ENGINEERING TOMORROW

Design Guide

VLT® Integrated Servo Drive ISD® 510 System

vlt-drives.danfoss.com

Contents

1 Introduction

1.1 Purpose of the Design Guide

This design guide for Danfoss VLT® Integrated Servo Drive ISD® 510 System is intended for:

- Project and systems engineers.
- Design consultants.
- Application and product specialists.

The design guide provides technical information to understand the capabilities of the VLT® Integrated Servo Drive ISD® 510 System, and to provide design considerations and planning data for integration of the system into an application.

Also included are:

- Safety features.
- Fault condition monitoring.
- Operational status reporting.
- Serial communication capabilities.
- Programmable options and features.

Design details, such as site requirements, cables, fuses, control wiring, the size and weight of units, and other important information necessary to plan for system integration are also provided.

The design guide caters for the selection of ISD 510 servo system components and options for a diversity of applications and installations. Reviewing the detailed product information in the design stage enables the development of a well-conceived system with optimal functionality and efficiency.

1.2 Additional Resources

Available manuals for the VLT® Integrated Servo Drive ISD® 510 System:

Manual	Contents
VLT® Integrated Servo Drive ISD® 510 System Operating Instructions	Information about the installation, commissioning, and operation of the ISD 510 servo system.
VLT® Integrated Servo Drive ISD® 510 System Design Guide	Information about the set-up of the ISD 510 servo system and detailed technical data.
VLT® Integrated Servo Drive ISD® 510 System Programming Guide	Information about the programming of the ISD 510 servo system.

Table 1.1 Available Manuals for the ISD 510 Servo System

Technical literature for Danfoss drives is also available online at *drives.danfoss.com/knowledge-center/technical-documentation/*.

1.3 Abbreviations and Conventions

1.3.1 Abbreviations

All abbreviations can be found in *chapter 7.1 Glossary*.

1.3.2 Conventions

Numbered lists indicate procedures.
Bullet lists indicate other information and descriptions of figures.
Italicized text indicates:

- Cross-reference.
- Link.
- Footnote.
- Parameter name, parameter group name, parameter option.

All dimensions in drawings are in mm (inch).

1.4 Copyright

VLT®, ISD®, and SAB® are Danfoss registered trademarks.

1.5 Approvals and Certifications

The VLT® Integrated Servo Drive ISD® 510 System fulfills the standards listed in *Table 1.2*.

IEC/EN 61800-3	Adjustable speed electrical power drive systems. Part 3: EMC requirements and specific test methods.
IEC/EN 61800-5-1	Adjustable speed electrical power drive systems. Part 5-1: Safety requirements – Electrical, thermal, and energy.
IEC/EN 61800-5-2	Adjustable speed electrical power drive systems. Part 5-2: Safety requirements – Functional.
IEC/EN 61508	Functional safety of electrical/electronical/programmable electronic safety-related systems.
EN ISO 13849-1	Safety of machinery – Safety-related parts of control systems. Part 1: General principles for design.
EN ISO 13849-2	Safety of machinery – Safety-related parts of control systems. Part 2: Validation.

IEC/EN 60204-1	Safety of machinery – Electrical equipment of machines. Part 1: General requirements.
IEC/EN 62061	Safety of machinery – Functional safety of safety-related electrical, electronic, and programmable electronic control systems.
IEC/EN 61326-3-1	Electrical equipment for measurement, control, and laboratory use – EMC requirements. Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications.
UL 508C	UL Standard for Safety for Power Conversion Equipment.
2006/42/EC	Machinery Directive
CE	
2014/30/EU	EMC Directive
2014/35/EU	Low Voltage Directive
RoHS (2011/65/EU)	Restriction of hazardous substances.
EtherCAT®	Ethernet for Control Automation Technology. Ethernet-based fieldbus system.
Ethernet POWERLINK®	Ethernet-based fieldbus system.
PLCopen®	Technical specification. Function blocks for motion control (formerly Part 1 and Part 2) Version 2.0 March 17, 2011.

Table 1.2 Approvals and Certifications

1.5.1 Low Voltage Directive

The VLT® Integrated Servo Drive ISD® 510 System components are classified as electronic components and must be CE labeled in accordance with the Low Voltage Directive. The directive applies to all electrical equipment in the 50–1000 V AC and the 75–1600 V DC voltage ranges.

The directive mandates that the equipment design must ensure the safety and health of people and livestock are not endangered and the preservation of material worth so long as the equipment is properly installed, maintained, and used as intended. Danfoss CE-labels comply with the Low Voltage Directive. Danfoss provides a declaration of conformity on request.

1.5.2 EMC Directive

Electromagnetic compatibility (EMC) means that electromagnetic interference between apparatus does not hinder their performance. The basic protection requirement of the EMC Directive 2014/30/EU states that devices that generate electromagnetic interference (EMI), or whose operation could be affected by EMI, must be designed to limit the generation of electromagnetic interference and must have a suitable degree of immunity to EMI when properly installed, maintained, and used as intended.

Devices used as standalone or as part of a system must bear the CE mark. Systems must not be CE marked but must comply with the basic protection requirements of the EMC directive.

1.5.3 Machinery Directive

The VLT® Integrated Servo Drive ISD® 510 System components are classified as electronic components subject to the Low Voltage Directive, however components or systems with an integrated safety function must comply with the machinery directive 2006/42/EC. Components or systems without a safety function do not fall under the machinery directive. If components are integrated into a machinery system, Danfoss provides information on safety aspects relating to them.

Machinery Directive 2006/42/EC covers a machine consisting of an aggregate of interconnected components or devices, of which at least 1 is capable of mechanical movement. The directive mandates that the equipment design must ensure the safety and health of people and livestock are not endangered and the preservation of material worth so long as the equipment is properly installed, maintained, and used as intended.

When servo system components are used in machines with at least 1 moving part, the machine manufacturer must provide a declaration stating compliance with all relevant statutes and safety measures. Danfoss CE-labels comply with the machinery directive for drives with an integrated safety function. Danfoss provides a declaration of conformity on request.

1.6 Safety

The following symbols are used in this guide:

WARNING

Indicates a potentially hazardous situation that could result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation that could result in minor or moderate injury. It can also be used to alert against unsafe practices.

NOTICE

Indicates important information, including situations that can result in damage to equipment or property.

The following safety instructions and precautions relate to the VLT® Integrated Servo Drive ISD® 510 System.
Read the safety instructions carefully before starting to work in any way with the ISD 510 servo system or its components.
Pay particular attention to the safety instructions in the relevant sections of this manual.

WARNING

HAZARDOUS SITUATION

If the servo drive, SAB, or the bus lines are incorrectly connected, there is a risk of death, serious injury, or damage to the unit.

- **Always comply with the instructions in this manual and national and local safety regulations.**

WARNING

GROUNDING HAZARD

The ground leakage current is >3.5 mA. Improper grounding of the ISD 510 servo system components may result in death or serious injury.

- **For reasons of operator safety, ground the components of the ISD 510 servo system correctly in accordance with national or local electrical regulations and the information in this manual.**

WARNING

HIGH VOLTAGE

The ISD 510 servo system contains components that operate at high voltage when connected to the electrical supply network.
A hazardous voltage is present on the servo drives and the SAB whenever they are connected to the mains network.
There are no indicators on the servo drive or SAB that indicate the presence of mains supply.
Incorrect installation, commissioning, or maintenance can lead to death or serious injury.

- **Installation, commissioning, and maintenance must only be performed by qualified personnel.**

WARNING

UNINTENDED START

The ISD 510 servo system contains servo drives and the SAB that are connected to the electrical supply network and can start running at any time. This may be caused by a fieldbus command, a reference signal, or clearing a fault condition. Servo drives and all connected devices must be in good operating condition. A deficient operating condition may lead to death, serious injury, damage to equipment, or other material damage when the unit is connected to the electrical supply network.

- **Take suitable measures to prevent unintended starts.**

WARNING

UNINTENDED MOVEMENT

Unintended movement may occur when parameter changes are carried out immediately, which may result in death, serious injury, or damage to equipment.

- **When changing parameters, take suitable measures to ensure that unintended movement cannot pose any danger.**

1

⚠WARNING

DISCHARGE TIME

The servo drives and the SAB contain DC-link capacitors that remain charged for some time after the mains supply is switched off at the SAB. Failure to wait the specified time after power has been removed before performing service or repair work could result in death or serious injury.

- **To avoid electrical shock, fully disconnect the SAB from the mains and wait for at least the time listed in *Table 1.3* for the capacitors to fully discharge before carrying out any maintenance or repair work on the ISD 510 servo system or its components.**

Number	Minimum waiting time (minutes)
0–64 servo drives	10

Table 1.3 Discharge Time

NOTICE

Never connect or disconnect the hybrid cable to or from the servo drive when the ISD 510 servo system is connected to mains or auxiliary supply, or when voltage is still present. Doing so damages the electronic circuitry. Ensure that the mains supply is disconnected and the required discharge time for the DC-link capacitors has elapsed before disconnecting or connecting the hybrid cables or disconnecting cables from the SAB.

NOTICE

Full safety warnings and instructions are detailed in the *VLT® Integrated Servo Drive ISD 510 System Operating Instructions*.

1.7 Terminology

VLT® Integrated Servo Drive ISD 510	Integrated servo drive
VLT® Servo Access Box SAB®	Unit that generates the DC-link voltage and passes the U_{AUX}, Real-Time Ethernet, UDC, and STO signals to the servo drives via a hybrid cable.
PLC	External device for controlling the VLT® Integrated Servo Drive ISD® 510 System.
Loop cable	Hybrid cable for connecting servo drives in daisy-chain format.
Feed-in cable	Hybrid cable for connection from the SAB to the 1st servo drive.

Table 1.4 Terminology

An explanation of all terminology and abbreviations can be found in *chapter 7.1 Glossary*.

2 System Overview

2.1 General Description of the Servo System

The VLT® Integrated Servo Drive ISD® 510 System is a high-performance decentral servo motion solution.

It comprises:

- A central power supply: VLT® Servo Access Box (SAB®).
- VLT® Integrated Servo Drives ISD® 510.
- Cabling infrastructure.

The decentralization of the drive unit offers benefits in mounting, installation, and operation. Depending on the application, the SAB can power up to 64 servo drives in a servo drive system when using 2 hybrid lines. It generates a DC-link voltage of 565–680 V DC ±10% and guarantees high power density. It has a removable local control panel (LCP), and is based on the proven quality of a Danfoss frequency converter.
The motion control is integrated into the servo drive so that the motion sequences can take place independently. This reduces the required computing power of the central PLC and offers a highly flexible drive concept. Danfoss offers libraries for various IEC 61131-3 programmable PLCs. Due to the standardized and certified fieldbus interfaces of the ISD devices, any PLC with an EtherCAT® master functionality, or Ethernet POWERLINK® managing node functionality according to the standards can be used.
Hybrid cables are used to connect the servo drives, making installation fast and simple. These hybrid cables contain the DC-link supply, the Real-Time Ethernet, U_{AUX}, and STO signals.

NOTICE

The ISD 510 servo drives cannot be used in servo systems from other manufacturers without changing the cabling infrastructure. Contact Danfoss for further information.
Drives from other manufacturers cannot be used in the ISD 510 servo system when using Danfoss hybrid cables.

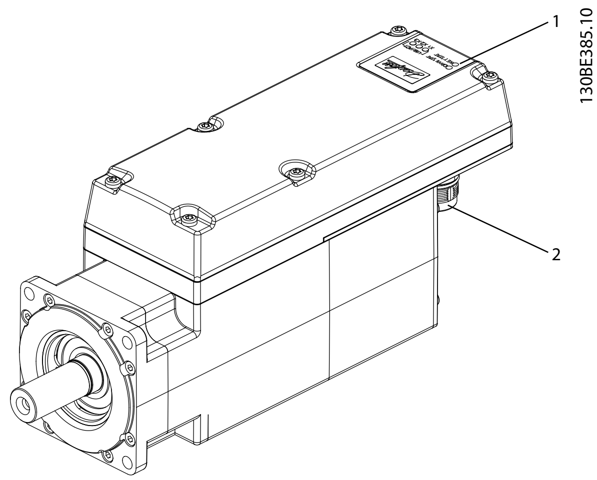
NOTICE

Only the components described in this manual may be fitted or installed. Third-party devices and equipment may be used only in consultation with Danfoss.

2.2 VLT® Integrated Servo Drive ISD® 510

ISD is the abbreviation of integrated servo drive, which is a compact drive with an integrated permanent magnet synchronous motor (PMSM). This means that the entire power drive system consisting of motor, position sensor, mechanical brake, and also power and control electronics is integrated into 1 housing. Additional circuits, such as low voltage supply, bus drivers, and functional safety are implemented within the servo drive electronics. All servo drives have 2 hybrid connectors (M23) that connect power and communication signals from a hybrid cable. The advanced version has 3 additional interfaces for external encoder or I/Os, fieldbus devices, and for the local control panel (LCP) to be connected directly.

LEDs on the top of the servo drive show the current status. Data transfer takes place via Real-Time Ethernet.



1	Operating LEDs
2	Connectors

Illustration 2.1 ISD 510 Servo Drive

Illustration 2.1 and *Table 2.1* show the external interfaces on the ISD 510 servo drive.

Interface	Description
Shaft	Mechanical interface.
Operating LEDs	Provides the status of the servo drive.
M23 hybrid input connector	Input connector for power and communication signals.
M23 hybrid output connector	Output connector for power and communication signals.
M8 4-pole connector (advanced servo drive only)	Input connector for fieldbus devices.
M12 8-pole connector (advanced servo drive only)	Input connector for external encoder or I/Os.
M8 6-pole connector (advanced servo drive only)	Input connector for LCP.

Table 2.1 External Interfaces on the ISD 510 Servo Drive

The ISD 510 servo drive has the flange sizes shown in *Table 2.2*.

	Size 1, 1.5 Nm	Size 2, 2.1 Nm	Size 2, 2.9 Nm	Size 2, 3.8 Nm
Flange size	76 mm	84 mm		

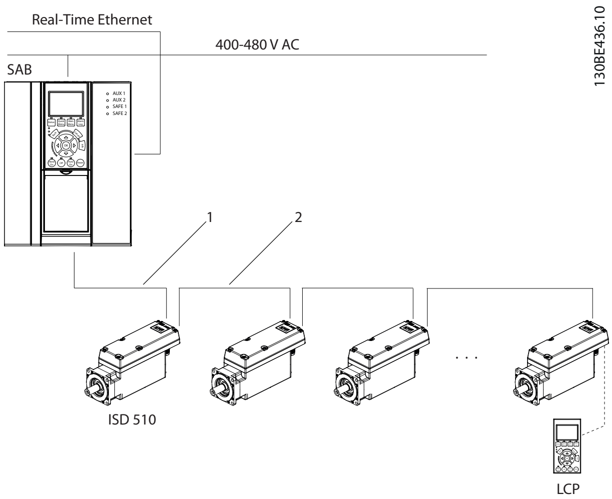
Table 2.2 Motor and Flange Sizes

All dimensions of the servo drive are listed in *chapter 6.1.1 Dimensions*.

2.3 System Wiring

2.3.1 Ethernet POWERLINK® without Redundancy

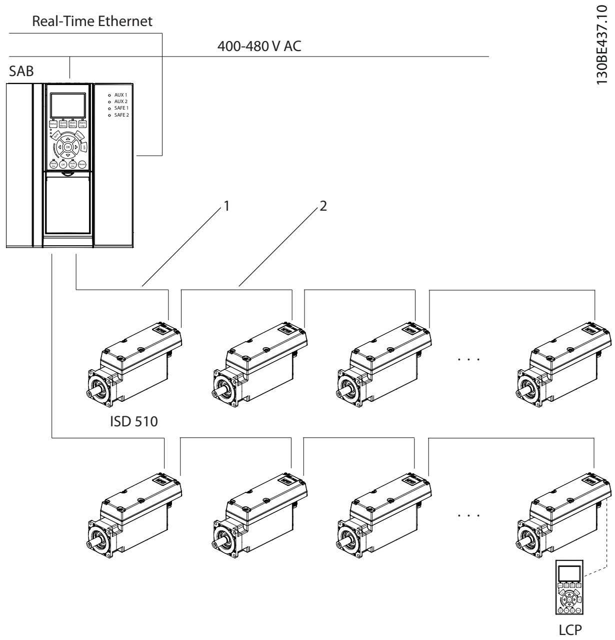
2.3.1.1 Standard Cabling Concept for 1 Line



1	M23 Feed-in cable
2	M23 Loop cable

Illustration 2.2 Standard Cabling Concept for 1 Line

2.3.1.2 Standard Cabling Concept for 2 Lines



1	M23 Feed-in cable
2	M23 Loop cable

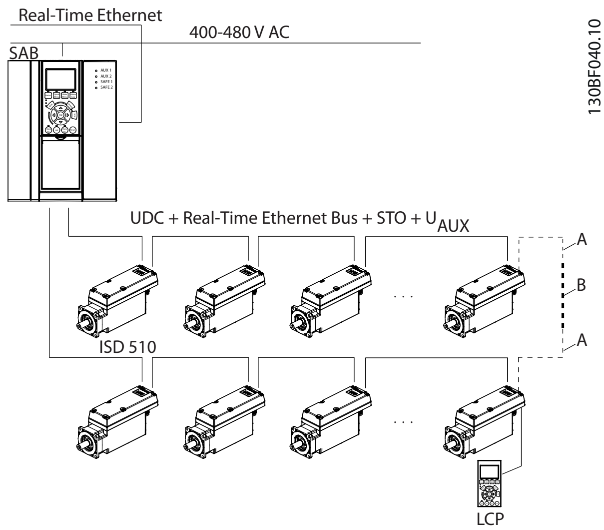
Illustration 2.3 Standard Cabling Concept for 2 Lines

2.3.2 Ethernet POWERLINK® with Redundancy

There are 2 methods to use Ethernet POWERLINK® with redundancy:

- Via a fieldbus extension cable
- Via the PLC

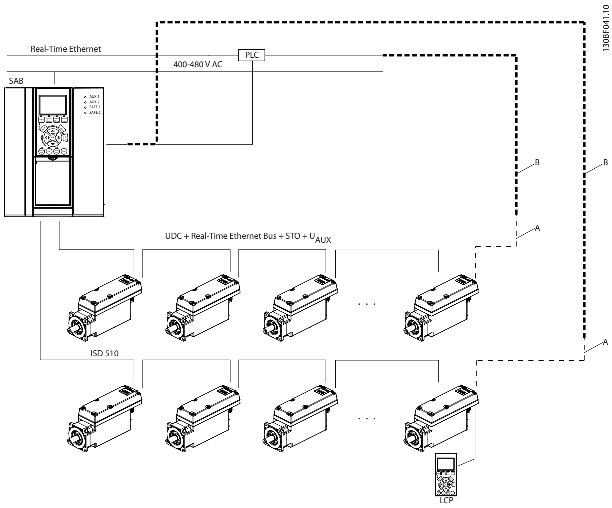
Illustration 2.4 shows Ethernet POWERLINK® with redundancy via a fieldbus extension cable.



A	Fieldbus extension cable
B	3rd party network cable

Illustration 2.4 Ethernet POWERLINK® with Redundancy via Fieldbus Extension Cable

Illustration 2.5 shows Ethernet POWERLINK® with redundancy via the PLC.

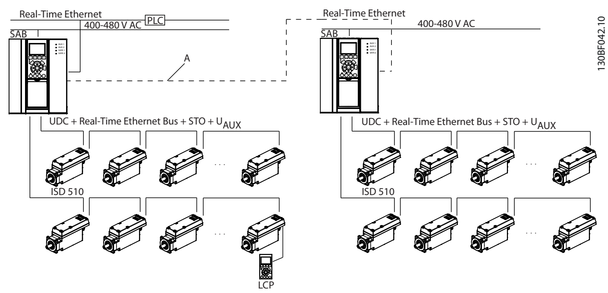


A	Fieldbus extension cable
B	3rd party network cable

Illustration 2.5 Ethernet POWERLINK® with Redundancy via PLC

2.3.3 Wiring with more than 1 SAB

Illustration 2.6 shows how to wire the servo system using >1 SAB.



A	3rd party network cable

Illustration 2.6 Wiring with >1 SAB

2.3.3.1 Ethernet POWERLINK®

To connect additional SAB units in the same Ethernet POWERLINK® network, use an RJ45 to RJ45 network cable from the *Ethernet X2* connection on the 1st SAB to the *Ethernet X1* connection on the 2nd SAB, and so on.

2.3.3.2 EtherCAT®

To connect additional SAB units in the same EtherCAT® network, use an RJ45 to RJ45 network cable from the *Ethernet X2* connection on the 1st SAB to the *Ethernet X1* connection on the 2nd SAB, and so on.

2.4 EtherCAT® with Redundancy

Ring redundancy can be achieved using a special cabling scheme. Connect the fieldbus extension cable to the last servo drive on the line and connect the other end of the cable with an Ethernet CAT5 cable. Settings must also be made in the engineering environment; see the corresponding online help for further information.

2.5 Description of Operation

Illustration 2.7 shows the VLT® Integrated Servo Drive ISD® 510 System and components.

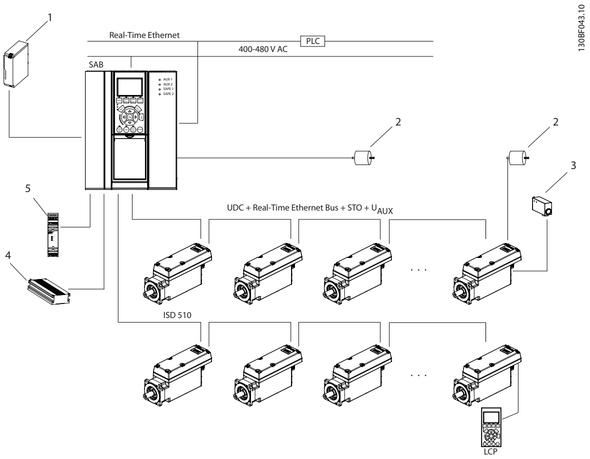


Illustration 2.7 Overview of the ISD 510 Servo System and Components

1	24/48 V power supply
2	Encoder
3	I/O
4	Brake resistor
5	Safety relay1)

Table 2.3 Legend to *Illustration 2.7*

1) Safety relays that have a plus and minus switching output signal can be directly connected to the ISD 510 servo system to activate STO.

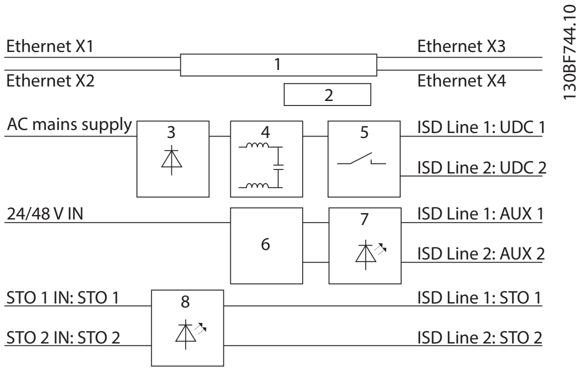
Component	Description
ISD 510 servo drive	Motors with integrated signal and power electronics. They are mounted decentrally in the application and have advanced motion control functionality on board.
Servo Access Box (SAB)	Central supply and access unit for mounting inside a control cabinet. The SAB is the power supply for the ISD 510 servo drives and is the central access point for the fieldbus.
Hybrid cable	There are 2 types of hybrid cable: • Feed-in cable: Connects the SAB to the 1st servo drive. • Loop cable: Connects the servo drives in an application in daisy-chain format. Speed connectors minimize installation time, cost, and risk of failures.
Local Control Panel (LCP)	Graphical user interface for diagnostic and operating purposes. The LCP is mounted on the SAB but can be removed and connected to the servo drive via connector X5 (advanced version only). The LCP can be used for the ID assignment of the advanced servo drives. The ID assignment is started via LCP and the LCP also indicates if the procedure is finished.
External encoder	An external encoder can be connected to each SAB and servo drive in the system.
PLC	PLC with Ethernet POWERLINK® and EtherCAT® fieldbus master functionality.
STO	Safe torque off feature can be provided via external safety circuits.
Analog/Digital Sensor	Connection to the servo drives is possible.
3rd party fieldbus device	Connection to the M8 4-pole fieldbus port on the servo drive (advanced servo drive only)

Table 2.4 ISD 510 System Components

2.6 Sequence of Operation

2.6.1 VLT® Servo Access Box (SAB)

Illustration 2.8 shows a simplified block diagram of the SAB.

