the functions of a master controller. The tractor ECU (TECU) is a gateway between the ISOBUS and tractor internal bus(es) including the attached controls; thus it exchanges communication objects between both buses, but fulfils also further functions. On-board the implement at least one ECU (also known as Job Controller or Task Controller) interconnects the ISOBUS with the implement application specific controls, optionally via implement internal bus(es); thus, it exchanges communication objects between both buses, but fulfils also further functions.

Note 2 to entry: For details, see the ISO 11783 series.

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.

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3.19
load logical box
LLB
collects and transfers sensor data and specific parameters from the load to the PC/S via fieldbus

Note 1 to entry: electronical device connected to the fieldbus as slave controller and optionally topic electrical load internal communication bus; intended use as memory of load specific data (e.g. electric machine specific data) and load sensor electronics (e.g. for processing of temperature, speed, or position sensor signal)

3.20
load
electrical load that is resistive, capacitive or inductive or any combination

Note 1 to entry: Electrical loads are not restricted to drives, either in AC or DC mode

3.21
maximum working voltage
highest value of AC voltage (rms) or of DC voltage that can occur under any normal operating conditions according to the manufacturer's specifications, disregarding transients and ripple

3.22
overvoltage
OV
voltage higher than the rated operating voltage range

3.23
plug
connector attached to the consumer system cable

Note 1 to entry: Within this standard the plug contains the male power pins

3.24
power converter
PC
device that converts electric energy from DC to AC or from AC to DC

[SOURCE: ISO 21782-1:2019, 3.18]

3.25
power converter/switch
PC/S
Device controlling the power outlet

Note 1 to entry: for AC mode, a power converter; for DC mode, a switch such as a contactor or solid-state switch

3.26
power supply
power supply system
PS
provision of electric energy from a source

[SOURCE: IEC 60050-151]

Note 1 to entry: If implements are connected in series, the predecessor implement can also provide the PS

3.27
pulse width modulation
PWM
pulse time modulation in which the pulse duration varies in accordance with a given function of the value of the modulating signal

[SOURCE: IEC 60050-702]

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3.28
reference value
several communication objects on ISOBUS and field bus are defined as percentage values in relation to 'reference values'

3.29
receptacle
connector mounted on supply system

Note 1 to entry: Within this document, the receptacle contains the female power pins.

3.30
ripple
set of unwanted periodic deviations with respect to the average value of the measured or supplied quantity, occurring at frequencies which can be related to that of mains supply, or of some other definite source, such as chopper

[SOURCE: IEC 60050-312]

3.31
root mean square
RMS
positive square root of the mean value of the square of the quantity taken over a given time interval for a time-dependent quantity

Note 1 to entry: The root-mean-square value of a periodic quantity is usually taken over an integration interval the range of which is the period multiplied by a natural number.

Note 2 to entry: For a sinusoidal quantity $a(t)=\hat{A}\cos(\omega t+\varphi)$, the root-mean-square value is $A_{eff}=\hat{A}/\sqrt{2}$.

Note 3 to entry: The root-mean-square value of a quantity may be denoted by adding one of the subscripts eff or rms to the symbol of the quantity.

Note 4 to entry: In electrical technology, the root-mean-square values of electric current i(t) and voltage u(t) are usually denoted I and U, respectively.

Note 5 to entry: The abbreviation RMS was formerly denoted as r.m.s. or rms, but these notations are now deprecated.

[SOURCE: IEC 60050-103]

3.32
space vector modulation
SVM
algorithm for the control of pulse width modulation (3.55).

Note 1 to entry: It is used for the creation of *alternating current (AC)* (3.1) waveforms; most commonly to drive 3 phase AC powered motors at varying speeds from DC using multiple class-D amplifiers. There are variations of SVM that result in different quality and computational requirements. One active area of development is in the reduction of total harmonic distortion created by the rapid switching inherent to these algorithms.

3.33
supply system
all elements required to provide electrical power over the HPI.

3.34
task controller
TC
device integrated in the implement job controller to monitor and control implement activity

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3.35
Tractor ECU
TECU
unit adjustable by other than mechanic means (e.g. sensing unit), containing electronic components and controlling the output via electronic components, in that case used on a tractor

[SOURCE: IEC 60050-442]

3.36
transient
phenomenon or a quantity which varies between two consecutive steady states during a time interval short compared with the timescale of interest

3.37
undervoltage
UV
voltage lower than the rated operating voltage range

3.38
voltage class B2
VC-B2
voltage class B2 system with voltage limits as defined in Table 1

3.39
voltage class B2 network
VC-B2 network
arrangement of one or more electrically connected VC-B2 devices

3.40
virtual terminal
VT
electronic control unit (3.18) consisting of a graphical display and input controls providing the capability to display information to and retrieve data from an operator for a connected implement or working set

Note 1 to entry: display and/or other devices for interaction between the user and the system in scope, typically on a tractor.