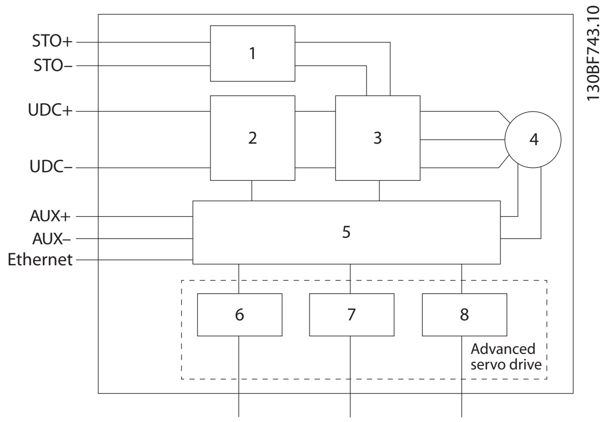


1	Control logic	Used for communication and monitors the status of the SAB.
2	SMPS (Switch mode power supply)	Used to generate the control voltage from the intermediate bus.
3	When power is first applied to the SAB, it enters through the input terminals (L1, L2, and L3) and on to the RFI filter.	
4	Following the rectifier section, voltage passes to the intermediate section. This rectified voltage is smoothed by a sine-wave filter circuit, consisting of the DC bus inductor and the DC bus capacitor bank. The DC bus inductor provides series impedance to changing current. This aids the filtering process while reducing harmonic distortion to the input AC current waveform normally inherent in rectifier circuits.	
5	Switch	For enabling or disabling the UDC output lines. Inrush current limitation for the servo drives is also done within this section.
6	Overvoltage/overcurrent protection	For the auxiliary line.
7	LED indicators	Show the presence of the AUX voltage at the outputs of the SAB.
8	LED indicators	Show the presence of the STO voltage.

Illustration 2.8 Simplified Block Diagram of the Servo Access Box

2.6.2 VLT® Integrated Servo Drive ISD 510

Table 2.1 shows a simplified block diagram of the ISD 510 servo drive.



1	STO circuit	If STO is activated, the STO circuit disables the inverter.
2	DC bus and filter	The DC bus and filter smooth the voltage.
3	Inverter	In the inverter section, once run command and speed/position references are present, the IGBTs begin switching to create the output waveform.
4	Motor	Synchronous permanent magnet motor.
5	Control circuit	Used for generating the PWM pattern and monitoring the status of the ISD.
6	X4: M12 I/O and/or encoder connector (advanced servo drive only)	This interface can be used to connect digital inputs/outputs. It can also be used for analog values. SSI/BISS encoders can be connected to this interface.
7	X5: LCP connector (advanced servo drive only)	An LCP can be connected to read out parameters and set-up of the servo drive.
8	X3: Ethernet connector (advanced servo drive only)	This interface can be used to connect external real-time Ethernet devices.

Illustration 2.9 Simplified Block Diagram of the ISD 510 Servo Drive

2.6.3 Switching on the VLT® Integrated Servo Drive ISD 510 System

The cabling in the ISD 510 servo system provides the supply voltage and the communication signals. This is a fundamental requirement for operation of the servo drives.

The ISD 510 servo system can be switched on in 3 ways:

- If the SAB is supplied with mains and U_{AUX}, communication to the SAB internal controller is established and U_{AUX} is automatically passed on to the connected servo drives.
- If the SAB is only powered by U_{AUX}, then the SAB and servo drive control units are running.

2

- If the SAB is only supplied with mains power, then only the SAB control unit is running and power is not passed on to the connected servo drives.

Procedure for switching on the ISD 510 servo system

1. Switch U_{AUX} power on to enable communication to the SAB and servo drives.
2. Switch the mains on.
3. Set the SAB to state *Operation Enabled*.
4. The SAB and servo drives are now ready for operation.

2.7 Functional Safety Concept

2.7.1 Notes

Use of the STO function requires that all provisions for safety, including relevant laws, regulations, and guidelines, are satisfied.

The integrated STO function complies with the following standards:

- EN 60204-1: 2006 Stop Category 0 – uncontrolled stop
- IEC/EN 61508: 2010 SIL 2
- IEC/EN 61800-5-2: 2007 SIL 2
- IEC/EN 62061: 2005 SIL CL2
- EN ISO 13849-1: 2015

The VLT® Integrated Servo Drive ISD 510 System has been tested for higher EMC immunity as described in EN 61800-5-2:2017.

2.7.2 Abbreviations and Conventions

Abbreviation	Reference	Description
Cat.	EN ISO 13849-1	Category, level B, 1–4
DC	–	Diagnostic coverage
FIT	–	Failure in time Failure rate: 1E-9/hour
HFT	EN IEC 61508	Hardware fault tolerance H = n means that n + 1 faults may lead to a loss of the safety function.
$MTTF_D$	EN ISO 13849-1	Mean time to failure – dangerous Unit: years
PFH	EN IEC 61508	Probability of dangerous failures per hour Take this value into account if the safety device is operated in high demand mode or in continuous operating mode, where the frequency of demands for operation made on a safety-related system occurs more than once per year.
PFD	EN IEC 61508	Average probability of failure on demand This value is used for low demand operation.
PL	EN ISO 13849-1	Performance level A discrete level used to specify the capability of safety-related parts of a system to perform safety-oriented functions under foreseeable conditions. Levels: a–e.
SFF	EN IEC 61508	Safe Failure Fraction [%] Proportion of safe failures and detected dangerous failures of a safety function or a subsystem as a percentage of all possible failures.
SIL	EN IEC 61508 EN IEC 62061	Safety Integrity Level
STO	EN IEC 61800-5-2	Safe Torque Off

Table 2.5 Abbreviations and Conventions

2.7.3 Functional Description

The STO function in the VLT® Integrated Servo Drive ISD 510 System features a separate STO function for each line of servo drives in daisy-chain format. The function is activated by inputs on the SAB. Using the STO function activates the STO for all servo drives on that line. Once the STO is activated, no torque is generated on the axes. Reset of the safety function and diagnostics can be carried out via the PLC.

NOTICE

The ISD 510 servo system does not implement a manual reset function as required by ISO 13849-1. The standard failure reset from the PLC cannot be used for this purpose.
For automatic restart without manual reset, observe the requirements detailed in paragraph 6.3.3.2.5 of ISO 12100:2010 or equivalent standard.

NOTICE

Carry out a risk assessment to select the correct stop category for each stop function in accordance with EN 60204-1.

NOTICE

When designing the machine application, consider timing and distance for coast to stop (*Stop Category 2* or STO). See EN 60204-1 for further information.

NOTICE

All signals connected to the STO must be supplied by a SELV or PELV supply.

2.7.4 Installation

Only Danfoss cables may be used for the installation of the servo system, however cables from other suppliers may be used for the user connection to the STO terminals (*STO 1 IN* and *STO 2 IN*) on the SAB.

NOTICE

If the application does not require the Safe Torque Off (STO) functionality, build a bridge by connecting +24 V from the connector *STO 1 IN: +24V* to *STO 1 IN: +STO*, and from *STO 1 IN: –24 V* to *STO 1 IN: –STO*. Repeat this process for STO line 2 if used.

Safety relays that have a plus and minus switching output signal can be directly connected to the VLT® Integrated Servo Drive ISD 510 System to activate STO (see *Illustration 2.10*). Route the wires for STO 1 and STO 2 separately and not in a single multicore cable.

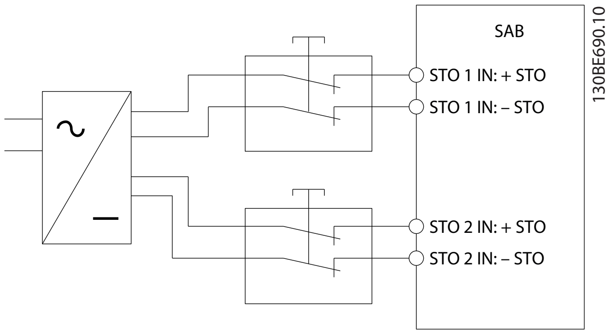


Illustration 2.10 Safety Relay with Plus and Minus Switching Output

Signals with test pulses must not have test pulses of >1 ms. Longer pulses may lead to reduced availability of the servo system.

2.7.5 Commissioning Test

NOTICE

Perform a commissioning test after installation of the STO function, after every change to the installed function, or after a safety fault. Perform the test for each STO line.

There are 2 ways to implement the commissioning test depending on the method used to program the PLC, however the steps of the test are the same:

- Using the Danfoss Library or the TwinCAT® Library.
- Bit-wise readout of the status.

Commissioning test using libraries

Depending on the application, 1 or both of the following libraries are required to program the commissioning test:

- Danfoss Library
  - MC_ReadAxisInfo_ISD51x
  - MC_ReadStatus_ISD51x
  - MC_ReadAxisError_ISD51x
  - MC_Reset_ISD51x
- TwinCAT® Library
  - MC_ReadStatus
  - MC_ReadAxisError
  - MC_Reset

	Test steps	Reason for the test step	Expected result for Danfoss library	Expected result for TwinCAT® library
1	Run the application (all the servo drives are enabled).	Check that the application can run.	Application runs as expected.	Application runs as expected.
2	Stop the application.	–	All servo drives are at speed 0 RPM.	All servo drives are at speed 0 RPM.
3	Disable all the servo drives.	–	All servo drives are disabled.	All servo drives are disabled.
4	Enable STO.	Check that STO can be activated without error.	*MC_ReadAxisInfo_ISD51x output SafeTorqueOff* = True for all servo drives on the corresponding line.	–
5	Disable STO.	Check that STO can be deactivated without error. No reset is required.	*MC_ReadAxisInfo_ISD51x output SafeTorqueOff* = False for all servo drives on the corresponding line.	–
6	Run the application (all the servo drives are enabled).	–	Application runs as expected.	Application runs as expected.
7	Enable STO.	Check that errors are generated correctly when STO is activated while the servo drives are running.	Motors are torque free. Motors coast and stop after some time. *MC_ReadAxisInfo_ISD51x output SafeTorqueOff* = True and *MC_ReadStatus_ISD51x output ErrorStop* = True and *MC_ReadAxisError_ISD51x output AxisErrorID* = 0xFF80 on all enabled servo drives.	Motors are torque free. Motors coast and stop after some time. For enabled motors: *MC_ReadStatus output ErrorStop* = True and *MC_ReadAxisError output AxisErrorID* = 0xFF80 on all enabled servo drives.
8	Try to run the application (enable 1 or more servo drives).	Checks that the STO function is working correctly.	Application does not run.	Application does not run.
9	Disable STO.	Check that the STO start is still inhibited by the error signal.	*MC_ReadAxisInfo_ISD51x output SafeTorqueOff* = False and *MC_ReadStatus_ISD51x output ErrorStop* = True	*MC_ReadStatus output ErrorStop* = True
10	Try to run the application (enable 1 or more servo drives).	Check whether reset is required.	Application does not run.	Application does not run.
11	Send a reset signal via *MC_Reset(_ISD51x)*.	–	*MC_ReadAxisInfo_ISD51x output SafeTorqueOff* = False and *MC_ReadStatus_ISD51x output ErrorStop* = False	*MC_ReadStatus output ErrorStop* = False
12	Try to run the application (all servo drives are enabled).	–	Application runs as expected.	Application runs as expected.

Table 2.6 Commissioning Test using Libraries

Commissioning test using bit-wise readout

	Test steps	Reason for the test step	Expected result
1	Run the application (all the servo drives are enabled).	Check that the application can run.	Application runs as expected.
2	Stop the application.	–	All servo drives are at speed 0 RPM.
3	Disable all the servo drives.	–	All servo drives are disabled.
4	Enable STO.	Check that STO can be activated without error.	*Statusword* bit 3 = 0 and bit 14 =1 in all servo drives.
5	Disable STO.	Check that STO can be deactivated without error. No reset is required.	*Statusword* bit 3 = 0 and bit 14 =0 in all servo drives.
6	Run the application (all the servo drives are enabled).	–	Application runs as expected.
7	Enable STO.	Check that errors are generated correctly when STO is activated while the servo drives are running.	Motors are torque free. Motors coast and stop after some time. *Statusword* bit 3 = 1, bit 14 = 1 and object 0x603F shows fault 0xFF80 in all servo drives.
8	Try to run the application (enable 1 or more servo drives).	Checks that the STO function is working correctly.	Application does not run.
9	Disable STO.	Check that the STO start is still inhibited by the error signal.	*Statusword* bit 3 = 1, bit 14 = 0 and object 0x603F shows fault 0xFF80 in all servo drives.
10	Try to run the application (enable 1 or more servo drives).	Check whether reset is required.	Application does not run.
11	Send a reset signal via the PLC.	–	*Statusword* bit 3 = 0 in all servo drives.
12	Try to run the application (all servo drives are enabled).	–	Application runs as expected.

Table 2.7 Commissioning Test using Bit-Wise Readout

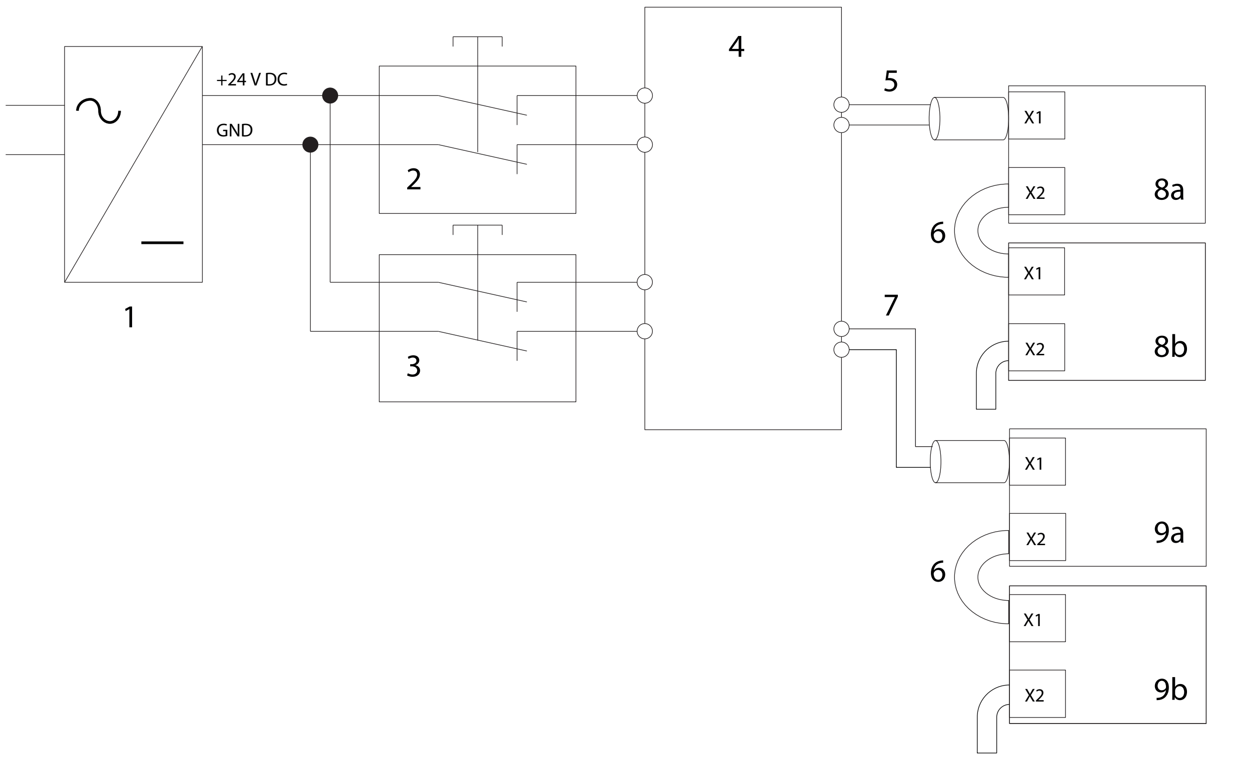
2.7.6 Application Example

Illustration 2.11 shows an example of an installation for 2 lines that can be put in Safe Torque Off mode by separate safety circuits for each line.

The safety circuits may be remote from each other and are not supplied from the VLT® Integrated Servo Drive ISD 510 System.

The 2 lines in the example are controlled separately. If the Safe Torque Off function is triggered on line 1, line 2 remains in normal operation and the servo drives on this line are not affected. There may still be a hazard from the servo drives on line 2.

Select the safety switch devices in accordance with the requirements of the application.



1a/1b	ISD 510 servo drive on line 1	8	Line 2 emergency stop button
2a/2b	ISD 510 servo drive on line 2	9	Line 2 safety device contacts
3	Servo Access Box (SAB)	10	Line 1 hybrid cable
4	Safety device on line 1	11	Line 2 hybrid cable
5	Line 1 emergency stop button	12	Feed-in cable
6	Line 1 safety device contacts	13	Loop cable
7	Safety device on line 2	14	24 V DC supply

Illustration 2.11 Application Example: Safe Torque Off Function with 2 Lines

2.7.7 Safety Function Characteristic Data

General information	
Response time (from switching on the input until torque generation is disabled)	<100 ms
Lifetime	20 years
Data for EN/ISO 13849-1	
Performance level (PL)	d
Category	3
Mean time to dangerous failure ($MTTF_d$) for maximum system size of 32 servo drives on each STO line	233 years (limited to 100 years if the VLT® Integrated Servo Drive ISD 510 System forms an entire safety channel)
Diagnostic coverage (DC)	60%
Data for EN/IEC 61508 and EN/IEC 62061	
Safety integrity level (SIL)	2
Probability of failure per hour (PFH) for maximum system size of 32 servo drives on each STO line	$<5 \times 10^{-8}$/h
Safe failure fraction (SFF)	>95%
Hardware fault tolerance (H)	0
Subsystem classification	Type A
Proof test interval	1 year

Table 2.8 Safety Function Characteristic Data

2.8 Communication

2.8.1 Fieldbus

The VLT® Integrated Servo Drive ISD 510 System has an open system architecture realized by fast Ethernet (100BASE-T) based communication. The system supports both EtherCAT® and Ethernet POWERLINK® fieldbuses. See the *VLT® Integrated Servo Drive ISD® 510 System Programming Guide* for further information.

In productive environments, communication to the devices always takes place via a PLC that acts as a master. The servo drives and the SABs can be controlled by these communication methods:

- Using the Danfoss VLT® Servo Motion library (available for TwinCAT® and Automation Studio™).
- Using the NC axis functionality of TwinCAT® for the servo drives.
- Using the CANopen® CiA DS 402 standard by reading and writing to objects.

The servo drives and the SABs can be operated with the following cycle times (for both fieldbuses):

- 400 μs and multiples of it (for example, 800 μs, 1200 μs, and so on).
- 500 μs and multiples of it (for example, 500 μs, 1 ms, and so on).

When the cycle time is a multiple of 400 μs and 500 μs, the time base of 500 μs is used.

The servo drive and the SAB are certified for both fieldbuses according to the corresponding rules and regulations. The servo drive conforms to the CANopen® CiA DS 402 Drive Profile.

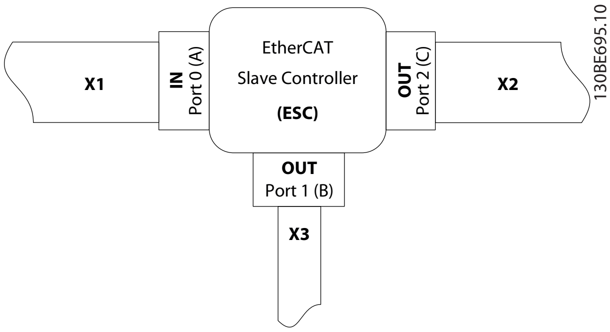
2.8.1.1 EtherCAT®

The servo drive and the SAB support the following EtherCAT® protocols:

- CANopen over EtherCAT® (CoE)
- File Access over EtherCAT® (FoE)
- Ethernet over EtherCAT® (EoE)

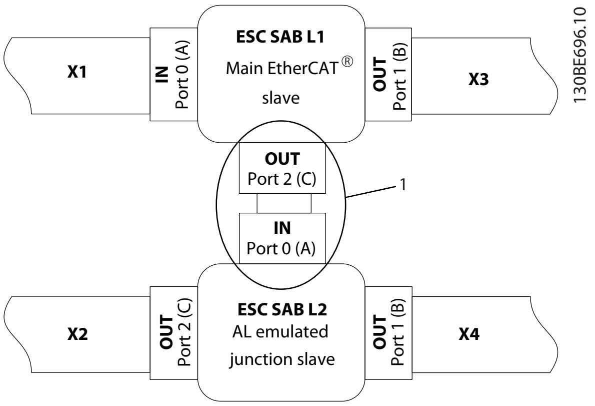
The servo drive and the SAB support distributed clocks. To compensate for the failure of a communication cable section in the system, cable redundancy is available for both fieldbuses.

The EtherCAT® port assignment for the servo drive and SAB is shown in *Illustration 2.12* and *Illustration 2.13*.



X1	M23 hybrid cable connector to SAB or previous servo drive.
X2	M23 hybrid cable connector to the next servo drive.
X3	M8 Ethernet cable connector to other EtherCAT® slaves, for example EtherCAT® encoder. The connector is only available on the advanced servo drive.

Illustration 2.12 EtherCAT® Port Assignment for the ISD 510 Servo Drive



1	Ports always connected internally in the SAB.
X1	RJ45 cable connector to the PLC or previous slave.
X2	RJ45 cable connector to the PLC or next slave.
X3	M23 feed-in cable to the 1st servo drive on line 1 with RJ45 connector.
X4	M23 feed-in cable to the 1st servo drive on line 2 with RJ45 connector.

Illustration 2.13 EtherCAT® Port Assignment for the SAB in Line Topology Mode (default)

2.8.1.2 Ethernet POWERLINK®

The servo drive and the SAB are certified according to DS301 V1.1.0. The following features are supported for the servo drive and the SAB:

- Work as controlled node.
- Can be operated as multiplexed stations.
- Support of cross-communication.
- Ring redundancy is supported for media redundancy.

Specific ports are not assigned for Ethernet POWERLINK®.

2.8.2 PC-Software

The DDS Toolbox is a standalone PC software designed by Danfoss. It is used for parameterization and diagnostics of the servo drives and the SAB and can also be used to operate the devices in a non-productive environment. The DDS Toolbox contains several functionalities, called sub-tools, which in turn provide various functionalities.

The most important sub-tools are:

- *Scope* for visualization of the tracing functionality of the servo drives and SAB.
- *Parameter list* for reading/writing parameters.
- *Firmware update*
- *ISD 500 Drive control/SAB control* to operate the servo drives and/or SAB for testing purposes.
- *CAM editor* for designing CAM profiles for the servo drives.

The detailed description of the DDS Toolbox functionality and the full parameter lists can be found in the *VLT® Integrated Servo Drive ISD® 510 System Programming Guide*.

2.8.2.1 System Requirements

To install the DDS Toolbox software, the PC must meet the following requirements:

- Supported hardware platforms: 32-bit, 64-bit.
- Supported operating systems: Microsoft® Windows XP Service Pack 3, Windows 7, Windows 8.1.
- .NET framework version: 3.5 Service Pack 1.
- Minimum hardware requirements: 512 MB RAM, Intel Pentium 4 with 2.6 GHz or equivalent, 40 MB hard disk space.
- Recommended hardware requirements: Minimum 1 GB RAM, Intel Core i5/i7 or compatible.

2.9 Operating Modes

The VLT® Integrated Servo Drive ISD 510 implements several modes of operation. The behavior of the servo drive depends on the activated mode of operation. It is possible to switch between the modes while the servo drive is enabled. The supported modes of operation are according to CANopen® CiA DS 402 and there are also ISD-specific modes of operation. All supported modes of operation are available for *EtherCAT®* and Ethernet *POWERLINK®*.
The various modes of operation are described in detail in the *VLT® Integrated Servo Drive ISD® 510 System Programming Guide*.

Mode	**Description**
ISD Inertia measurement mode	This mode measures the inertia of an axis. It is used to measure the inertia of the servo drive and the external load, and to optimize the control loop settings. The friction effects are eliminated automatically.
Profile velocity mode	In profile velocity mode, the servo drive is operated under velocity control and executes a movement with constant speed. Additional parameters, such as acceleration and deceleration, can be parameterized.
Profile position mode	In profile position mode, the servo drive is operated under position control and executes absolute and relative movements. Additional parameters, such as velocity, acceleration, and deceleration, can be parameterized.
Profile torque mode	In profile torque mode, the servo drive is operated under torque control and executes a movement with constant torque. Linear ramps are used. Additional parameters, such as torque ramp and maximum velocity, can be parameterized.
Homing mode	In homing mode, the application reference position of the servo drive can be set. Several homing methods, such as homing on actual position, homing on block, limit switch, or home switch are available.
CAM mode	In CAM mode, the servo drive executes a synchronized movement based on a master axis. The synchronization takes place by means of a CAM profile that contains slave positions corresponding to master positions. CAMs can be designed graphically with the DDS Toolbox software, or can be parameterized via the PLC. The guide value can be provided by an external encoder, virtual axis, or the position of another axis.
Gear mode	In gear mode, the servo drive executes a synchronized movement based on a master axis by using a gear ratio between the master and the slave position. The guide value can be provided by an external encoder, virtual axis, or the position of another axis.
Cyclic synchronous position mode	In cyclic synchronous position mode, the trajectory generator of the position is located in the control device, not in the servo drive.
Cyclic synchronous velocity mode	In cyclic synchronous velocity mode, the trajectory generator of the velocity is located in the control device, not in the servo drive.

Table 2.9 Operating Modes

2

2.10 Automated Operational Functions

2.10.1 Short Circuit Protection

2.10.1.1 Servo Access Box Features

The SAB has several protection functions for limiting the current:

- I_N 100% (15 A_{RMS}), no limitation.
- 100–200% current is limited by an I^2t function. A load of 160% is allowed for 1 minute. The RMS current must be lowered to ≤100% before a new overload is allowed. The time taken to reset the I^2t function depends on the load current. A 2 A overload for 10 s (17 A) requires a nominal current of ≤13 A for 10 s to reset the I^2t function.

I_{DC} protection (UDC)

- Imax0: At 200% RMS, the output will be disconnected within 1.5 s.
- Imax1: At 51 A peak current, the output will be disconnected within 500 µs.
- Imax2: At 125 A peak current, the output will be disconnected within 10 µs.

I_{AUX} protection

- Software limit range: 0–15 A
    - A warning and alarm is issued at user-specified levels. A warning is issued at 90% of the selected value. An alarm is issued when the measured value has exceeded the software limit.
- These software limits are disabled by default. See parameters *AUX line 1 user current limit* and *AUX line 2 user current limit* in the *VLT® Integrated Servo Drive ISD 510 System Programming Guide*.
- A low-pass filter is implemented in the firmware to avoid unintended warnings or alarms due to inrush currents.

2.10.1.2 ISD 510 Servo Drive Features

To protect the servo drive and the machinery attached to the servo drive shaft, a current limit protection is implemented in the servo drive.

Current limit protection is implemented on the servo drive and the currents are constantly monitored. If an overcurrent occurs, an error is issued and the servo drive coasts to stop as default. For servo drives with the mechanical brake option, the brake engages.

2.10.2 Ground Fault Protection

When a ground fault current of >3 A is present, a warning is issued immediately. The SAB issues an error if the warning is present for 10 s.

2.10.3 Temperature-controlled Fans

The SAB has 2 built-in forced air convection fans to ensure optimum cooling. The main fan forces the airflow along the cooling fins on the heat sink, ensuring cooling of the internal air. A secondary fan cools the SAB power control board. Both fans are controlled by the internal temperature and speed increases. The fans not only ensure maximum cooling when required, but also reduce noise and energy consumption when the workload is low.

If overtemperature occurs in the SAB, an error/warning is issued, resulting in a coast and trip lock.

2.10.4 Thermal Protection

Thermal protection exists for both the servo drive and the SAB. See *chapter 4.6.3 Thermal Protection* for further information.

2.10.5 Additional Protection Features

2.10.5.1 Servo Access Box

The SAB has the additional protection features detailed in *Table 2.10*.

Function	Description	Limits/errors
UDC overvoltage	When the DC-link voltage rises above a certain level, a warning/error is issued. A brake resistor can be connected to the SAB and activated via *parameter 0x2030* in the DDS Toolbox software.	• Brake active: >778 V • Warning: >810 V • Error: >820 V
UDC undervoltage	When the DC-link voltage drops below a certain level, a warning/error is issued.	• Warning: <410 V • Error: <373 V

Function	Description	Limits/errors
AUX overvoltage	When the AUX voltage rises above a certain level, a warning/error is issued.	• Warning: >53 V • Error: >56 V
AUX undervoltage	When the AUX voltage drops below a certain level, a warning/ error is issued.	• Warning: <21.6 V • Error: <19 V
AUX overcurrent	When the AUX current rises above a certain level, a warning/error is issued.	• Warning: >90% of user-defined limit • Error: >100% of user-defined limit The default value of 15 A is used if no limits are defined by the user.
Brake error	The SAB reports various brake-related errors.	• Shorted brake resistor • Shorted brake IGBT • Thermal overload • Disconnected brake resistor
Inrush fault	The SAB can handle up to 2 inrush cycles per minute.	Error issued if >2 inrush cycles occur per minute.
Mains phase loss	The SAB detects the mains phase loss and issues a warning/error when limits are reached.	• Warning: 3–10% mains phase imbalance • Error: - >10% mains phase imbalance - 3–10% mains phase imbalance for >10 minutes
STO 1 & STO 2 indicators	The SAB indicates the presence of the STO 1 & STO 2 voltage.	LED on: STO deactivated LED off: STO activated

Table 2.10 Additional Protection Features for SAB

2.10.5.2 VLT® Integrated Servo Drive ISD 510

The VLT® Integrated Servo Drive ISD 510 has the additional protection features detailed in *Table 2.10*.

Function	Description	Limits/errors
UDC overvoltage	When the DC-link voltage rises above a certain level, a warning/error is issued.	• Warning: >810 V • Error: >820 V
UDC undervoltage	When the DC-link voltage drops below a certain level, a warning/error is issued.	• Warning: <410 V • Error: <373 V
Overcurrent at output	To protect the servo drive and any machinery attached to the servo drive shaft, a current limit protection is implemented. The current limit protection on the servo drive is available for motor phase current. All 3 phase currents are constantly monitored. If an overcurrent occurs, the servo drive stops the actual operation. The servo drive stops the shaft rotation, engages the brake (if present), and an error is issued.	• Size 1: >8 A • Size 2: >9 A
Motor position	CRC check of each encoder value, resolver amplitude, and consistency check.	–
Brake control	The brake current is controlled by the servo drive firmware.	–
Maximum shaft speed	The shaft speed of each servo drive type is limited to protect the motor mechanical parts.	Maximum motor speed: • Size 1, 1.5 Nm: 7000 RPM • Size 2, 2.1 Nm: 6000 RPM • Size 2, 2.9 Nm: 5000 RPM • Size 2, 3.8 Nm: 4000 RPM
Torque limit	The application peak torque limit [M_{max}] can be set via parameters *52-15*, *52-23*, and *52-36 Application Torque Limit (0x2053)*. The maximum torque per servo drive is calculated as: *Maximum phase current x torque factor*	Peak torque M_{max}: • Size 1, 1.5 Nm: 6.1 Nm • Size 2, 2.1 Nm: 7.8 Nm • Size 2, 2.9 Nm: 10.7 Nm • Size 2, 3.8 Nm: 12.7 Nm

Table 2.11 Additional Protection Features for ISD 510 Servo Drive

2.11 Custom Application Functions

2.11.1 Brake Resistor

When the servo drives are decelerating, the motors act like a generator. This means that the energy coming back from the servo drives is collected in the DC-link. The function of the brake resistor is to provide a load on the DC-link during braking, thereby ensuring that the brake power is absorbed by the brake resistor. If no brake resistor is used and the servo drives are decelerating, the DC-link voltage will rise to a dangerous level. The SAB disconnects the ISD lines when the DC-link voltage is too high. A DC-link overvoltage will result in damage to the SAB and the servo drives.

2.11.1.1 Mechanical Installation

The brake resistors are cooled by natural convection.

The ventilation must be efficient enough to dispatch the regenerative power in the brake resistor.

2.11.1.2 Electrical Installation

EMC precautions

The following EMC precautions are recommended to achieve interference-free operation of fieldbus cables, and digital and analog inputs and outputs.

Observe any relevant national and local regulations, for example regarding protective earth connection.

Keep the fieldbus cables away from the brake resistor cables to avoid coupling of high frequency noise from one cable to the other. The minimum distance of 200 mm is sufficient, however a greater distance between the cables is recommended, especially where the cables run in parallel over long distances. When crossing is unavoidable, the fieldbus cables must cross the brake cable at an angle of 90°.

Cable connection
To comply with the EMC emission and immunity specification, the use of shielded/armored cables is mandatory.

Brake cable
Maximum length: 20 m shielded cable

Ensure that the connection cable to the brake resistor is shielded. Use cable clamps to connect the shielding to the conductive decoupling plate of the SAB, and to the brake resistor metal cabinet.

Protective functions
The VLT® Brake Resistor MCE 101 is equipped with a galvanic isolated temperature switch (PELV) that is closed under normal operating conditions and opens if the brake resistor overheats.

The temperature switch can be used as an overtemperature protection feature to prevent damage to the brake resistor caused by overtemperature.
The temperature switch can also be used to disable the mains supply to the SAB by a contactor.

1. Connect the built-in thermal switch on the brake resistor to the K1 input contactor.
2. Connect the start and stop push buttons in series with the thermal switch.
3. Connect to a contactor in the mains supply on the front of the SAB.

Thermal overheating in the brake resistor disables the mains supply of the SAB.

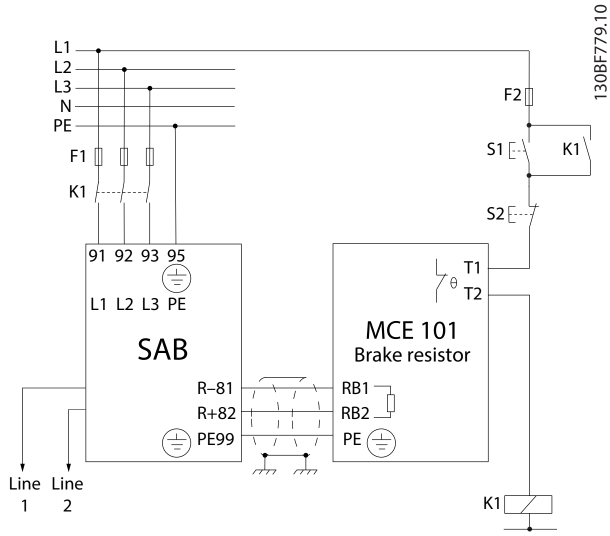


Illustration 2.14 Temperature Switch Disconnecting the Mains from the SAB

In addition, the brake power monitor function enables readouts of the momentary power and the mean power for a selected period. A brake power limit can be set and if the brake power exceeds the set limit, the SAB issues a warning or an error. When the SAB issues a warning, the UDC output remains enabled. However, when an error is issued, the UDC output to the servo drives is disconnected. The brake is protected against short-circuiting of the brake resistor, and the brake transistor is monitored to ensure that short-circuiting of the transistor is detected.

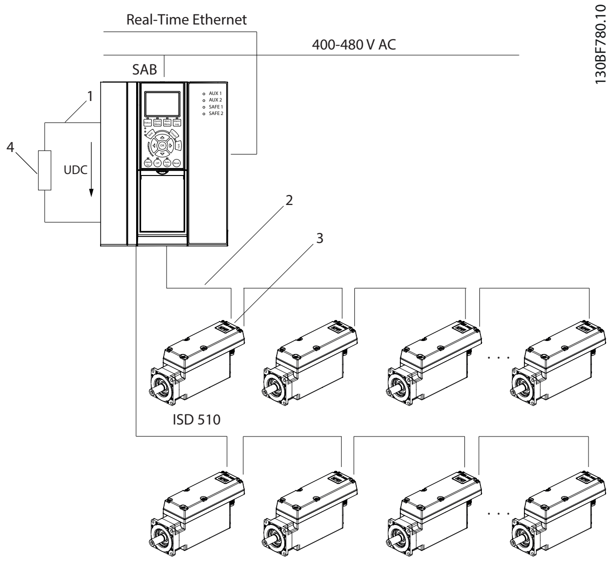
2.11.1.3 Brake Resistor Calculation

To select the most suitable brake resistor for a given application, the following information is required:

- The number of servo drives in the application.
- The inertia connected to the servo drives.
- The braking/accelerating profile.

Brake set-up

Illustration 2.15 shows the brake set-up in the VLT® Integrated Servo Drive ISD 510 System.



1	I_{brake}
2	P_{Line}
3	P_{ISD}
4	Brake resistor R_{brake}: Absorbs brake power P_{brake}.

Illustration 2.15 Brake Set-up

Brake resistance

To prevent the SAB from cutting out for protection when the servo drives are braking, select brake resistor values on the basis of the peak braking power.

$$R_{brake} = \frac{UDC^2}{P_{peak\ brake}}$$

The SAB starts braking when the UDC voltage exceeds 778 V.

The brake resistor can range from 54.6–200 Ω. Brake resistors within this range are detected by the configurable brake check. The brake check is executed each time before the SAB enters the state *Operation enabled* and when mains is powered up. The brake check activates the brake and checks if the DC-link voltage drops.

The minimum brake resistance is 54.6 Ω. When higher brake resistor resistance is selected, the maximum braking torque cannot be reached, and there is a risk that the SAB will cut out due to DC-link overvoltage protection.

Calculation of brake power

When calculating the brake power, ensure that the brake resistor is scaled for the average power as well as for the peak power.

- The peak brake power depends on the number of servo drives that are in acceleration mode and deceleration mode. The torque used to accelerate and decelerate is also important.
- The average power is determined by the process period time, for example the length of the braking time in relation to the process period time.

Calculation of brake resistor peak power

The brake active voltage for the SAB is 778 V. When using the minimal brake resistance of 54.6 Ω, a current of 14.25 A will flow at 778 V.
The brake resistor peak power is then calculated as follows:

$$P_{peak\ brake} = \frac{UDC^2}{R_{brake\ min}} = \frac{778\ V \times 778\ V}{54.6\ \Omega} = 11086\ W$$

If the application does not require braking with the maximum current, a higher brake resistance can be selected. A higher brake resistance results in a lower brake peak power.
When the servo drives are accelerating, $P_{ISD\ n}$ is positive.
When the servo drives are decelerating, $P_{ISD\ n}$ is negative.
If the sum of all P_{ISD} connected to the SAB results in a negative value, the energy must be absorbed in the brake resistor.
If the sum of all $P_{ISD\ n}$ is positive, energy from the mains is converted into rotation energy and the brake resistor does not need to absorb energy.

To calculate the peak brake power, select the moment where the most servo drives are decelerating and the fewest servo drives are accelerating.
The peak power of a decelerating servo drive can be calculated as:

$$P_{peak\ ISD} = \eta_{ISD} \times \omega_{Start} \times j \times \frac{\Delta\omega}{\Delta t}$$

$$P_{peak\ ISD} = \eta_{ISD} \times n_{Start} \times \left(\frac{2 \times \pi}{60}\right) \times j \times \frac{\Delta n}{\Delta t}$$

j: Shaft inertia
n_{ISD}: Efficiency of the servo drive (typically 0.88)

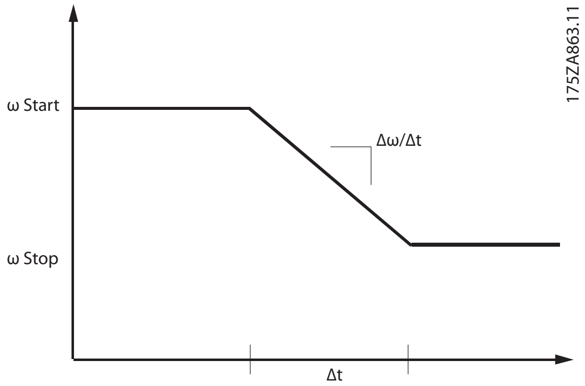


Illustration 2.16 Decelerating Servo Drive

The peak power connected to line 1 can be calculated as:

$$P_{peak\ ISD\ line\ 1} = P_{Peak\ ISD\ 1.1} + P_{Peak\ ISD\ 1.2} + P_{Peak\ ISD\ 1.n} + \ldots$$

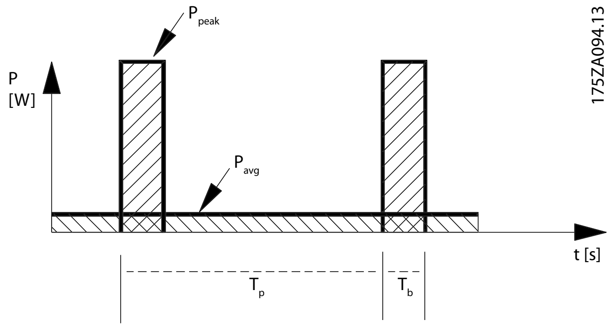
The calculation for line 2 can be done in the same way.

The maximum peak brake power is the sum of the peak brake power on both lines when the result is a negative value.

$$P_{peak\ brake} = P_{Peak\ ISD\ line\ 1} + P_{Peak\ ISD\ line\ 2}$$

With $P_{peak\ brake}$, the optimal resistance value can be calculated using the formula for brake resistance.

Calculation of brake resistor average power
The average power is determined by the length of the braking time in relation to the process period.



T_p	Process period time in s.
T_b	Braking time in s.

Illustration 2.17 Relation between Average Power and Peak Power

The average power is calculated as follows:

$$P_{ave} = P_{peak} \times \frac{T_p}{T_b}$$

The duty cycle is calculated as follows:

$$Duty\ cycle\ [\%] = \frac{T_p \times 100}{T_b}$$

Danfoss offers brake resistors with a duty cycle of maximum 10% and 40%. If a 10% duty cycle is applied, the brake resistors are able to absorb P_{peak} for 10% of the period time. The remaining 90% of the period is used on deflecting excess heat.

2.11.2 External Encoder and Sensors

2.11.2.1 External Encoder

An external encoder can be connected to the X4 connector on the advanced servo drive or the encoder connector on the SAB. The encoder value can be used as guide value provider.

Further information on external encoders and sensors can be found in the *VLT® Integrated Servo Drive ISD® 510 Operating Instructions*.

2.11.2.2 Sensor

The M12 I/O and/or encoder connector (X4) is available of the advanced servo drive. See *chapter 6.1.2.1 Connectors on the Servo Drives* for pin assignment.

2.11.3 Relays

Relays are used for customer-defined reactions. For example, the relay can be triggered if the SAB issues a warning.

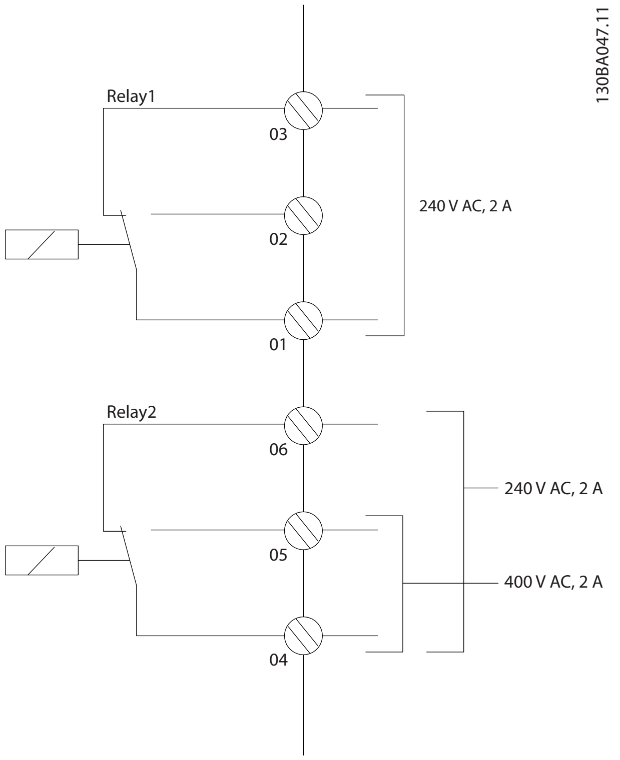


Illustration 2.18 Relay Outputs 1 and 2

See *chapter 6.2.3.4 Relay Connectors* for further information.

2.12 Faults, Warnings, and Alarm Functions

2.12.1 Overview

For diagnostic purposes, there are several possibilities to obtain information:

- Current status
    - The LEDs on the ISD 510 servo drive (see *Illustration 2.19*) show the current status of the servo drive.
    - The LEDs on the SAB (see *Illustration 2.20*) show the current status of the SAB.
- Readout of errors/warnings
    - Use the LCP to read out the error or warning that occurred last on either the servo drive or the SAB.
    - Use the DDS Toolbox to read out the error or warning that occurred last on either the servo drive or the SAB, or to read out a history of errors that occurred.
    - Use the Danfoss VLT® Servo Motion library on the PLC to read out the error or warning that occurred last.

Refer to the *VLT® Integrated Servo Drive ISD 510 System Programming Guide* for details on how to use the mentioned functions and the list of fault codes.

2.12.2 Operating LEDs on the VLT® Integrated Servo Drive ISD 510

Illustration 2.19 shows the operating LEDs on the servo drive.

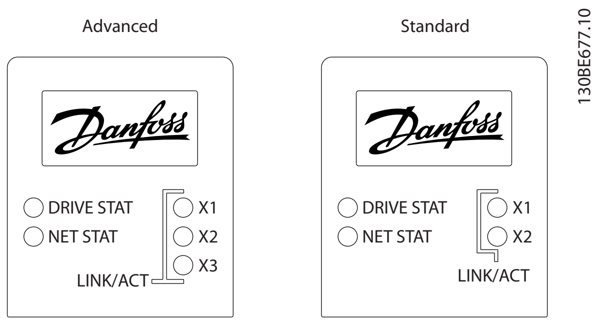


Illustration 2.19 Operating LEDs on the Servo Drive

LED	Color	Flash status	Description
DRIVE STAT	Green	On	Servo drive is in state *Operation enabled*.
		Flashing	Auxiliary voltage is applied.
	Red	On	Servo drive is in *Fault* or *Fault reaction active* state.
		Flashing	DC-link voltage is not applied.
NET STAT	Green/ red	Fieldbus dependent	Network status of the device (see corresponding fieldbus standard).