[SOURCE: ISO 11783-1:2017, 3.67, modified — A note to entry has been added.]

3.41
voltage classes
letter symbol indicating a range of voltages according to the voltage limits in Table 1

4 Voltage classes

Table 1 indicates the range of voltages. The definition of voltage classes is based on ISO 6469-3.

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
U = nominal voltage		

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Table 1 *(continued)*

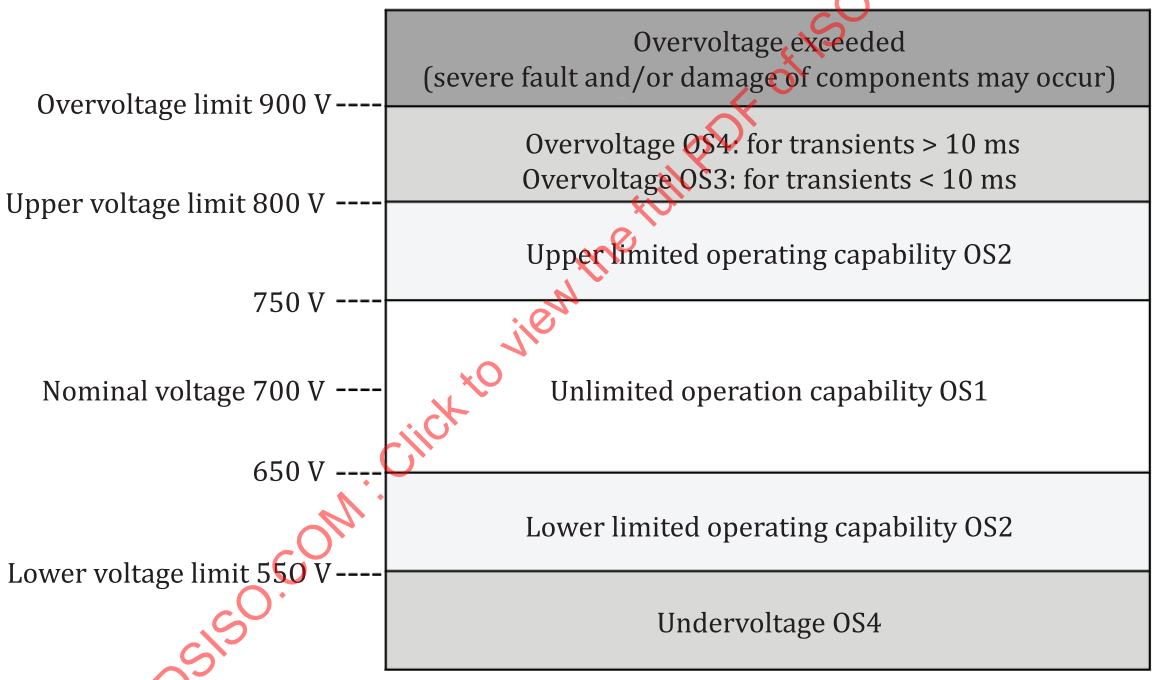
Voltage class	Maximum working voltage	
	V DC	V AC RMS
VC-B2	75 < U ≤ 1 500	50 < U ≤ 1 000
U = nominal voltage		

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 can differ from them.

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

5 System voltage thresholds

Figure 2 indicates the DC link thresholds for systems covered by this document. The voltage threshold values are the actual voltages including transients and ripple voltage. The definition of operating statuses is based on ISO 21498-1.



OS1: Operating Status 1

OS2: Operating Status 2

OS3: Operating Status 3

OS4: Operating Status 4

NOTE When the voltage exceeds the overvoltage limit, a severe fault, e.g. breakdown of a component, can occur.

Figure 2 — DC link voltage thresholds

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The definition of operating statuses, based on ISO/PAS 19295 are as follows.

a) OS1: The component shall provide the specified full performance (reduction of performance not allowed).

   The component shall automatically change its operating status depending on the voltage relevant for the operating status.

b) OS2: The component shall provide the specified reduced performance within its permissible deviations (reduction of performance allowed).

   The component shall automatically change its operating status depending on the voltage relevant for the operating status.

   NOTE 1 A load with 480 V AC (RMS) requires a minimum voltage of 650 V DC (based on space vector modulation without over modulation).

   NOTE 2 A load with 400 V AC (RMS) requires a minimum voltage of 550 V DC (based on space vector modulation without over modulation).

c) OS3: The component may derate or cut-off its performance for self-protection purpose.

   The component shall automatically change its operating status depending on the voltage relevant for the operating status.

d) OS4: The component may cut-off its performance.

   Triggered by a reset or an external event (e.g. change of ignition status, restart vehicle), the component shall change its operating status depending on the voltage relevant for the operating status.

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