LED	Color	Flash status	Description
Link/ACT X1	Green	–	Link/activity status of *Hybrid In* (X1)
		On	Ethernet link established.
		Flashing	Ethernet link established and active.
		Off	No link.
Link/ACT X2	Green	–	Link/activity status of *Hybrid Out* (X2)
		On	Ethernet link established.
		Flashing	Ethernet link established and active.
		Off	No link.
Link/ACT X3[1)]	Green	–	Link/activity status of the Ethernet port (X3).
		On	Ethernet link established.
		Flashing	Ethernet link established and active.
		Off	No link.

Table 2.12 Legend to *Illustration 2.19*

1) Advanced version only

2.12.3 Operating LEDs on the VLT® Servo Access Box

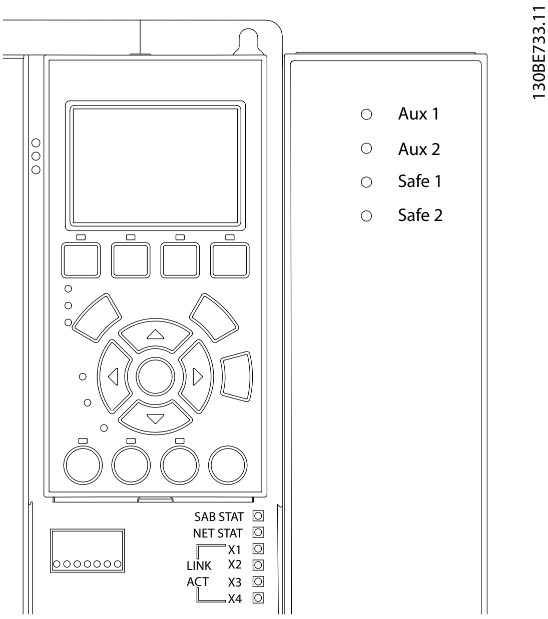


Illustration 2.20 Operating LEDs on the SAB

LED	Color	Flash status	Description
Aux 1	Green	–	State of the auxiliary voltage on line 1.
		On	State machine is in state *Standby*, *Power up*, or *Operation enabled*. Auxiliary voltage is applied to the output connectors on line 1.
		Off	State machine is in state U_{AUX} *disabled* or *Fault*. Auxiliary voltage is not applied to line 1.
Aux 2	Green	–	State of the auxiliary voltage on line 2.
		On	State machine is in state *Standby*, *Power up*, or *Operation enabled*. Auxiliary voltage is applied to the output connectors on line 2.
		Off	State machine is in state U_{AUX} *disabled* or *Fault*. Auxiliary voltage is not applied to line 2.
Safe 1	Green	On	24 V for STO is present on line 1.
		Off	24 V for STO is not present on line 1.
Safe 2	Green	On	24 V for STO is present on line 2.
		Off	24 V for STO is not present on line 2.
SAB STAT	Green	On	SAB is in state *Operation enabled*.
		Flashing	Auxiliary voltage is applied at the input.
		Off	No auxiliary voltage is applied at the input.
	Red	On	The SAB is in state *Fault*.
		Flashing	Mains is not applied at the input.
NET STAT	Green/red	Fieldbus dependent.	Network status of the device (see corresponding fieldbus standard).
Link/ACT X1	Green	–	Link/activity status of *In*.
		On	Ethernet link established.
		Flashing	Ethernet link established and active.
		Off	No link.

LED	Color	Flash status	Description
Link/ACT X2	Green	–	Link/activity status of *Out*.
		On	Ethernet link established.
		Flashing	Ethernet link established and active.
		Off	No link.
Link/ACT X3	Green	–	Link/activity status of line 1.
		On	Ethernet link established.
		Flashing	Ethernet link established and active.
		Off	No link.
Link/ACT X4	Green	–	Link/activity status of line 2.
		On	Ethernet link established.
		Flashing	Ethernet link established and active.
		Off	No link.

Table 2.13 Legend to *Illustration 2.20*

2.13 User Interfaces

2.13.1 Overview

The LCP is the graphical user interface on the SAB for diagnostic and operating purposes. It is included as standard with the SAB but can also be connected to the advanced version servo drives using an optional cable (M8 to LCP SUB-D extension cable).

The LCP display provides the operator with a quick view of the state of the servo drive or SAB, depending on which device it is connected to. The display shows parameters and alarms/errors and can be used for commissioning and troubleshooting. It can also be used to perform simple functions, for example activating and deactivating the output lines on the SAB.

The LCP can be mounted on the front of the control cabinet and then connected to the SAB via SUB-D cables (available as an accessory).

NOTICE

Do not permanently connect the LCP to the servo drive. Doing so will reduce the IP-rating.

2.13.2 DDS Toolbox Software

The DDS Toolbox is a standalone PC software designed by Danfoss. It is used for parameterization and diagnostics of the servo drives and the SAB. See *chapter 2.8.2 PC-Software* for further details.

2.13.3 Overview

The libraries provided for the VLT® Integrated Servo Drive ISD 510 System can be used in TwinCAT® V2 and in the Automation Studio™ (Version 3.0.90 and 4.x, supported platform SG4) environment to easily integrate the functionality without the need of special motion run-time on the controller. The provided function blocks conform to the PLCopen® standard. Knowledge of the underlying fieldbus communication and/or the CANopen® CiA DS 402 profile is not necessary.

The library contains:

- Function blocks for controlling and monitoring the servo drive and the SAB.
- Function blocks for all available motion commands of the servo drive.
- Function blocks and structures for creating *Basic CAM* profiles.
- Function blocks and structures for creating *Labeling CAM* profiles.

2.13.4 TwinCAT® NC Axis

The VLT® Integrated Servo Drive ISD 510 can be operated with the built-in NC functionality of TwinCAT®. This means that the trajectory calculations are all done within the PLC. The servo drive can be used with cyclic synchronous position mode or cyclic synchronous velocity mode to follow the setpoints given by the controller. The features are provided by the TwinCAT® library. To use this functionality, the controller must have an NC-PTP-Runtime system installed.

For details on how to configure the servo drive to use this functionality, refer to the *VLT® Integrated Servo Drive ISD® 510 System Programming Guide*.

NOTICE

A servo drive can either be controlled by the Danfoss VLT® Servo Motion library, or operated as a TwinCAT® NC axis. However, it is possible to mix both types of operation within 1 application.

3 Application Examples

3.1 Intended Applications

There are numerous possible applications for the VLT® Integrated Servo Drive ISD® 510 system as per the following examples.

Beverage machines:

- Labelling
- Capping
- Filling
- PET blow-moulding
- Digital bottle printing

Food and beverage packaging machines:

- Flow wrapping
- Bag maker
- Tray sealing
- Shrink wrapping

Industrial and pharmaceutical packaging machines:

- Palletization
- Top loader
- Cartoning
- Tube filling
- Blister machine
- Liquid filling
- Solid dosing

4 System Integration

4.1 Operating Environment: VLT® Integrated Servo Drive ISD 510

4.1.1 Humidity

Although the VLT® Integrated Servo Drive ISD 510 can operate properly at high humidity, avoid condensation. There is a specific risk of condensation when the servo drive is colder than moist ambient air. Moisture in the air can also condense on the electronic components and cause short circuits. Condensation occurs in units without power. Avoid installation in areas subject to frost. Alternatively, operating the servo drive in standby mode (with the servo drives connected to the auxiliary power supply via the SAB) reduces the risk of condensation. Ensure that the power dissipation is sufficient to keep the servo drive circuitry free of moisture.

4.1.2 Ambient Temperature

Minimum and maximum ambient temperature limits are specified for the VLT® Integrated Servo Drive ISD 510 (see *chapter 6.1.4 General Specifications and Environmental Conditions*). Avoiding extreme ambient temperatures prolongs the life of the equipment and maximizes the overall system reliability. Follow the recommendations listed for maximum performance and equipment longevity.

- Although the servo drive can operate at temperatures as low as 0 °C, proper operation at rated load is only guaranteed at ≥5 °C.
- Do not exceed the maximum temperature limit.
- The lifetime of electronic components decreases by 50% for every 10 °C operated above the design temperature.
- Devices with IP54, IP65, or IP67 protection ratings must also adhere to the specified ambient temperature ranges.
- Additional air conditioning of the cabinet or installation site may be required.

4.1.3 Cooling

The servo drives are self-cooling. Cooling (heat dispersal) is primarily via the flange, with a small amount dispersed by the housing. The following recommendations are necessary for effective cooling of the units.

- Maximum air temperature to enter enclosure must never exceed 55 °C (131 °F).
- Day/night average temperature must not exceed 35 °C (95 °F).
- Mount the unit to allow for free cooling airflow.
- Provide minimum front and rear clearance requirements for cooling airflow.

It is possible to install 2 or more servo drives next to each other, however the surfaces of the servo drives must not be in contact with each other. Ensure that there is a minimum gap of 1.2 mm between the servo drives to provide adequate ventilation of the servo drives and to allow sufficient heat transfer to take place in the surrounding areas.

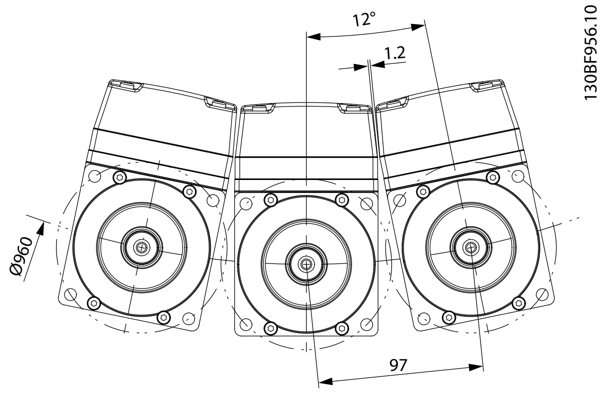


Illustration 4.1 Example of Servo Drive Installation on the Same Flange

4.1.4 Motor-generated Overvoltage

The DC voltage in the intermediate circuit (DC bus) increases when the servo drive acts as a generator. This can occur in 2 ways:

- The load drives the servo drive when it is operated at a constant speed. This is referred to as an overhauling load.
- During deceleration, if the inertia of the servo drives is high and the deceleration of the servo drives is set to a high value.

4

The SAB cannot regenerate energy back to the grid. It is possible to connect and configure a brake resistor to the SAB that can consume some power if the DC-link voltage becomes too high (see *chapter 2.11.1 Brake Resistor*). If this is unsuccessful, or if the load drives the servo drive, the SAB shuts down and shows a fault when a critical DC bus voltage level is reached.

The servo drive cannot regenerate energy back to the input. Therefore, it limits the energy accepted from the motor. If this is unsuccessful, or if the load drives the motor, the servo drive shuts down and displays a fault when a critical DC bus voltage level is reached.

4.1.5 Acoustic Noise

Acoustic noise from the servo drive comes from the following sources:

- Shaft seal
- Ball bearings
- Speed
- Brake

4.1.6 Vibration and Shock

The VLT® Integrated Servo Drive ISD 510 is tested according to a procedure based on IEC 60068-2-64.

The servo drive is intended for use on rotary parts/ machines.

4.2 Operating Environment: SAB

4.2.1 Humidity

Although the SAB can operate properly at high humidity, avoid condensation. There is a specific risk of condensation when the SAB is colder than moist ambient air. Moisture in the air can also condense on the electronic components and cause short circuits. Condensation occurs in units without power. It is recommended to install a cabinet heater when condensation is possible due to ambient conditions. Avoid installation in areas subject to frost. Alternatively, operating the SAB in standby mode (with the unit connected to the mains) reduces the risk of condensation. Ensure that the power dissipation is sufficient to keep the SAB circuitry free of moisture.

4.2.2 Ambient Temperature

Minimum and maximum ambient temperature limits are specified for the SAB (see *chapter 6.2.5 General Specifications and Environmental Considerations*). Avoiding extreme ambient temperatures prolongs the life of the equipment and maximizes the overall system reliability.

Follow the recommendations listed for maximum performance and equipment longevity.

- Although the SAB can operate at temperatures down to 0 °C, proper operation at rated load is only guaranteed at ≥5 °C.
- Do not exceed the maximum temperature limit.
- The lifetime of electronic components decreases by 50% for every 10 °C operated above the design temperature.
- Additional air conditioning of the cabinet or installation site may be required.

4.2.3 Cooling

The SAB dissipates power in the form of heat. Cooling (heat dispersal) is primarily via the integrated fans. The following recommendations are necessary for effective cooling of the units.

- Maximum air temperature to enter enclosure must never exceed 50 °C (122 °F).
- Day/night average temperature must not exceed 45 °C (113 °F).
- Mount the unit to allow for free cooling airflow through the cooling fins. See *chapter 6.2.2 Clearance* for correct mounting clearances.
- Provide minimum front and rear clearance requirements for cooling airflow. See the *VLT® Integrated Servo Drive ISD 510 System Operating Instructions* for the installation requirements.

4.2.3.1 Cooling Fans

The SAB has built-in fans to ensure optimum cooling. The main fan forces the airflow along the cooling fins on the heat sink, ensuring cooling of the internal air. The SAB has a small secondary fan on the power control board, ensuring that the internal air is circulated to avoid hot spots. The main fan is controlled by the internal temperature in the SAB and the speed gradually increases along with temperature. This reduces noise and energy consumption when the need is low, and ensures maximum cooling when needed.

In case of overtemperature inside the SAB, an alarm or warning is issued and a coast and trip lock occurs.

4.2.3.2 Calculation of Airflow Required for Cooling the SAB

The airflow required to cool the SAB (or multiple SABs in 1 cabinet) can be calculated as follows:

1. Determine the power loss at maximum output for all SABs.
2. Add the power loss values of all SABs that can operate at same time. The resulting sum is the heat *Q* to be transferred. Multiply the result with the factor *f*, read from *Table 4.2*.
   For example, $f = 3.1$ m³ x K/Wh at sea level.
3. Determine the highest temperature of the air entering the enclosure. Subtract this temperature from the required temperature inside the enclosure, for example 45 °C (113 °F).
4. Divide the total from step 2 by the total from step 3.

The calculation is expressed by the following formula:

$$V = \frac{f \times Q}{T_i - T_A}$$

V	Airflow in m³/h
f	Factor in m³ x K/Wh (calculated as: cp x ρ (specific heat of air x density of air))
Q	Heat to be transferred in W
T_i	Temperature inside the enclosure in °C
T_A	Ambient temperature in °C

Table 4.1 Formula Abbreviations

NOTICE

Specific heat of air (cp) and density of air (ρ) are not constants, but depend on temperature, humidity, and atmospheric pressure. Therefore, they depend on the altitude above sea level.
***Table 4.2* shows typical values of the factor f, calculated for different altitudes.**

Altitude [m]	Specific heat of air (cp) [kJ/kgK]	Density of air (p) [kg/m³]	Factor (f) [m³K/Wh]
0	0.9480	1.225	3.1
500	0.9348	1.167	3.3
1000	0.9250	1.112	3.5
1500	0.8954	1.058	3.8
2000	0.8728	1.006	4.1
2500	0.8551	0.9568	4.4
3000	0.8302	0.9091	4.8
3500	0.8065	0.8633	5.2

Table 4.2 Factor f, Calculated for Various Altitudes

Example

How to calculate the airflow required to cool 2 SABs (with heat losses of 295 W and 1430 W) running simultaneously, mounted in an enclosure with an ambient temperature peak of 37 °C, and an installation altitude of 500 m:

1. The sum of the heat losses of both frequency converters (295 + 150 W) = 445 W.
2. Multiply 445 W by 3.3 m³ x K/Wh = 1468.5 m³ x K/h.
3. Subtract 37 °C from 45 °C = 8 °C (=8 K).
4. Divide 1468.5 m³ x K/h by 8 K = 183.56 m³/h.

If the airflow is required in CFM (cubic feet per minute), use the conversion 1 m³/h = 0.589 CFM. For this example, 183.56 m³/h = 108.1 CFM.

4.2.4 Acoustic Noise

Acoustic noise from the SAB comes from 3 sources:

- DC-link (intermediate circuit) coils
- RFI filter choke
- Internal fans

The acoustic noise ratings shown in *Table 4.3* were measured 1 m from the unit.

	50% fan speed [dBA]	Full fan speed [dBA]
SAB	51	60

Table 4.3 Acoustic Noise Ratings

4.2.5 Vibration and Shock

The SAB is tested according to a procedure based on the IEC 60068-2-6. The SAB complies with requirements that correspond to these conditions when the unit is wall or floor-mounted, as well as when mounted within panels, or bolted to walls or floors.

4.3 Operating Environment: General

4.3.1 Aggressive Atmospheres

4.3.1.1 Gases

Aggressive gases, such as hydrogen sulphide, chlorine, or ammonia can damage SAB electrical and mechanical components. Contamination of the cooling air can also cause the gradual decomposition of PCB tracks and door seals. Aggressive contaminants are often present in sewage treatment plants or swimming pools. A clear sign of an aggressive atmosphere is corroded copper.

In aggressive atmospheres, restricted IP enclosures of cabinet are recommended.

Gas type	Unit	Class				
		3C1	3C2 (SAB)		3C3 (ISD)	
			Average value	Maximum value[1)]	Average value	Maximum value[1)]
Sea salt	n/a	0.1	0.3	1.0	5.0	10.0
Sulphur oxides	mg/m³	0.01	0.1	0.5	3.0	10.0
Chlorine	mg/m³	0.01	0.1	0.03	0.3	1.0
Hydrogen chloride	mg/m³	0.01	0.1	0.5	1.0	5.0
Hydrogen fluoride	mg/m³	0.003	0.01	0.03	0.1	3.0
Ammonia	mg/m³	0.3	1.0	3.0	10.0	35.0
Ozone	mg/m³	0.01	0.05	0.1	0.1	0.3
Nitrogen	mg/m³	0.1	0.5	1.0	3.0	9.0

Table 4.4 Conformal Coating Values

1) Maximum values are transient peak values not to exceed 30 minutes per day.

4.3.1.2 Exposure to Dust

Servo drive:
Installation of the servo drives in environments with high dust exposure is often unavoidable. Dust affects the servo drives with IP54, IP65, and IP67 protection ratings. Consider the 2 aspects described in this section when servo drives are installed in such environments.

Reduced cooling
Dust forms deposits on the surface of the device and inside on circuit boards and the electronic components. These deposits act as insulation layers and hamper heat transfer to the ambient air. This reduces the cooling capacity, resulting in the components becoming warmer. This causes accelerated aging of the electronic components, and the service life of the servo drive decreases.

Shaft seal
Dust can form deposits on the shaft and can lead to abrasion on the shaft seal. This can lead to a reduced lifetime of the shaft seal.

Periodic maintenance
Under the conditions described above, it is recommended to clean the servo drive during periodic maintenance. Remove dust from the housing and the shaft.

Servo Access Box:
Installation of the SAB in environments with high dust exposure is often unavoidable. Dust affects wall- or frame-mounted units and also cabinet-mounted devices with IP20 protection ratings. Consider the 2 aspects described in this section when the SAB is installed in such environments.

Reduced cooling
Dust forms deposits on the surface of the device and inside on circuit boards and the electronic components. These deposits act as insulation layers and hamper heat transfer to the ambient air, reducing the cooling capacity. The components become warmer. This causes accelerated aging of the electronic components, and the service life of the SAB decreases. Dust deposits on the heat sink at the back of the SAB also decrease the service life.

Cooling fans
The airflow for cooling the SAB is produced by cooling fans on the top and bottom of the SAB. The fan rotors have small bearings into which dust can penetrate and act as an abrasive. This leads to bearing damage and fan failure.

Periodic maintenance:
Under the conditions described above, it is recommended to clean the SAB during periodic maintenance. Remove dust from the heat sink and fans.

4.3.2 Electromagnetic Compatibility

4.3.2.1 Emission Requirements

The EMC product standard for frequency converters defines 4 categories (C1, C2, C3, and C4) with specified requirements for emission and immunity. *Table 4.5* states the definition of the 4 categories and the equivalent classification from EN 55011.

The VLT® Integrated Servo Drive ISD 510 System complies with the emission limits Class A Group 1 according to EN 55011 and Category C2 according to EN 61800-3.

Category	Definition	Equivalent emission class in EN 55011
C1	Frequency converters installed in the first environment (home and office) with a supply voltage less than 1000 V.	Class B
C2	Frequency converters installed in the first environment (home and office) with a supply voltage less than 1000 V, which are not plug-in or movable and are intended to be installed and commissioned by a professional.	Class A Group 1
C3	Frequency converters installed in the second environment (industrial) with a supply voltage lower than 1000 V.	Class A Group 2
C4	Frequency converters installed in the second environment with a supply voltage equal to or above 1000 V or rated current equal to or above 400 A or intended for use in complex systems.	No limit line. Make an EMC plan.

Table 4.5 Correlation between IEC 61800-3 and EN 55011

4.3.2.2 Immunity Requirements

The immunity requirements for the servo drives and SAB depend on the environment where they are installed. The requirements for the industrial environment are higher than the requirements for the home and office environment. All servo drives and the SABs comply with the requirements for the industrial environment and consequently also comply with the lower requirements for home and office environment with a large safety margin.

The VLT® Integrated Servo Drive ISD 510 System complies with the immunity requirements for 2nd environment according to EN 61800-3.

To document immunity against electrical interference, the following immunity tests have been made in accordance with following basic standards:

- EN 61000-4-2 (IEC 61000-4-2): Electrostatic discharges (ESD): Simulation of electrostatic discharges from human beings.
- EN 61000-4-3 (IEC 61000-4-3): Incoming electromagnetic field radiation, amplitude modulated simulation of the effects of radar and radio communication equipment as well as mobile communications equipment.
- EN 61000-4-4 (IEC 61000-4-4): Burst transients: Simulation of interference brought about by switching a contactor, relay, or similar devices.
- EN 61000-4-5 (IEC 61000-4-5): Surge transients: Simulation of transients brought about for example by lightning that strikes near installations.
- EN 61000-4-6 (IEC 61000-4-6): RF Common mode: Simulation of the effect from radio-transmission equipment joined by connection cables.

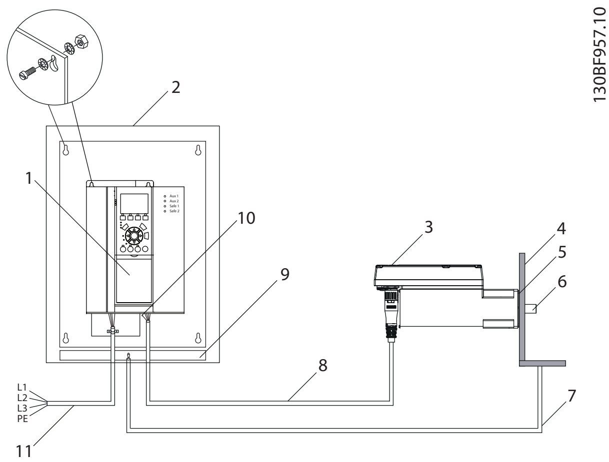
Basic standard	Burst IEC 61000-4-4	Surge IEC 61000-4-5	ESD IEC 61000-4-2	Radiated electro-magnetic field IEC 61000-4-3	RF common mode voltage IEC 61000-4-6
Acceptance Criterion	B	B	B	A	A
Line	2 kV/ 5 kHz	1 kV DM 2 kV CM	–	–	10 V_{RMS}
Brake	2 kV/ 5 kHz	–	–	–	10 V_{RMS}
Relay wires	2 kV/ 5 kHz	2 kV[1)]	–	–	10 V_{RMS}
LCP cable	–	–	–	–	10 V_{RMS}
SAB Encoder cable	2 kV/ 5 kHz	–	–	–	10 V_{RMS}
Ethernet cable	2 kV/ 5 kHz	1 kV[1)]	–	–	10 V_{RMS}
U_{AUX} supply cable	2 kV/ 5 kHz	–	–	–	10 V_{RMS}
U_{safe} supply cable	2 kV/ 5 kHz	1 kV[1)]	–	–	10 V_{RMS}
Feed-in cable	2 kV/ 5 kHz	1 kV[1)]	–	–	10 V_{RMS}
Loop cable	2 kV/ 5 kHz	1 kV[1)]	–	–	10 V_{RMS}
M8 LCP cable	–	–	–	–	10 V_{RMS}
M8 3rd Ethernet cable	2 kV/ 5 kHz	–	–	–	10 V_{RMS}
M12 Sensor cable	2 kV/ 5 kHz	–	–	–	10 V_{RMS}
Enclosure	–	–	4 kV CD 8 kV AD	80 MHz – 1 GHz: 10 V/m 1.4 GHz – 2.7 GHz: 3 V/m 2.0 GHz – 2.7 GHz: 1 V/m	–

Table 4.6 EMC Immunity Form

1) Injection on cable shield.

4.3.2.3 Grounding for Electrical Safety

- Ground the servo drive with the PE wire of the feed-in cable.
- Ensure that the machine frame has a proper electrical connection to the flange of the servo drive because this is the main PE connection. Use the front side flange surface. Ensure PE connection on that part of the machine.
- Ensure that the ground connections are tight and free of oxidation for the lifetime of the machine.
- Use a dedicated ground wire for input power and control wiring.
- Do not ground 1 SAB to another in daisy-chain format.
- Keep the ground wire connections as short as possible.
- Follow the wiring requirements in this manual.
- Ensure a minimum ground wire cross-section of 10 mm^2 on the SAB, or 2 separate ground wires, both complying with the dimensioning rules.
- See EN/IEC 61800-5-1 for further information on grounding.



1	Servo Access Box (SAB)	7	Equalizing minimum 16 mm^2 (AWG 5)
2	Control cabinet	8	Feed-in cable
3	Servo drive	9	Grounding rail (PE)
4	Machine frame	10	Grounding of feed-in cable
5	Flange	11	Mains, 3-phase, and reinforced PE
6	Shaft	–	–

Illustration 4.2 Recommended Installation for Electrical Safety

4.3.2.4 EMC Grounding

Proper EMC grounding practice:

- Respect safety grounding.
- The best EMC performance is achieved when the ground connection is kept as short as possible.
- Wires with a large cross-section have lower impedance and better EMC grounding.
- In cases where more devices with metal cabinets are used, mount them on a common metal mounting plate to improve EMC performance.

NOTICE

If necessary, use washers for fastening bolts, for example, in case of painted parts.

Grounding for EMC-compliant installation

- Establish electrical contact between the cable shield and the SAB enclosure by using metal cable glands, or by using the clamps provided on the SAB.
- Use high-strand wire to reduce electrical interference.
- Do not use pigtails.
- Ensure a minimum distance of 200 mm between signal and power cables.
- Only cross cables at 90°.

NOTICE

POTENTIAL EQUALIZATION

There is a risk of electrical interference when the ground potential between the servo system and the machine is different. Install equalizing cables between the system components. The recommended cable cross-section is 16 mm^2.

NOTICE

EMC INTERFERENCE

Use shielded cables for control wiring and separate cables for power and control wiring. Failure to isolate power and control wiring can result in unintended behavior or reduced performance. Ensure a minimum clearance of 200 mm between signal and power cables.

4.3.2.5 Motor Bearing Currents

To minimize bearing and shaft currents, ground the following to the driven machine:

- SAB
- Servo drive
- Driven machine

Standard mitigation strategies:

1. Apply rigorous installation procedures:
   - 1a Ensure that the motor and motor load are aligned.
   - 1b Strictly follow the EMC Installation guideline.
   - 1c Reinforce the PE so the high frequency impedance is lower in the PE than the input power leads.
   - 1d Provide a good high frequency connection between the system components, for instance, by using shielded cable.
   - 1e Make sure that the impedance from the VLT® Integrated Servo Drive ISD 510 System to building ground is lower that the grounding impedance of the machine.
   - 1f Make a direct ground connection between the motor and load motor.
2. Install a shaft grounding system or use an isolating coupling.
3. Apply conductive lubrication.
4. Use minimum speed settings if possible.
5. Try to ensure that the line voltage is balanced to ground.

4.3.2.6 Earth Leakage Current

Follow national and local codes regarding protective earthing of equipment where leakage currents are >3.5 mA. High frequency switching at high power generates a leakage current in the ground connection.

The earth leakage current is made up of several contributions and depends on various system configurations, including:

- RFI filtering.
- Cable length.
- Cable shielding.
- Frequency converter power.

Compliance with EN/IEC61800-5-1 (power drive system product standard) requires special care if the leakage current is >3.5 mA. Reinforce grounding with the following protective earth connection requirements:

- Ground wire (terminal 95) of at least 10 mm^2 cross-section.
- 2 separate ground wires, both complying with the dimensioning rules.

See EN/IEC 61800-5-1 and EN 50178 for further information.

4

Using RCDs

Where residual current devices (RCDs), also known as earth leakage circuit breakers (ELCBs), are used, comply with the following:

- Only use type B RCDs, as they are capable of detecting AC and DC currents.
- Use RCDs with a delay to prevent faults due to transient ground currents.
- Dimension RCDs according to the system configuration and environmental considerations.

The leakage current includes several frequencies originating from both the mains frequency and the switching frequency. Whether the switching frequency is detected depends on the type of RCD used.

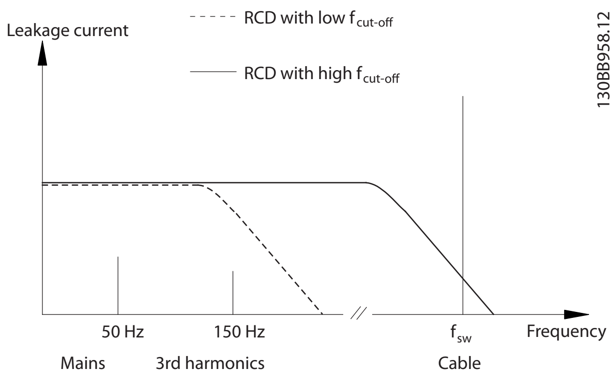


Illustration 4.3 Main Contributions to Leakage Current

The amount of leakage current detected by the RCD depends on the cut-off frequency of the RCD.

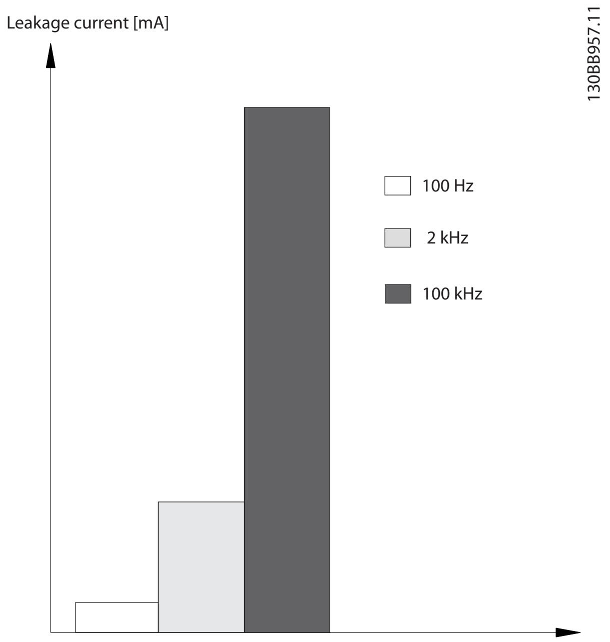


Illustration 4.4 Influence of RCD Cut-off Frequency on Leakage Current

4.3.2.7 Touch Current

The purpose of the touch current is to test if the leakage current in the protective earth (PE) of the power drive system is less than 3.5 mA AC or 10 mA DC.

If the leakage current is below or equal to 3.5 mA AC or 10 mA DC, no special measures relating to the PE connection are required.

The leakage current of the VLT® Integrated Servo Drive ISD 510 System is greater than 3.5 mA AC or 10 mA DC, therefore a fixed connection is required and 1 or more of the following conditions must be satisfied when installing the DUT:

1. A cross-section of the protective earthing conductor of at least 10 mm² Cu or 16 mm² Al.
2. Automatic disconnection of the supply in case of discontinuity of the protective earthing conductor.
3. Provision of an additional terminal for a protective earthing conductor of the same cross-sectional area as the original protective earthing conductor.

⚠WARNING

LEAKAGE/GROUNDING CURRENT HAZARD

Leakage/grounding currents are >3.5 mA. Failure to ground the SAB and the servo drives properly could result in death or serious injury.

- **Ensure the correct grounding of the SAB and servo drives by a certified electrical installer in accordance with applicable national and local electrical standards and directives, and the instructions contained in this manual.**

4.3.3 IP Ratings

4.3.3.1 Definitions

First digit		**Against penetration by solid foreign objects**	**Against access to hazardous parts by:**
	0	(not protected)	(not protected)
	1	≥50 mm diameter	Back of hand
	2	12.5 mm diameter	Finger
	3	2.5 mm diameter	Tool
	4	≥1.0 mm diameter	Wire
	5	Dust protected	Wire
	6	Dust-tight	Wire
Second digit		**Against water penetration with harmful effect**	–
	0	(not protected)	–
	1	Drops falling vertically	–
	2	Drops at 15° angle	–
	3	Spraying water	–
	4	Splashing water	–
	5	Water jets	–
	6	Powerful water jets	–
	x7	Temporary immersion	–
	8	Long-term immersion	–
	9	High pressure and temperature water jet	–
First letter		–	**Additional information**
	A	–	Back of hand
	B	–	Finger
	C	–	Tool
	D	–	Wire
Additional letter		**Additional information**	–
	H	High voltage device	–
	M	Device moving during water test	–
	S	Device stationary during water test	–
	W	Weather conditions	–

Table 4.7 IEC 60529 Definitions for IP Ratings

4.3.3.2 IP Ratings for SAB and Servo Drive

SAB

The SAB is available with the following protection rating:

- IP20 for cabinet installation (UL rating: Open type).

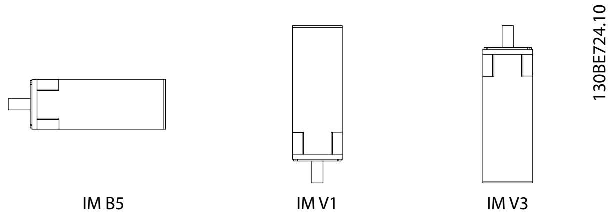
Servo drive

The servo drive is available with the following protection rating:

- IP54 (without shaft sealing)
- IP65 (with shaft sealing)

The protection rating is reduced from IP54 to IP50 and from IP65 to IP60 if the shaft is mounted upwards. The IP rating of the electronic housing of the servo drive is IP67 ((UL rating: Type 4X indoor use).

Protection ratings



	Mounting position of servo drive (according to DIN 42950)	**IP rating (according to EN 60529)**
Housing	All positions	IP67
Shaft without shaft seal	IM B5 & IM V1	IP54
	IM V3	IP50
Shaft with shaft seal	IM B5 & IM V1	IP65
	IM V3	IP60

Illustration 4.5 Mounting Positions

4.3.4 Radio Frequency Interference

The main objective is to obtain systems that operate stably without radio frequency interference between components. The SAB is therefore equipped with an RFI filter specified in EN 61800-3, which conforms to the Class A limits of the general standard EN 55011.

Filters that are built in to the equipment take up space in the cabinet, but eliminate additional costs for fitting, wiring, and material. However, the most important advantage is the perfect EMC conformance and cabling of integrated filters.

4.3.5 PELV and Galvanic Isolation Compliance

PELV (Protective Extra Low Voltage) offers protection by using extra low voltage. Protection against electric shock is ensured when the electrical supply is PELV and the installation complies with local and national PELV regulations.

To maintain PELV at the control terminals, all connections must be PELV, such as thermistors being reinforced/double insulated. All SAB control and relay terminals comply with PELV.

Galvanic (ensured) isolation is obtained by fulfilling requirements for higher isolation and by providing the relevant creepage/clearance distances. These requirements are described in EN 61800-5-1.

Electrical isolation is provided and the components comply with both PELV and galvanic isolation requirements. The components also comply with the requirements for higher isolation and the relevant test as described in EN 61800-5-1.

All control terminals and relay terminals 01-03/04-06 comply with PELV.

Installation at high altitude
Installations exceeding high altitude limits may not comply with PELV requirements. The insulation between components and critical parts could be insufficient. There is a risk of overvoltage. Reduce the risk of overvoltage using external protective devices or galvanic isolation.

NOTICE

For installations at high altitude, contact Danfoss regarding PELV compliance.

4.3.5.1 Discharge Time

⚠WARNING

DISCHARGE TIME

The servo drives and the SAB contain DC-link capacitors that remain charged for some time after the mains supply is switched off at the SAB. Failure to wait the specified time after power has been removed before performing service or repair work could result in death or serious injury.

- **To avoid electrical shock, fully disconnect the SAB from the mains and wait for at least the time listed in *Table 4.8* for the capacitors to fully discharge before carrying out any maintenance or repair work on the ISD 510 servo system or its components.**

Number	Minimum waiting time (minutes)
0–64 servo drives	10

Table 4.8 Discharge Time

4.3.6 Maintenance

The SAB is mainly maintenance free. A maintenance interval for the cooling fans (approximately 3 years) is recommended in most environments.
The ISD is largely maintenance free. Only the shaft seal (if used) is subject to wear.

Component	Maintenance task	Maintenance interval	Instruction
Servo drive	Carry out a visual inspection.	Every 6 months	Check for any abnormalities on the surface of the servo drive.
Shaft seal	Check the condition and check for leakage.	Recommended every 4500 hrs. A shorter or longer interval is possible depending on the application.	If damaged, replace the shaft seal.
Hybrid cable	Check for damage and wear.	Every 6 months	If damaged or worn, replace the hybrid cable.
Mechanical holding brake (optional)	Check the brake.	Every 6 months	Ensure that the brake can achieve the holding torque.
Functional safety	Perform a system power cycle and check the STO function.	Every 12 months	Activate the STO and check the status with the PLC.
SAB	Check the fan.	Every 12 months	Check that the fan can turn and remove any dust or dirt.

Table 4.9 Maintenance Tasks

4.3.7 Storage

Like all electronic equipment, SABs and servo drives must be stored in a dry, dust-free location with low vibration (veff ≤0.2 mm/s). Do not store the packaged system components on top of each other. The storage location must be free from corrosive gases. Avoid sudden temperature changes.

Keep the equipment sealed in its packaging until installation. Periodic forming (capacitor charging) is necessary once per year during storage.

NOTICE

To recondition the electrolytic capacitors, servo drives and SABs not in service must be connected to a supply source once per year to allow the capacitors to charge and discharge. Otherwise the capacitors could suffer permanent damage.

4.4 Mains Input

4.4.1 General Requirements

Ensure that the supply has the following properties:

- Grounded 3-phase mains network, 400–480 V AC
- 3-phase frequency: 47–63 Hz
- 3-phase lines and PE line
- Mains supply: 400–480 V ±10%
- Continuous input current SAB: 12.5 A
- Intermittent input current SAB: 20 A

NOTICE

Use fuses and/or circuit breakers on the supply side of the SAB to comply with CE or UL as detailed in *Table 4.10*.

CE Compliance (IEC 60364)			UL Compliance (NEC 2014)
Recommended fuse size	**Recommended circuit breaker**	**Maximum trip level in [A]**	**Recommended maximum fuse size**
gG-16	Eaton/Moller PKZM0-16	16	• Littelfuse® KLSR015 • Littelfuse® FLSR015

Table 4.10 Fuses and Circuit Breakers

Maximum imbalance temporary between mains phase	3% of the rated supply voltage
True power factor [λ]	≥0.9 at rated current
Switching on input supply	Maximum 2 times per minute
Environment according to EN60664-1	• Overvoltage category III • Pollution degree 2
Mains drop out	During low mains or a mains drop-out, the SAB and the servo drives keep running until the DC-link voltage drops below 373 V. Full torque of the servo drives cannot be expected at mains voltage 10% below the rated supply voltage.

Table 4.11 Additional Specifications

4.4.2 Harmonics

The VLT® Integrated Servo Drive ISD 510 System takes up non-sinusoidal current from the mains, which increases the input current IRMS. A non-sinusoidal current is transformed by means of a Fourier analysis and split up into sine-wave currents with different frequencies, that is different harmonic currents *IN* with 50 Hz as the basic frequency.

The harmonics do not affect the power consumption directly, but increase the heat losses in the installation (transformer, cables). Consequently, in plants with a high percentage of rectifier load, maintain harmonic currents at a low level to avoid overload of the transformer and high temperature in the cables.

NOTICE

Some of the harmonic currents might disturb communication equipment connected to the same transformer or cause resonance in connection with power factor correction units.

To ensure low harmonic currents, the SAB is equipped with intermediate circuit coils as standard. DC-coils reduce the total harmonic distortion (THD) to 40%.

4.4.2.1 Mains Configuration and EMC effects

Only TN mains systems are allowed for powering the VLT® Integrated Servo Drive ISD 510 System.

- TN-S: A 5-wire system with separate neutral (N) and protective earth (PE) conductors. It provides the best EMC properties and avoids transmitting interference.
- TN-C: A 4-wire system with a common neutral and protective earth (PE) conductor throughout the system. The combined neutral and protective earth conductor results in poor EMC characteristics.

IT mains systems and AC mains systems with a grounded mains are not allowed.

4.4.2.2 Mains Transients

Transients are brief voltage peaks in the range of a few thousand volts. They can occur in all types of power distribution systems, including industrial and residential environments.

Lightning strikes are a common cause of transients. However, they are also caused by switching large loads on line or off, or switching other mains transients equipment, such as power factor correction equipment. Transients can also be caused by short circuits, tripping of circuit breakers in power distribution systems, and inductive coupling between parallel cables.

EN 61000-4-1 describes the forms of these transients and how much energy they contain. Their harmful effects can be limited by various methods. Gas-filled surge arresters and spark gaps provide first-level protection against high-energy transients. For second-level protection, most electronic devices, use voltage-dependent resistors (varistors) to attenuate transients.

4.5 System Concepts

4.5.1 Auxiliary Power Supply Selection

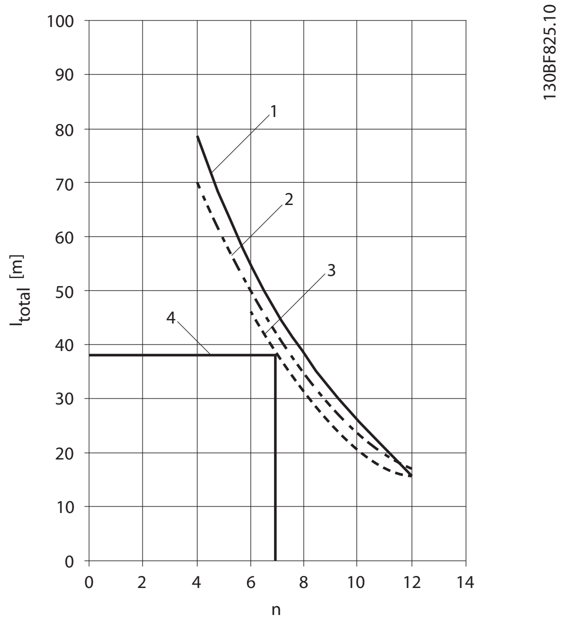
4.5.1.1 Shell Diagram

The allowed number of servo drives on a hybrid line is limited by the fact that voltage drops occur on the hybrid cable. These voltage drops involve the auxiliary voltage (24/48 V DC). The voltage drops on the cable depend on the power consumption of the servo drives on the hybrid line. The differences in power consumption are due to servo drives with integrated holding brake, servo drives without integrated holding brake, and ISD standard and ISD advanced servo drive versions.

The number of ISD servo drives connected on 1 line depends on several conditions. The most important conditions are:

- Power required by the servo drives on the auxiliary supply
- Auxiliary voltage
- Cable length

The shell diagram is only calculated for servo drives without sensors connected (8–9.6 W) and only with a feed-in cable length of 10 m. The 1st step is that the power consumption of each servo drive is set to 8 W. Then the number of servo drives with brake (9.6 W) is increased step-by-step. The servo drives with brake must be connected at the beginning of the output line to lower the voltage drop for all servo drives.

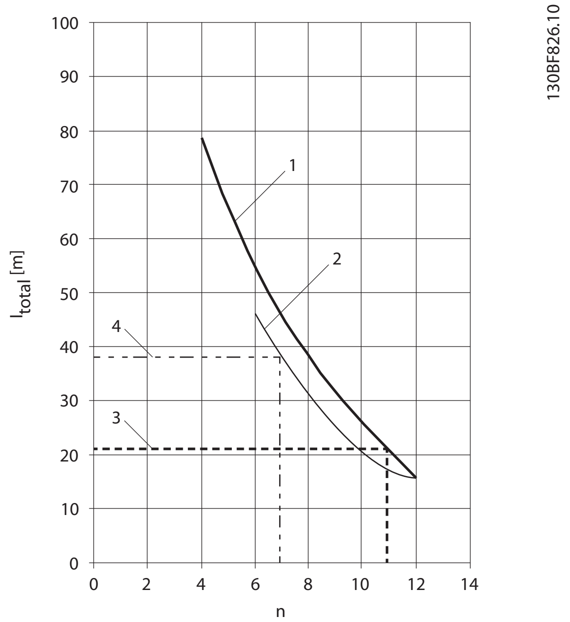


1	0 ISD servo drives with brake
2	3 ISD servo drives with brake
3	6 ISD servo drives with brake
4	Example 1

Illustration 4.6 24 V and 10 m Feed-in Cable

Example I: 7 servo drives are possible with a cable length of 38 m, and 6 of them can be equipped with a brake.

The graphs are very close together because there is only a slight difference between the AUX power consumption of the servo drives with and without brake. The graphs are calculated with the servo drives with brake connected at the beginning of the line.



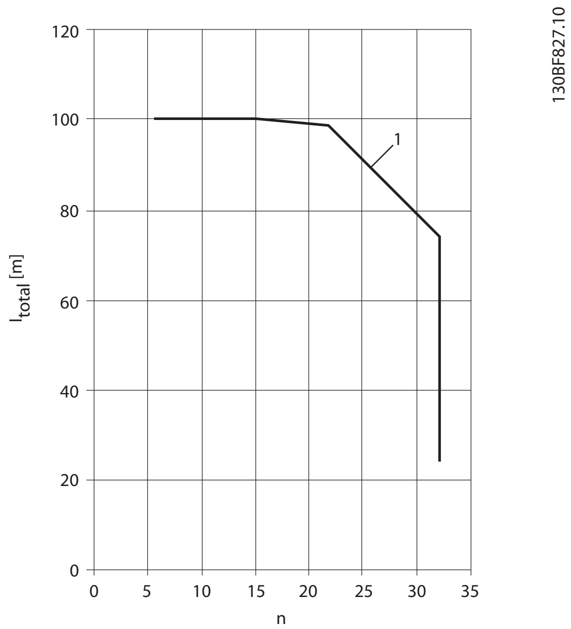
1	0 ISD servo drives with brake
2	6 ISD servo drives with brake
3	Example 2
4	Example 1

Illustration 4.7 24 V and 10 m Feed-in Cable - 6 Servo Drives with Brake

Illustration 4.7 shows 2 examples:

- Example I: 7 servo drives are possible with a cable length of 38 m, and 6 of them can be equipped with a brake.
- Example II: 11 servo drives are possible with a cable length of 21 m. No brakes are employed.

At 48 V AUX supply, the voltage drop is not the limiting factor. The maximum number of servo drives that can be connected per line is 32. The maximum cable length is 100 m per line.



1	Connected ISD servo drives

Illustration 4.8 48 V and 10 m Feed-in Cable - Servo Drives Connected

4.5.1.2 Auxiliary Power

4.5.1.3 24 V Supply

When 24 V AUX supply is used, the power losses on the cable are limited because only a limited number of servo drives can be connected. The maximum power loss on the cable is 6.4 W (when the servo drive draws 13.8 W and 8 servo drives are connected with 0.5 m loop cables). The nominal power of the servo drives is 8 x 13.8 W = 116.8 W. The AUX power supply has to provide ≈6% more than the nominal power.

4

AUX voltage (V)	Feed-in cable (m)	Power ISD [W]	Cable length [m]	Number of servo drives	Overall cable length [m]	Overall power (cable losses included) [W]
24	10	8	0.5	12	16.0	101.4
		8	1.0	11	21.0	93.0
		8	2.0	9	28.0	75.7
		8	4.0	8	42.0	65.7
		8	6.0	6	46.0	50.2
		10	0.5	10	15.0	105.6
		10	1.0	9	19.0	94.9
		10	2.0	8	26.0	84.4
		10	4.0	6	34.0	62.9
		10	6.0	6	46.0	63.4
		13.8	0.5	8	14.0	116.8
		13.8	1.0	7	17.0	101.8
		13.8	2.0	6	22.0	87.1
		13.8	4.0	5	30.0	72.5
		13.8	6.0	4	34.0	57.7
24	25	8	0.5	8	29.0	68.3
		8	1.0	7	32.0	59.36
		8	2.0	7	39.0	59.65
		8	4.0	6	49.0	51
		8	6.0	5	55.0	42.23
		8	8.0	5	65.0	42.46
		10	0.5	6	28.0	63.63
		10	1.0	6	31.0	63.8
		10	2.0	5	35.0	52.76
		10	4.0	5	45.0	53.12
		10	6.0	4	49.0	42.1
		10	8.0	4	57.0	42.3
		13.8	0.5	5	27.5	73.7
		13.8	1.0	4	29.0	58.28
		13.8	2.0	4	33.0	58.47
		13.8	4.0	4	41.0	58.84
		13.8	6.0	3	43.0	43.54
		13.8	8.0	3	49.0	43.7
24	40	8	0.5	5	42.5	42.41
		8	1.0	5	45.0	42.47
		8	2.0	5	50.0	42.58
		8	4.0	4	56.0	33.75
		8	6.0	4	64.0	33.88
		10	0.5	4	42.0	42.39
		10	1.0	4	44.0	42.44
		10	2.0	4	48.0	42.54
		10	4.0	3	52.0	31.5
		10	6.0	3	58.0	32.59
		13.8	0.5	3	41.5	43.94
		13.8	1.0	3	43.0	43.98
		13.8	2.0	3	46.0	44.07
		13.8	4.0	3	52.0	44.24

Table 4.12 24 V Auxiliary Supply

4.5.1.4 48 V Supply

When 48 V AUX supply is used, the power losses on the cable can be higher because up to 32 servo drives can be connected. The power losses of the feed-in cable have a higher influence. Therefore, the losses are calculated at 10 m, 25 m, or 40 m cable length.

AUX voltage (V)	Feed-in cable (m)	Power ISD [W]	Cable length [m]	Number of servo drives	Overall cable length [m]	Overall power (cable losses included) [W]
48	10	8	0.5	32	26.0	274.4
		8	1.0	32	42.0	279.1
		8	2.0	32	74.0	289.6
		8	4.0	22	98.0	193.0
		8	6.0	15	100.0	127.4
		10	0.5	32	26.0	349.9
		10	1.0	32	42.0	358.5
		10	2.0	32	74.0	378.8
		10	4.0	22	98.0	248.2
		10	6.0	15	100.0	161.7
		13.8	0.5	32	26.0	505.2
		13.8	1.0	32	42.0	525.3
		13.8	2.0	32	74.0	588.6
		13.8	4.0	22	98.0	368.3
		13.8	6.0	15	100.0	231.3

AUX voltage (V)	Feed-in cable (m)	Power ISD [W]	Cable length [m]	Number of servo drives	Overall cable length [m]	Overall power (cable losses included) [W]
		8	0.5	32	41.0	287.5
		8	1.0	32	57.0	293.1
		8	2.0	32	89.0	307.1
		8	4.0	18	97.0	157.1
		8	6.0	12	97.0	101.3
		10	0.5	32	41.0	374.0
48	25	10	1.0	32	57.0	383.6
		10	2.0	32	89.0	414.9
		10	4.0	18	97.0	201.9
		10	6.0	12	97.0	128.6
		13.8	0.5	32	41.0	547.2
		13.8	1.0	32	57.0	602.2
		13.8	2.0	30	85.0	637.0
		8	0.5	32	56.0	303.4
		8	1.0	32	72.0	311.6
		8	2.0	30	100.0	299.9
		8	4.0	15	100.0	130.5
		8	6.0	10	100.0	84.4
		10	0.5	32	56.0	406.3
48	40	10	1.0	32	72.0	424.3
		10	2.0	30	100.0	415.6
		10	4.0	15	100.0	167.6
		13.8	0.5	31	55.5	644.0
		13.8	1.0	30	70.0	650.6
		13.8	2.0	27	94.0	633.0
		13.8	4.0	15	100.0	243.7

Table 4.13 48 V Auxiliary Supply

The maximum power loss on the cable is 260.4 W when 40 m feed-in cable is used (the servo drives draw 13.8 W and 27 servo drives are connected with 2 m loop cables). The nominal power of the servo drives is 27 x 13.8 W = 372.6 W. The AUX power supply must provide 70% more than the nominal power.

4.5.2 Communication Topology

The maximum cable lengths are defined in *Table 4.14*.

Cable	Maximum length
Feed-in cable	40 m (shielded)[1)]
Loop cable	25 m (shielded)[1)]
Encoder cable	25 m (shielded)
Brake cable	20 m (shielded)
Fieldbus extension cable	2 m[2)]
24/48 V IN connector cable	3 m

Table 4.14 Maximum Cable Lengths

1) Maximum total length for each line: 100 m.

2) Maximum length to next port: 100 m.

4.6 VLT® Integrated Servo Drive ISD 510

4.6.1 Motor Selection Considerations

Danfoss offers 128 different servo variants, allowing selection of the most appropriate servo drive for the application. *Table 4.15* shows the available options. Refer to *chapter 5 Typecode and Selection* and *chapter 6 Specifications* for the ordering code and a detailed explanation of the available options.

Motor option	Control electronics	Servo drive version
• Torque/speed range • Mechanical holding brake • Feedback • Shaft seal	• Fieldbus	• Standard servo drive • Advanced servo drive

Table 4.15 Available Options for the Servo Drive

4.6.2 Motor Grounding

To ensure electrical safety, minimize EMC disturbances and ensure good thermal behavior, the servo drive must be grounded properly using the following 2 methods:

- Via the PE wire of the feed-in or loop cable.
- Via the servo drive flange.

Ensure that the machine frame has a proper electrical connection to the flange of the servo drive. Use the front side flange surface. Ensure PE connection on that part of the machine.

Refer to chapter *chapter 4.3.2.3 Grounding for Electrical Safety* for more information.

WARNING

LEAKAGE/GROUNDING CURRENT HAZARD

Leakage/grounding currents are >3.5 mA. Failure to ground the SAB and the servo drives properly could result in death or serious injury.

- **Ensure the correct grounding of the devices by a certified electrical installer in accordance with applicable national and local electrical standards and directives and the instructions contained in this manual.**

Potential equalization

There is a risk of electrical interference when the ground potential between the VLT® Integrated Servo Drive ISD 510 System and the machine is different. Install equalizing cables between the system components. The recommended cable cross-section is 16 mm^2.

4.6.3 Thermal Protection

IGBT overtemperature	During the operation of the servo drive, the power loss on the IGBT causes a temperature rise on the IGBT. The servo drive monitors the IGBT temperature constantly and, in case of overtemperature, stops operation and shows an IGBT overtemperature error.
PCB 1 overtemperature	To protect the servo drive electronics from thermal destruction, the temperature inside the electronic housing is monitored. The servo drive shuts down if the threshold level is reached.
PCB 2 overtemperature	To protect the servo drive electronics from thermal destruction, the temperature inside the electronic housing is monitored. The servo drive shuts down if the threshold level is reached.
Motor winding overtemperature	The motor winding temperature is protected against thermal runaway by constantly monitoring its temperature. The servo drive stops operation if the limit of winding temperature is reached.
Maximum winding energy	Another method to prevent motor wire damage is to monitor the power flow into the motor wire and its time duration. After reaching a certain energy level, the servo drive stops operation and an error is issued.

Table 4.16 Thermal Protection

4.7 VLT® Servo Access Box

4.7.1 Grounding

See *chapter 4.3.2.3 Grounding for Electrical Safety* and *chapter 4.3.2.4 EMC Grounding* for information on grounding the SAB.

4.7.2 Efficiency

The efficiency of the SAB is >98% at the nominal current of 15 A.

4.8 Cables

The VLT® Integrated Servo Drive ISD 510 System uses pre-configured hybrid cables to connect the SAB to the 1st servo drive on each line. This hybrid cable combines the DC link supply, the auxiliary voltage, the STO signal, and the bus communication. The hybrid cables pass these signals on to further servo drives connected in daisy-chain concept.

There are 2 types of hybrid cables available with both angled and straight M23 connectors:

- Feed-in cable:
  For connecting the 1st servo drive of a line to the connection point on the SAB.
  - Input end: Pigtailed with individual connectors for connection to the corresponding terminals on the SAB
  - Output end: M23 connector (for connection to the 1st servo drive on the line)
- Loop cable:
  For connecting the servo drives in daisy-chain format in an application.
  - Input end: M23 connector
  - Output end: M23 connector

Both these cables are provided by Danfoss and are available in various lengths.

See *chapter 5.5.1 Flexible Hybrid Cable* for cable specifications.

4.9 Peripheral Components

4.9.1 AUX Power Supply

Supply the SAB with a power supply unit with an output range of 24–48 V DC ±10%. The output ripple of the power supply unit must be <250 mV$_{pp}$. Only use supply units that conform to the PELV specification.

NOTICE

Use a supply that is CE-marked according to the standards EN 61000-6-2 and EN 61000-6-4 or similar for industrial use.

The power supply unit must be dedicated to the VLT® Integrated Servo Drive ISD 510 System, meaning that the supply is used exclusively for powering the servo system.

The maximum cable length between the supply unit and the SAB is 3 m.

4.9.2 Sensors

Digital input	Input range nominal	0–24 V
	Input range absolute maximum rating	-5 to +30 V
	Bandwidth (-3 dB, simulation results)	100 kHz
	Switching threshold high	10 V
	Switching threshold low	5 V
	Delay including ADC conversion: Rising edge 0–24 V Falling edge 24–0 V	 <8 us <12 us
	Input impedance 0–10.5 V	5.46 kΩ ±1%
	Input impedance 10.5–24 V	4.8–5.46 kΩ
	ADC resolution	12-bit
	ADC accuracy	±250 mV
Analog input	Input range nominal	0–10 V
	Input range absolute maximum rating	–5 to +30 V
	Bandwidth (-3 dB, simulation results)	25 kHz
	Input impedance 0–10 V	5.46 kΩ ±1%
	ADC resolution	12-bit
	ADC accuracy	±25 mV
	Sample rate for each channel	195.3 kHz ±1%
	SPI Interface from ADC to FPGA (PELV), functional isolated	12.5 MHz
Digital output	Switchable output voltage, controlled over fieldbus	0 V ±10% 24 V ±10%
	Maximum output current	150 mA
	Maximum switching period	100 Hz
	Maximum switching delay	100 µs

Table 4.17 Sensors

4.9.3 Safety Supply Requirements

Supply the STO line with a 24 V DC supply with the following properties:

- Output range: 24 V DC ±10%
- Maximum current: 1 A

NOTICE

Use a 24 V supply unit that is CE marked according to the standards EN 61000-6-2 and EN 61000-6-4 or similar for industrial use. The supply must only be used for the ISD 510 safety input. The supply must fulfill the PELV specification.
It is possible to use the auxiliary supply for the STO function if the following conditions are met:

- **Output range: 24 V DC ±10%**
- **Maximum cable length: 3 m**

4

5 Typecode and Selection

5.1 Drive Configurator for VLT® Integrated Servo Drive ISD 510

The Danfoss Drive Configurator (*vltconfig.danfoss.com*) is an advanced but easy-to-use tool to configure the Danfoss VLT® Integrated Servo Drive ISD 510 that exactly matches your requirements.

NOTICE

The Drive Configurator shows the valid configuration of servo drive variants. Only valid combinations are shown. Therefore, not all variants detailed in the type code (see *chapter 5.2.1 Typecode and Definitions*) are visible.

The Drive Configurator generates a unique code number for the servo drive required, preventing errors during order entry.

Decoding is also available: Enter a typecode and the Drive Configurator decodes the configuration and show the configuration of the servo drive.

5.2 VLT® Integrated Servo Drive ISD 510

5.2.1 Typecode and Definitions

Pos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Fixed	I	S	D	5	1	0		T					D	6																										
Variant							A		0	1	C	5			E	5	4	F	R	X	P	L	S	X	X	T	F	0	7	6	S	X	N	4	6	X	S	X	S	X
							S		0	2	C	1			E	6	7	F	S	1	E	C	S	C	O	F	F	0	8	4	C	0	N	4	0	B	K	S	C	X
									0	2	C	9						F	M	1	P	N					F	1	0	8			N	2	9		C			
									0	3	C	8									E	N					F	1	3	8			N	2	4					

Table 5.1 Type Code

[01–03]	Product group	[21–22]	Bus system	[33–35]	Motor speed
ISD	VLT® Integrated Servo Drive	**PL**	Ethernet POWERLINK®	**N46**	Rated speed 4600 RPM
[04–06]	Product variant	**EC**	EtherCAT®	**N40**	Rated speed 4000 RPM
510	ISD® 510	**PN**	PROFINET®1)	**N29**	Rated speed 2900 RPM
[07]	Hardware configuration	**EN**	EtherNet/IP™1)	**N24**	Rated speed 2400 RPM
A	Advanced	[23–25]	Firmware	[36]	Mechanical brake
S	Standard	**SXX**	Standard	**X**	Without brake
[08]	Drive torque	**SC0**	Customized version	**B**	With brake
T	Torque	[26]	Safety	[37]	Motor shaft
[09–12]	Torque	**T**	Safe Torque Off (STO)	**S**	Standard smooth shaft
01C5	1.5 Nm	**F**	Functional safety1)	**K**	Standard fitted key1)
02C1	2.1 Nm	[27–30]	Flange size	**C**	Customized
02C9	2.9 Nm	**F076**	76 mm	[38]	Motor sealing
03C8	3.8 Nm	**F084**	84 mm	**X**	Without sealing
[13–14]	DC voltage	**F108**	108 mm1)	**S**	With sealing
D6	600 V DC-link voltage	**F138**	138 mm1)	[39–40]	Surface coating
[15–17]	Drive enclosure	[31–32]	Flange type	**SX**	Standard
E54	IP54	**SX**	Standard	**CX**	Customized
E67	IP67 (shaft IP65)	**C0**	Customized version		
[18–20]	Drive feedback				
FRX	Resolver				
FS1	Single-turn feedback				
FM1	Multi-turn feedback				

Table 5.2 Legend to Typecode

1) In preparation

5.3 Servo Access Box

Description	Ordering number
VLT® Servo Access Box (SAB®) with Ethernet POWERLINK®	175G0117
VLT® Servo Access Box (SAB®) with EtherCAT®	175G0118

Table 5.3 SAB Ordering Numbers

5.4 Options

5.4.1 Mechanical Holding Brake

The optional mechanical holding brake is designed as a single-disc brake. The emergency stop function can be initiated at most once every 3 minutes and up to 2000 times in total, depending on the load.

The effective holding torque is:

- Size 1: 2.5 Nm
- Size 2: 5.3 Nm

The brake operates as a holding brake according to the fail-safe principle *closed when no current*. It is powered from the 24–48 V DC auxiliary supply. This enables low-backlash load holding when no current is present.

Power consumption:

- Size 1: 2.0 W
- Size 2: 2.5 W

NOTICE

Do not misuse the holding brake as a working brake because this causes increased wear, resulting in premature failure.

5.4.2 Feedback

5.4.2.1 Built-in Feedback Devices

The built-in feedback device measures the rotor position.

There are 3 feedback variants available:

- Resolver
- 17-bit single-turn encoder
- 17-bit multi-turn encoder

Table 5.4 summarizes the characteristic data of each variant.

Data/type	Resolver	Single-turn encoder	Multi-turn encoder
Signal	Sin/cos	BiSS-B	BiSS-B
Accuracy	±10 arcmin	±1.6 arcmin	±1.6 arcmin
Resolution	14 bit	17 bit	17 bit
Maximum number of turns	–	–	4096 (12 bit)

Table 5.4 Characteristic Data of Available Feedback Devices

5.4.3 Customized Flange

A customized flange is available on request. Contact Danfoss for further information.

5.4.4 Shaft Seal

The servo drives can be sealed by a shaft seal (optional) to achieve up to IP65 on the A-side of the motor.

Description	Ordering number
Shaft seal set for size 1 servo drive (10 pieces)	175G8192
Shaft seal set for size 2 servo drive (10 pieces)	175G8191

Table 5.5 Shaft Seal Ordering Numbers

See *chapter 4.5.1.3 24 V Supply* for further information on IP ratings.

5.5 Accessories

5.5.1 Flexible Hybrid Cable

5.5.1.1 Feed-In Cable

Description	Length [m]	Ordering number
Hybrid feed-in cable M23, 90° angled connector	2	175G8920
	4	175G8921
	6	175G8922
	8	175G8923
	10	175G8924
	15	175G8925
	20	175G8926
	25	175G8927
	30	175G8928
	40	175G8929
Hybrid feed-in cable M23, straight connector	2	175G8930
	4	175G8931
	6	175G8932
	8	175G8933
	10	175G8934
	15	175G8935
	20	175G8936
	25	175G8937
	30	175G8938
	40	175G8939

Table 5.6 Feed-In Cable Ordering Numbers

5.5.1.2 Loop Cable

Description	Length [m]	Ordering number
Hybrid loop cable M23, 90° angled connector	0.5	175G8900
	1	175G8901
	2	175G8902
	4	175G8903
	6	175G8904
	8	175G8905
	10	175G8906
	15	175G8907
	20	175G8908
	25	175G8909
Hybrid loop cable M23, straight connector	0.5	175G8910
	1	175G8911
	2	175G8912
	4	175G8913
	6	175G8914
	8	175G8915
	10	175G8916
	15	175G8917
	20	175G8918
	25	175G8919

Table 5.7 Loop Cable Ordering Numbers

5.5.2 Fieldbus Cables

Description	Length [m]	Ordering number
Fieldbus extension cable, M23 angled to M12 straight	2	175G8940
Fieldbus extension cable, M23 straight to M12 straight	2	175G8941

Table 5.8 Fieldbus Cable Ordering Numbers

The M8 Ethernet cable for the 3rd Ethernet port (X3) is not supplied by Danfoss.

5.5.3 LCP Cable

Description	Length [m]	Ordering number
LCP Cable (SUB-D to M8)	3	175G8942
SAB LCP cable	3	175Z0929

Table 5.9 LCP Cable Ordering Numbers

5.5.4 LCP Mounting Kit

Description	Ordering number
LCP remote mounting kit (IP21) including LCP, fasteners, 3 m cable, and gasket.	130B1170
LCP remote mounting kit (IP21) without LCP, but including fasteners, 3 m cable, and gasket.	130B1117

Table 5.10 LCP Mounting Kit Ordering Numbers

5.5.5 Blind Caps

Description	Ordering number
Blind cap for M23 connector, IP67	175G8805
Blind cap for M23 connector, IP40	175G8183
Blind cap for M12 connector	175G7162
Blind cap for M8 connector	175G8785

Table 5.11 Blind Caps Ordering Numbers

5.5.6 Sensor Cable

Other than the LCP cable (see *chapter 5.5.3 LCP Cable*), the cables for the sensor interface (X4) on the advanced version of the servo drive are not supplied by Danfoss.

6 Specifications

6.1 Servo Drive

6.1.1 Dimensions

Flange

Servo drive	Flange thickness
Size 1, 1.5 Nm	7 mm
Size 2, 2.1 Nm	–
Size 2, 2.9 Nm	8 mm
Size 2, 3.8 Nm	8 mm

Table 6.1 Flange Thickness

All dimensions are in mm (in).

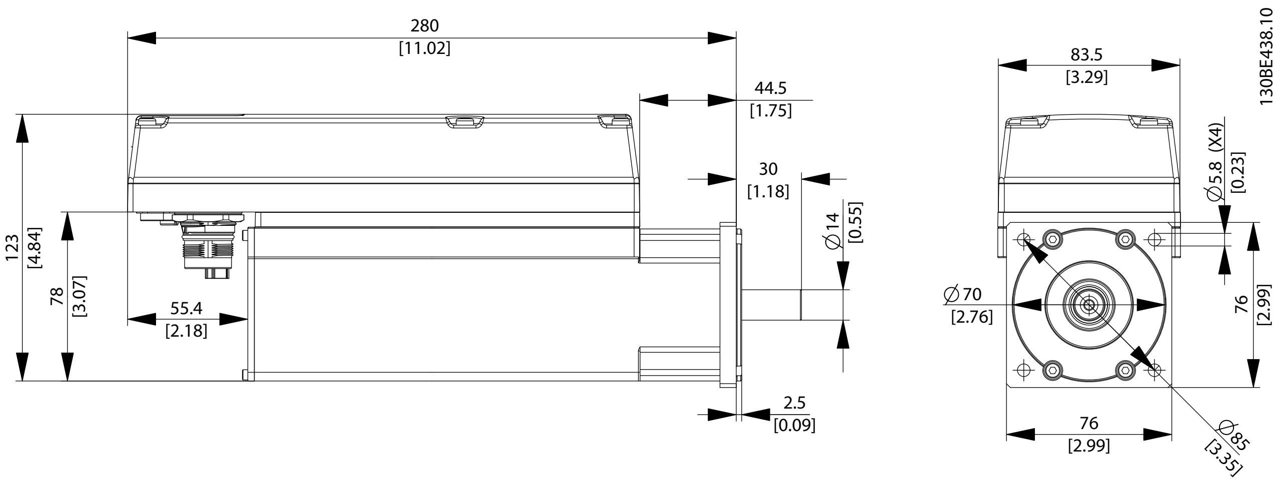


Illustration 6.1 Dimensions of ISD 510 Size 1, 1.5 Nm

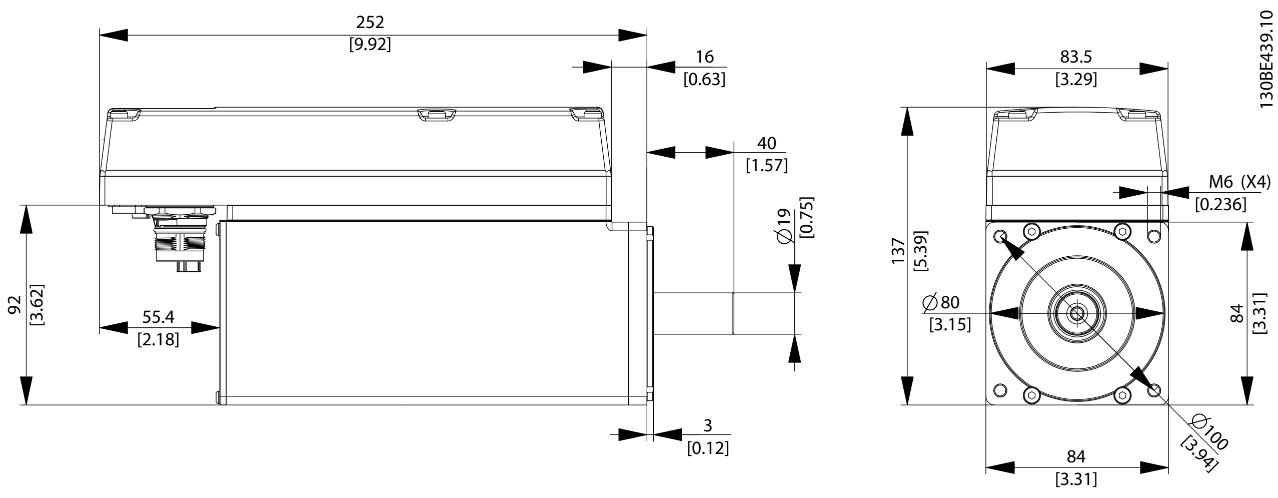


Illustration 6.2 Dimensions of ISD 510 Size 2, 2.1 Nm

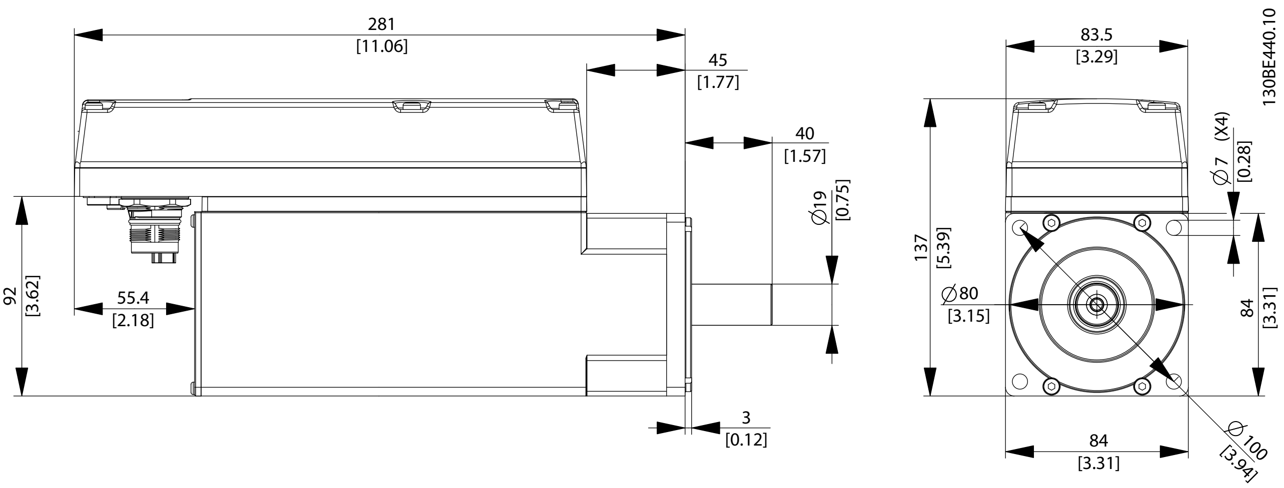


Illustration 6.3 Dimensions of ISD 510 Size 2, 2.9 Nm

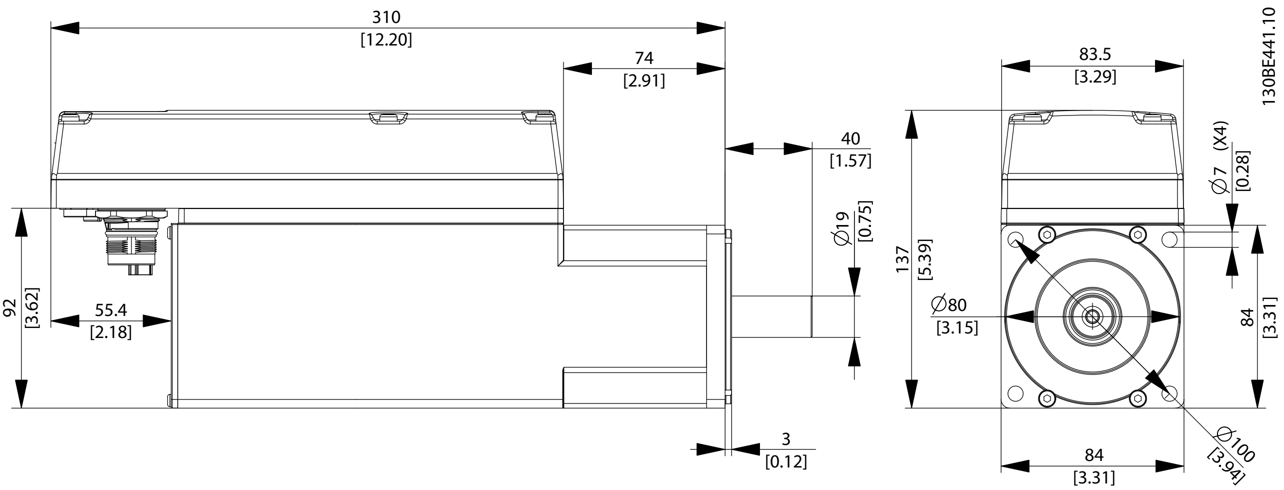


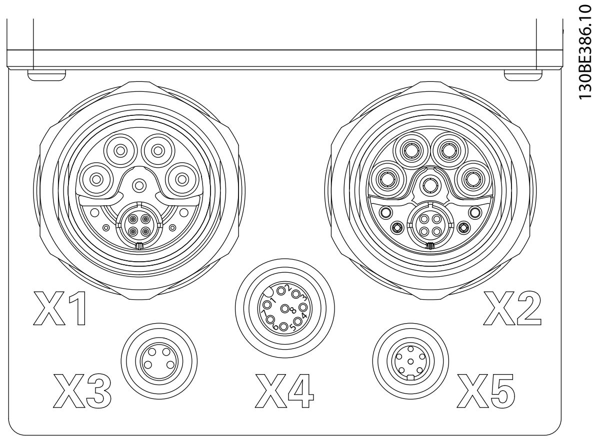
Illustration 6.4 Dimensions of ISD 510 Size 2, 3.8 Nm

6.1.2 Terminal Locations

6.1.2.1 Connectors on the Servo Drives

This chapter details all possible connections for the standard and advanced servo drive. Refer to the tables in this chapter for maximum cable lengths, ratings, and other limits.

There are 5 connectors on the servo drives.



Connector	Description
X1	M23 Feed-in or loop hybrid cable input
X2	M23 Loop hybrid cable output or fieldbus extension cable
X3 (advanced version only)	M8 Ethernet cable (minimum CAT5, shielded)
X4 (advanced version only)	M12 I/O and/or encoder cable (shielded)
X5 (advanced version only)	M8 LCP cable (shielded)

Illustration 6.5 Connectors on the Servo Drive

X1 and X2: Hybrid connector (M23)

The hybrid cable provides the supply (mains and auxiliary), the communication lines, and the safety supply for each line of servo drives. Input and output connectors are connected inside the servo drive.

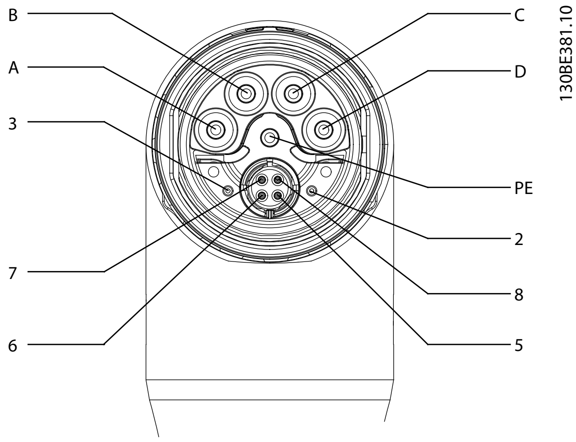


Illustration 6.6 X1: Male Hybrid Connector (M23)

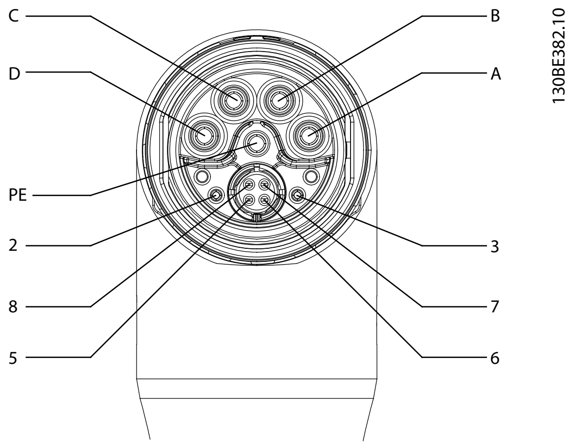


Illustration 6.7 X2: Female Connector (M23)

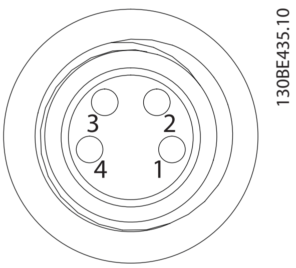
6

Pin	Description	Notes	Rating/parameter
A	UDC–	Negative DC mains supply	Operating voltage: Negative DC supply (maximum –15 A)
B	UDC+	Positive DC mains supply	Operating voltage: Positive DC supply (maximum 15 A)
C	AUX+	Auxiliary supply	24–48 V DC, 15 A Absolute maximum 55 V DC
D	AUX–	Auxiliary supply ground	15 A
PE	PE	PE connector	15 A
2	STO+	Safety supply	24 V DC ±10%, 1 A
3	STO–	Safety supply ground	1 A
5	TD+	Positive Ethernet transmit	According to standard 100BASE-T
6	RD+	Positive Ethernet receive	
7	TD–	Negative Ethernet transmit	
8	RD–	Negative Ethernet receive	

Table 6.2 Pin Assignment of X1 and X2 Hybrid Connectors (M23)

X3: 3rd Ethernet connector (M8, 4 pole)

The advanced servo drive has an additional fieldbus port (M8) for connecting a device that communicates via the selected fieldbus.



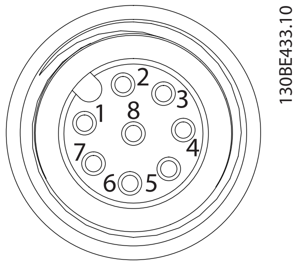
Pin	Description	Notes	Rating/parameter
1	TD+	Positive Ethernet transmit	According to standard 100BASE-T
2	RD+	Positive Ethernet receive	
3	TD–	Negative Ethernet transmit	
4	RD–	Negative Ethernet receive	

Illustration 6.8 Pin Assignment of X3 3rd Ethernet Connector (M8, 4 pole)

X4: M12 I/O and/or encoder connector (M12, 8-pole)

The M12 I/O and/or encoder connector is available on the advanced servo drive and can be used or configured as:

- Digital output
- Digital input
- Analog input
- 24 V supply
- External encoder interface (SSI or BiSS).



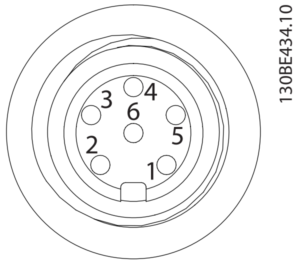
Pin	Description	Notes	Rating/parameter
1	Digital output	Switched 24 V as digital output or supply (24 V/150 mA)	Nominal voltage 24 V ±15% Maximum current 150 mA Maximum switching frequency 100 Hz
2	Ground	Ground isolated	–
3	Input 1	Analog/Digital input	Digital input: Nominal voltage 0–24 V Bandwidth: ≤100 kHz Analog input: Nominal voltage 0–10 V Input impedance 5.46 kΩ Bandwidth: ≤25 kHz
4	/SSI CLK	Negative SSI/BiSS clock out	SSI: Bus Speed: 0.5 Mbit with 25 m cable BiSS: Fulfills the RS485 specification. Maximum cable length (SSI & BiSS): 25 m
5	SSI DAT	Positive SSI/BiSS data in	
6	SSI CLK	Positive SSI/BiSS clock out	
7	Input 2	Analog/Digital input	Digital input: Nominal voltage 0–24 V Bandwidth: ≤100 kHz Analog input: Nominal voltage 0–10 V Input impedance 5.46 kΩ Bandwidth: ≤25 kHz

Pin	Description	Notes	Rating/parameter
8	/SSI DAT	Negative SSI/BiSS data in	SSI: Bus Speed: 0.5 Mbit with 25 m cable BiSS: Fulfills the RS485 specification. Maximum cable length (SSI & BiSS): 25 m

Illustration 6.9 Pin Assignment of X4 M12 I/O and/or Encoder Connector (M12)

X5: LCP connector (M8, 6 pole)

The X5 connector is used to connect the LCP directly to the advanced servo drive via a cable.



Pin	Description	Notes	Rating/ parameter
1	Not connected	–	–
2	/LCP RST	Reset	Active at <0.5 V
3	LCP RS485	Positive RS485 signal	Speed: 38.4 kBd The levels fulfill the RS485 specification.
4	/LCP RS485	Negative RS485 signal	
5	GND	GND	–
6	VCC	5 V Supply for LCP	5 V ±10% at 120 mA maximum load

Illustration 6.10 Pin Assignment of X5 LCP Connector (M8, 6-pole)

6.1.3 Characteristic Data

Table 6.3 and *Table 6.4* provide a summary of typical servo drive characteristics.

Specifications	Unit	Size 1 1.5 Nm	Size 2 2.1 Nm	Size 2 2.9 Nm	Size 2 3.8 Nm
Rated speed n_N	RPM	4600	4000	2900	2400
Rated torque M_N	Nm	1.5	2.1	2.9	3.8
Rated current I_N	A DC	1.4	1.7		1.8
Rated power P_N	kW	0.72	0.88		0.94
Standstill (Stall) torque M_0	Nm	2.3	2.8	3.6	4.6
Standstill (Stall) current I_0	A DC	2.1	2.3	2.1	2.2
Peak torque M_{max}	Nm	6.1	7.8	10.7	12.7
Peak current (rms value) I_{max}	A DC	5.7	6.4		
Rated Voltage	V DC	560/680			
Inductance L 2 ph	mH	18.5	26.8	32.6	33.9
Resistance R 2 ph	Ω	9.01	7.78	8.61	8.64
Voltage constant EMK	V/krms	70.6	80.9	111.0	132.0

6

Specifications	Unit	Size 1 1.5 Nm	Size 2 2.1 Nm	Size 2 2.9 Nm	Size 2 3.8 Nm
Torque constant K_t	Nm/A	1.10	1.26	1.72	2.04
Inertia	Kgm²	0.000085	0.00015	0.00021	0.00027
Shaft diameter	mm	14	19		
Pole pairs	–	4	5		
Flange size	mm	76	84		
Weight	kg	3.5	4.0	5.0	6.0

Table 6.3 Characteristic Data for Servo Drive without Brake

Specifications	Unit	Size 1 1.5 Nm	Size 2 2.1 Nm	Size 2 2.9 Nm	Size 2 3.8 Nm
Brake inertia	Kgm²	0.0000012	0.0000068	0.0000068	0.0000068
Brake weight	kg	0.34	0.63		

Table 6.4 Characteristic Data for Servo Drive with Brake

6.1.4 General Specifications and Environmental Conditions

Vibration test	Random vibration: 7.54 g (2h/axis according to EN 60068-2-64) Sinusoidal vibration: 0.7 g (2h/axis according to EN 60068-2-6)
Maximum relative humidity	Storage/transport: 5–93% (non-condensing) Stationary use: 15–85% (non-condensing)
Ambient temperature range	5–40 °C above derating, maximum 55 °C (24-hour average maximum 35 °C) Transport: -25 to +70 °C Storage: -25 to +55 °C
Installation elevation	Maximum 1000 m above sea level
EMC standard for emission and immunity	EN 61800-3

Table 6.5 General Specifications and Environmental Conditions for VLT® Integrated Servo Drive ISD 510

6.1.5 Motor Output and Data

Table 6.6 shows the nominal load points for the 4 different motor sizes. The DC-link voltage is 560 V and the ambient temperature is 40 °C.

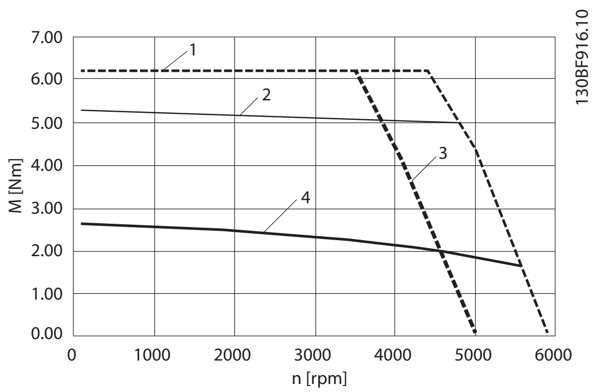
	Unit	Size 1 1.5 Nm	Size 2 2.1 Nm	Size 2 2.9 Nm	Size 2 3.8 Nm
N_mech_max	[RPM]	7000	6000	5000	4000
N_n	[RPM]	4600	4000	2900	2400
M_n	[Nm]	1.5	2.1	2.9	3.8
I_n_rms	[A]	1.4	1.7	1.7	1.8
P_n	[kW]	0.72	0.88	0.88	0.95
M_0	[Nm]	2.3	2.8	3.6	4.6
I_0_rms	[A]	2.1	2.3	2.1	2.2
M_0max	[Nm]	6.1	7.8	10.7	12.7
I_0max_pk	[A]	8.0	9.0	9.0	9.0
I_0max_rms	[A]	5.7	6.4	6.4	6.4

Table 6.6 Drive Loadpoints with 560 V DC and 40 °C Ambient Temperature

The following subchapters show:

- Speed-torque characteristics
- Maximum speed related to voltage.

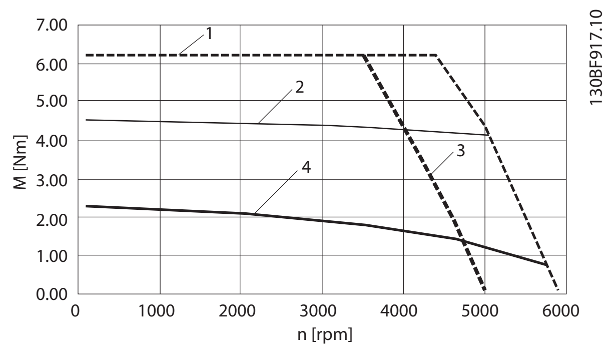
6.1.5.1 Speed-Torque Characteristics: Size 1, 1.5 Nm at 25 °C Ambient Temperature



1	SOA 680 V
2	S3
3	SOA 560 V
4	S1

Illustration 6.11 Performance at 25 °C Ambient Temperature: Size 1, 1.5 Nm

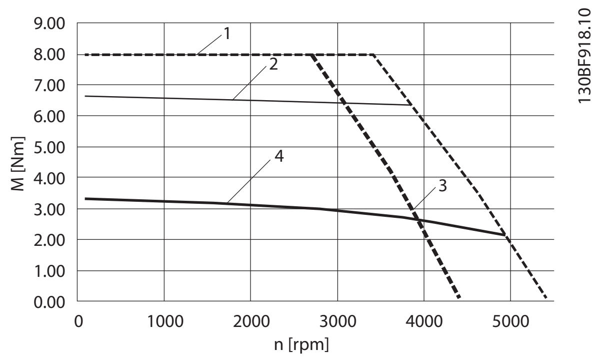
6.1.5.2 Speed-Torque Characteristics: Size 1, 1.5 Nm at 40 °C Ambient Temperature



1	SOA 680 V
2	S3
3	SOA 560 V
4	S1

Illustration 6.12 Performance at 40 °C Ambient Temperature: Size 1, 1.5 Nm

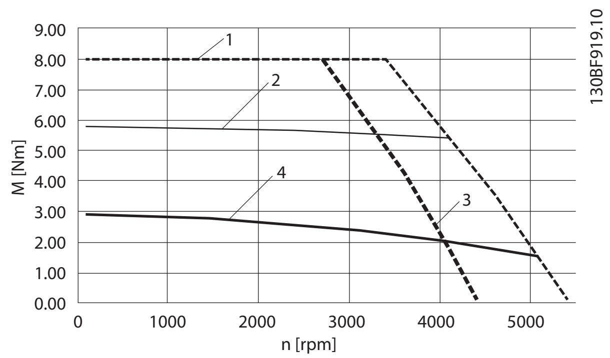
6.1.5.3 Speed-Torque Characteristics: Size 2, 2.1 Nm at 25 °C Ambient Temperature



1	SOA 680 V
2	S3
3	SOA 560 V
4	S1

Illustration 6.13 Performance at 25 °C Ambient Temperature: Size 2, 2.1 Nm

6.1.5.4 Speed-Torque Characteristics: Size 2, 2.1 Nm at 40 °C Ambient Temperature

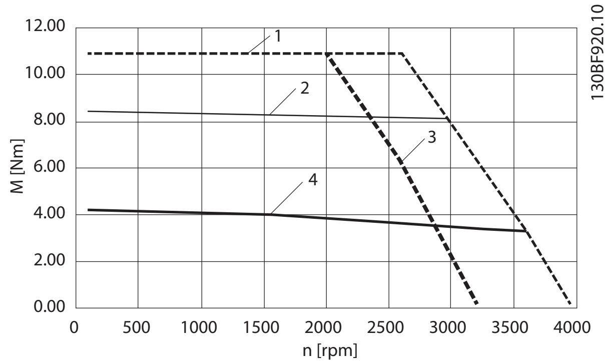


1	SOA 680 V
2	S3
3	SOA 560 V
4	S1

Illustration 6.14 Performance at 40 °C Ambient Temperature: Size 2, 2.1 Nm

6

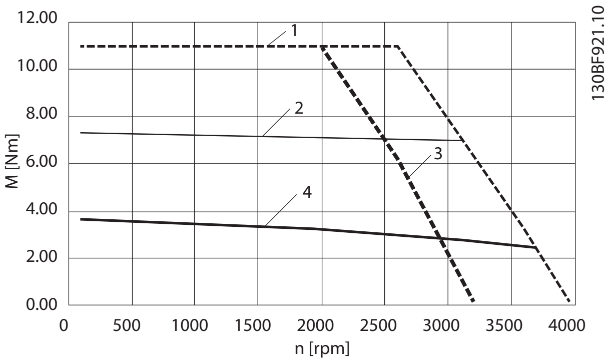
6.1.5.5 Speed-Torque Characteristics: Size 2, 2.9 Nm at 25 °C Ambient Temperature



1	SOA 680 V
2	S3
3	SOA 560 V
4	S1

Illustration 6.15 Performance at 25 °C Ambient Temperature: Size 2, 2.9 Nm

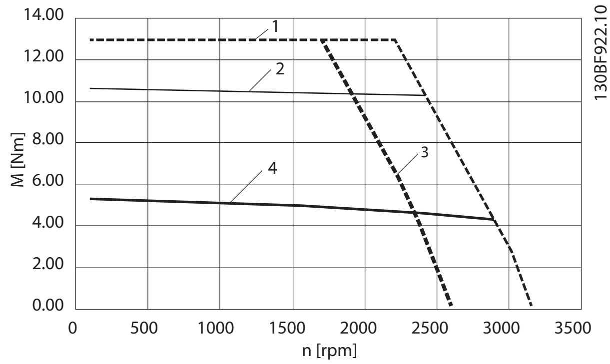
6.1.5.6 Speed-Torque Characteristics: Size 2, 2.9 Nm at 40 °C Ambient Temperature



1	SOA 680 V
2	S3
3	SOA 560 V
4	S1

Illustration 6.16 Performance at 40 °C Ambient Temperature: Size 2, 2.9 Nm

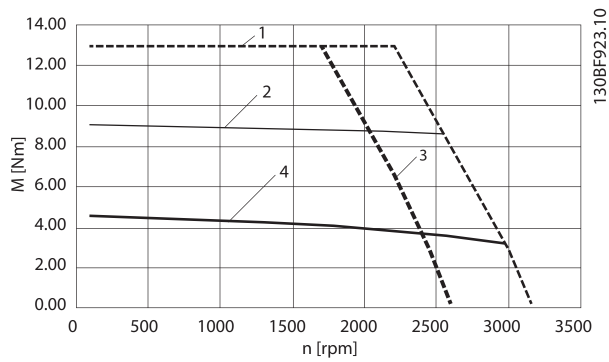
6.1.5.7 Speed-Torque Characteristics: Size 2, 3.8 Nm at 25 °C Ambient Temperature



1	SOA 680 V
2	S3
3	SOA 560 V
4	S1

Illustration 6.17 Performance at 25 °C Ambient Temperature: Size 2, 3.8 Nm

6.1.5.8 Speed-Torque Characteristics: Size 2, 3.8 Nm at 40 °C Ambient Temperature



1	SOA 680 V
2	S3
3	SOA 560 V
4	S1

Illustration 6.18 Performance at 40 °C Ambient Temperature: Size 2, 3.8 Nm

6.1.6 Derating

6.1.6.1 Derating at High Altitude

Illustration 6.19 shows the derating factor when using the servo drives above 1000 m.

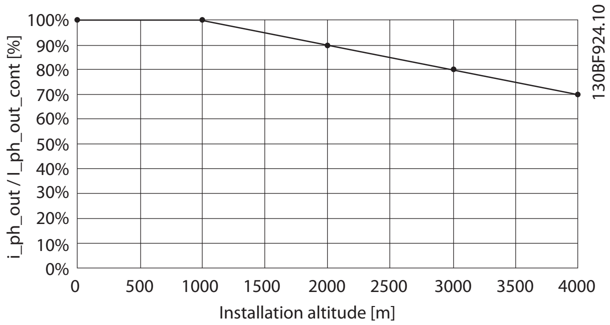


Illustration 6.19 Derating of Phase Output Current versus Installation Altitude

NOTICE

The components of the VLT® Integrated Servo Drive ISD 510 System are only approved for installation at altitudes up to 2000 m above sea level. Products used at altitudes above 2000 m above sea level means that such products are accepted "as is", and that Danfoss disclaims all warranties of quality, whether express or implied, including the warranties of merchantability and fitness for particular purpose. For any such products, Danfoss has no obligation to repair any damage to or defect in the products, replace the products, or otherwise remedy the products. Furthermore, Danfoss disclaims any liability for damage to person or property caused by the products due to the product being installed at altitudes above 2000 m above sea level.

6.1.6.2 Derating at High Ambient Temperature

Servo drive size	Temperature derating factor
Size 1, 1.5 Nm	0.032 Nm/°C
Size 2, 2.1 Nm	0.048 Nm/°C
Size 2, 2.9 Nm	0.056 Nm/°C
Size 2, 3.8 Nm	0.081 Nm/°C

Table 6.7 Derating at High Ambient Temperature

6.1.6.3 Derating using Servo Drives with Shaft Seals

Servo drive size	Derating
Size 1, 1.5 Nm	15%
Size 2, 2.1 Nm	11%
Size 2, 2.9 Nm	8%
Size 2, 3.8 Nm	4%

Table 6.8 Derating using Servo Drives with Shaft Seals

6.1.6.4 Derating using Servo Drives with Mechanical Holding Brake

Servo drive size	Derating
Size 1, 1.5 Nm	6%
Size 2, 2.1 Nm	5%
Size 2, 2.9 Nm	5%
Size 2, 3.8 Nm	5%

Table 6.9 Derating using Servo Drives with Mechanical Holding Brake

6.1.7 Connection Tightening Torques

Illustration 6.20 and *Illustration 6.21* show the fixing screws and mounting of the servo drives.

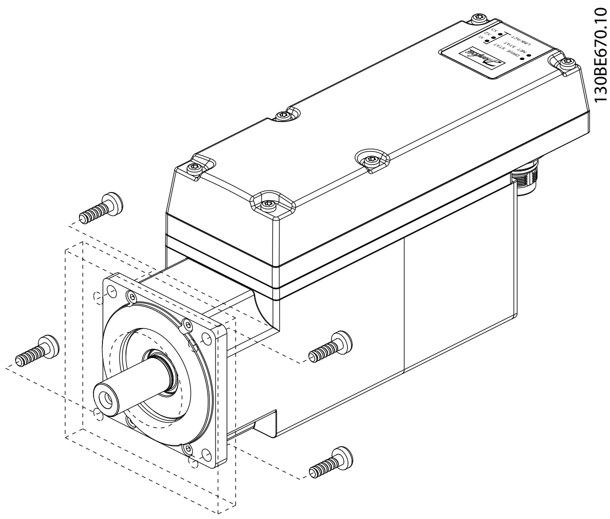


Illustration 6.20 Mounting of Size 1, 1.9 Nm, Size 2, 2.9 Nm, and Size 2, 3.8 Nm Servo Drives

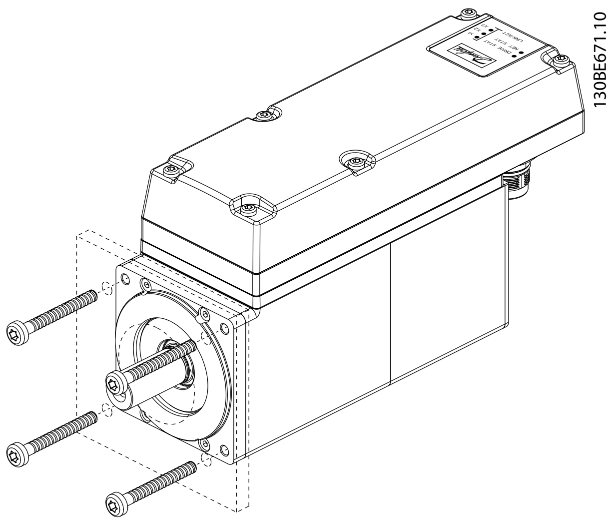


Illustration 6.21 Mounting of Size 2, 2.1 Nm Servo Drive

NOTICE

Do not machine the shaft.
Do not use the servo drive if the shaft does not match the coupling arrangement.

Table 6.10 lists the tightening torque values for the fixing screws. Always tighten the fixing screws uniformly and crosswise.

NOTICE

Failure to adhere to the specifications in *Table 6.10* may result in damage to the servo drive.

Servo drive size	Thread type/ hole size	Maximum thread length	Tightening torque
Size 1, 1.5 Nm	∅ 5.8 mm	–	–
Size 2, 2.1 Nm	M6 pitch 1 mm	23 mm	6 Nm
Size 2, 2.9 Nm	∅ 7 mm	–	–
Size 2, 3.8 Nm	∅ 7 mm	–	–

Table 6.10 Tightening Torques

NOTICE

The fixing screws are not supplied and must be selected according to the machine fixings.

6.1.8 Installation

6.1.8.1 Allowed Forces

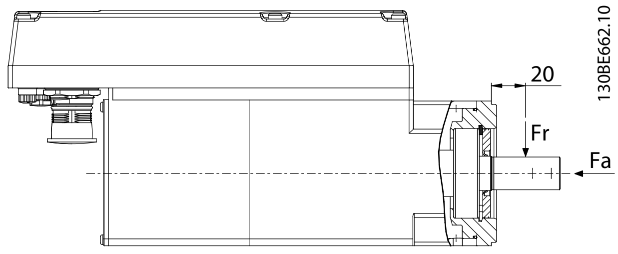


Illustration 6.22 Allowed Forces

Illustration 6.22 shows the maximum allowed forces on the motor shaft.

The maximum axial and radial load while assembling the motor and for any mechanical device connected to the shaft, must not exceed the values shown in *Table 6.11*. The shaft must be loaded slowly and in a constant manner: Avoid pulsating loads.

NOTICE

The bearing could be permanently damaged if the maximum allowed forces are exceeded.

Motor size	Radial Force (Fr) in N	Axial Force (Fa) in N
Size 1	450	1050
Size 2	900	1700

Table 6.11 Permitted Forces

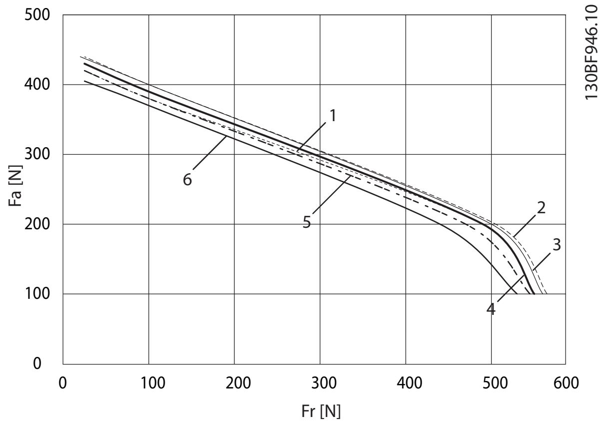
The maximum radial load ratings are based on the following assumptions:

- The servo drives are operated with peak torque of the longest member of the frame size.
- Fully reversed load is applied to the end of the smallest diameter standard mounting shaft extension.
- Infinite life with standard 99% reliability.
- Safety factor = 2

6.1.8.2 Bearing Load Curves

This section shows the bearing load curves (L10h – 10% failure) for each servo drive variant, which are calculated based on DIN ISO281. The curves show the maximum allowed radial force versus the maximum allowed axial force on the shaft end for different speeds. The estimated life-span of the bearing with this condition is 20000 h.

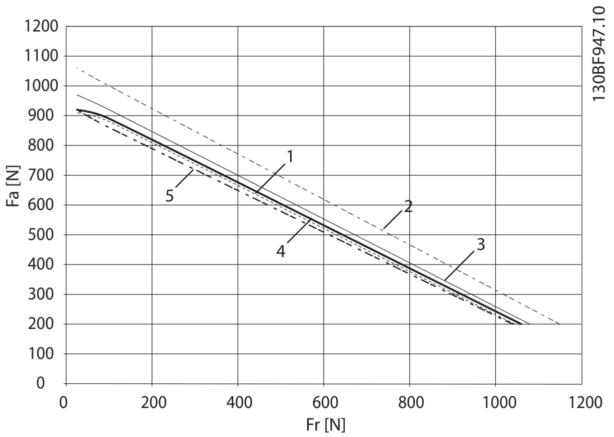
Size 1, 1.5 Nm



1	500 RPM
2	1000 RPM
3	2000 RPM
4	3000 RPM
5	4000 RPM
6	5000 RPM

Illustration 6.23 Size 1, 1.5 Nm

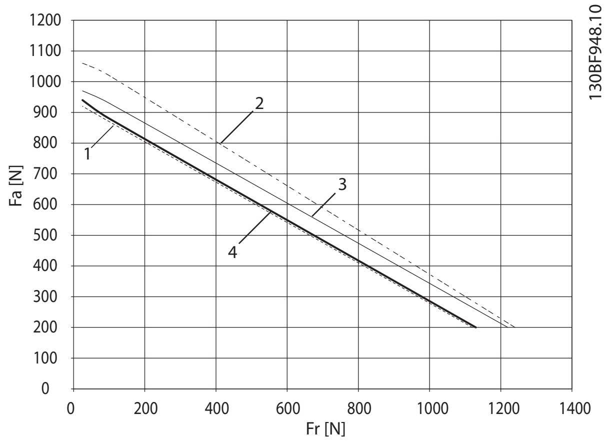
Size 2, 2.1 Nm



1	500 RPM
2	1000 RPM
3	2000 RPM
4	3000 RPM
5	4000 RPM

Illustration 6.24 Size 2, 2.1 Nm

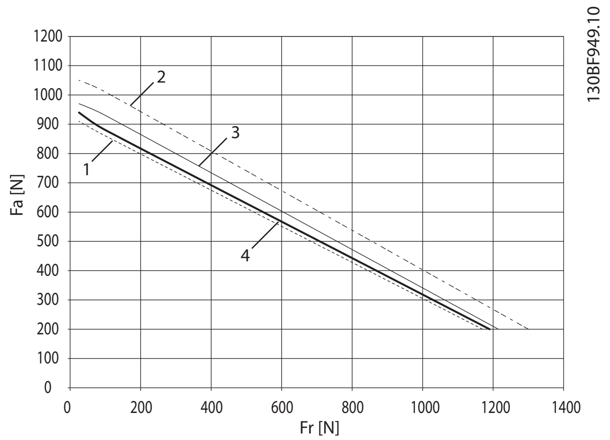
Size 2, 2.9 Nm



1	500 RPM
2	1000 RPM
3	2000 RPM
4	3000 RPM

Illustration 6.25 Size 2, 2.9 Nm

Size 2, 3.8 Nm



1	500 RPM
2	1000 RPM
3	2000 RPM
4	3000 RPM

Illustration 6.26 Size 2, 3.8 Nm

6.1.8.3 Installation Safety and Warnings

General

- The machine surface that comes in contact with the servo drive flange must be unpainted to guarantee good thermal behavior of the servo drive, and to minimize EMI disturbance in the servo system.
- Do not machine the shaft.
- Do not use the servo drive if the shaft does not match the coupling arrangement.
- Do not hammer the servo and do not use a hammer for fitting because this will damage the equipment.
- Ensure that the machinery is at a complete standstill before installing the servo drive.
- Ensure that the machinery is at a complete standstill and secured against unintended start before doing any work on the servo drive, for example dismounting the servo drive.
- During operation, the surface of both motor and electronic housing could reach temperatures of >100 °C. Ensure that the surface has cooled down before dismounting the servo drive.
- Avoid brute force while dismounting the servo drive and follow the instructions in the *VLT® Integrated Servo Drive ISD® 510 System Operating Instructions*.
- Before working on the power connector (connecting and disconnecting the M23 connector), disconnect the mains supply and wait for the discharge time (see *chapter 1.6 Safety*) to elapse.
- Mount the protection caps for any servo drive connectors that are not in use.

Warnings and notes for servo drive with optional brake

- Use an additional, external, mechanical brake to ensure personal safety in case of hanging loads (vertical axes). If the brake is released, then the rotor can be moved without remanent torque.
- The holding brakes are designed as standstill brakes and are not suitable for repeated operational braking. Frequent operational braking results in premature wear and failure of the holding brake.

Warnings and notes for servo drive with optional shaft seal

- Do not apply any axial load to the shaft seal.
- Prevent the seal from becoming dry by using adequate lubrication.
- Harsh environmental conditions, for example frictional heat, dirt, dust, or chemical substances, can reduce the lifetime of the shaft seal. Therefore the lifetime depends on the specific application.
- The maintenance task for the shaft seal is explained in *Table 6.12*.

Maintenance task	Maintenance interval	Instruction
Check the condition and check for leakage	Recommended every 4500 hours. A shorter or longer interval is possible depending on the application.	If damaged, replace the shaft seal.

Table 6.12 Maintenance Task: Shaft Seal

6.2 SAB

6.2.1 Dimensions

All dimensions are in mm (in).

Front view

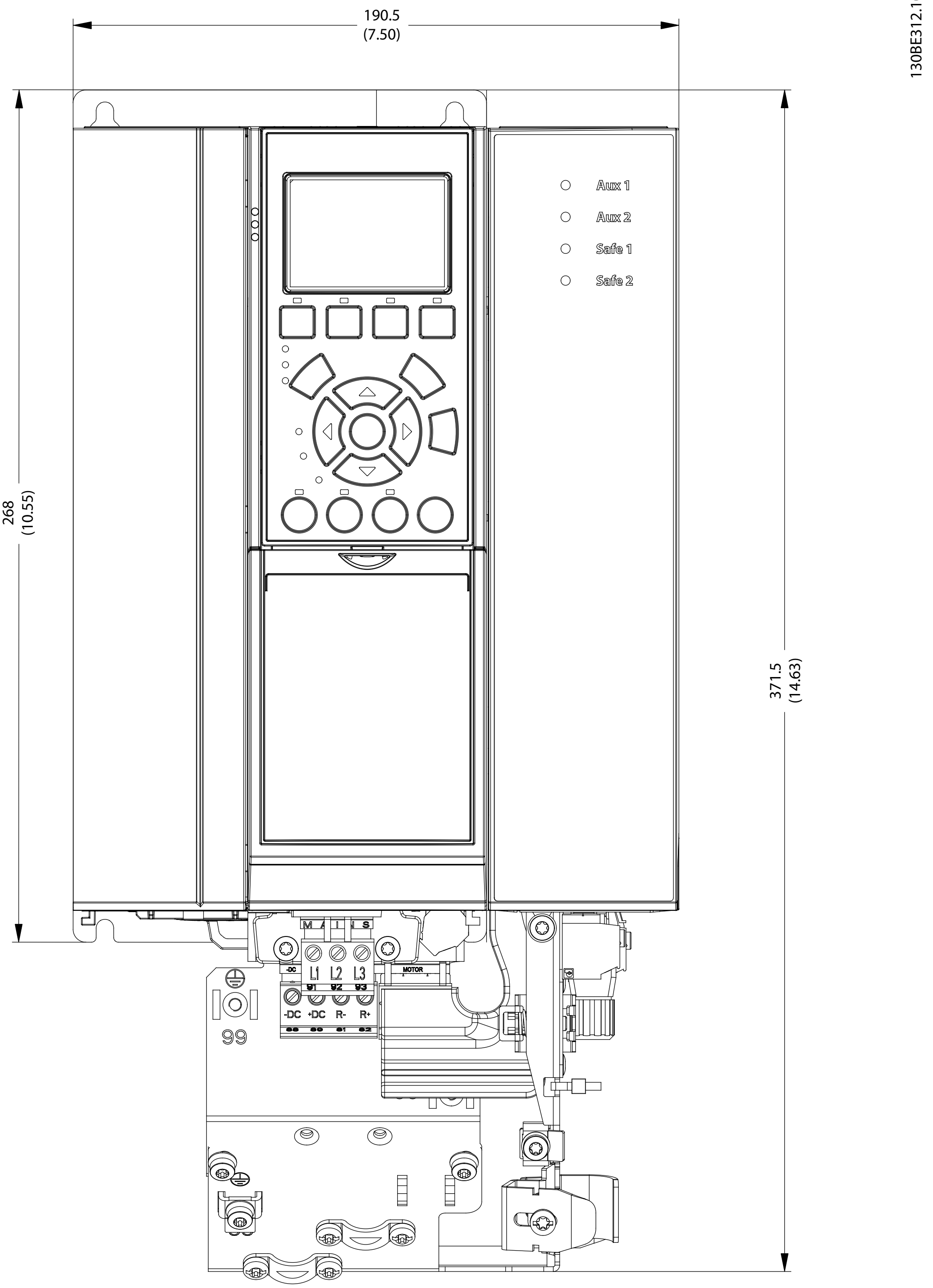


Illustration 6.27 Dimensions: Front View

Side view

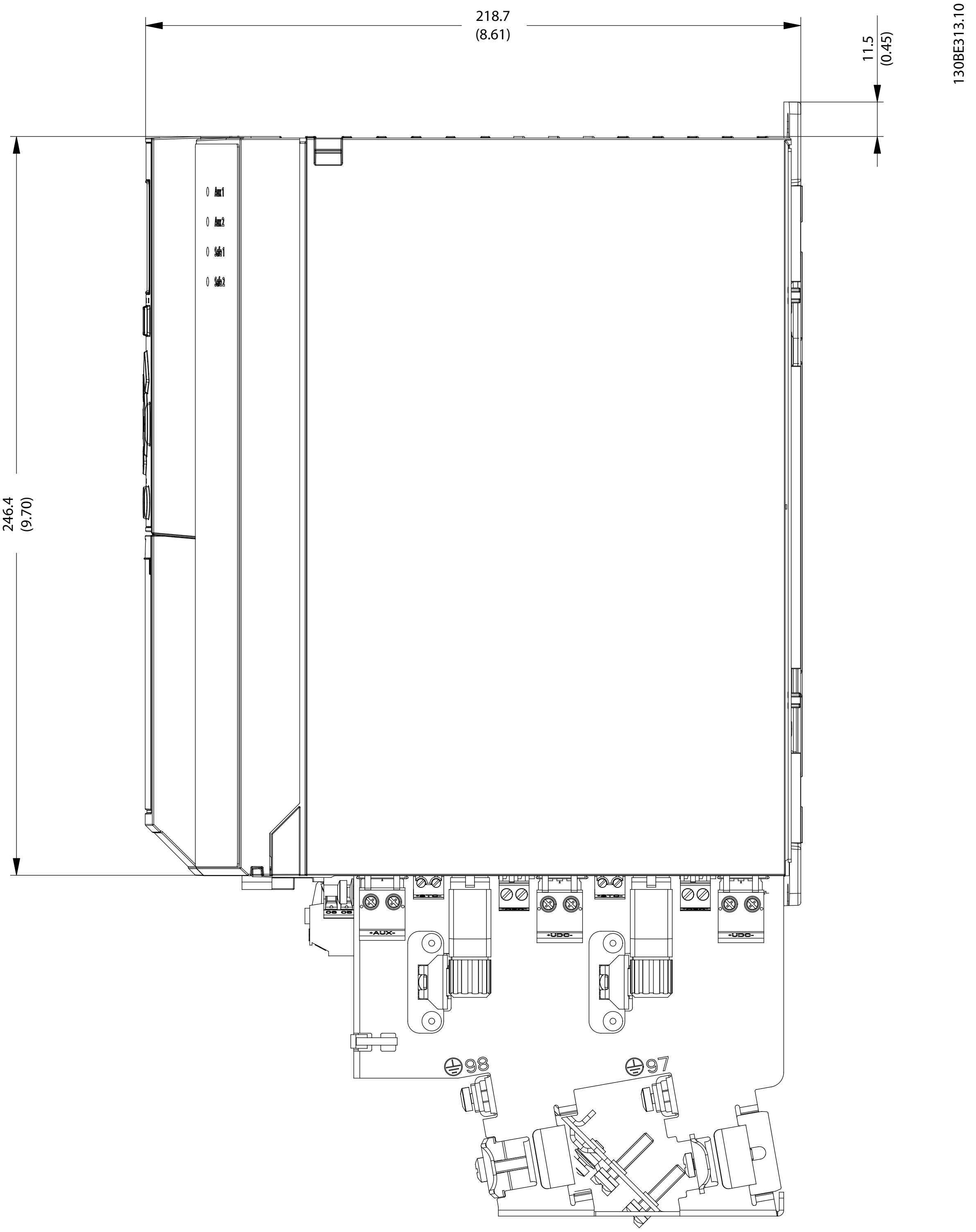


Illustration 6.28 Dimensions: Side View

Mounting plate

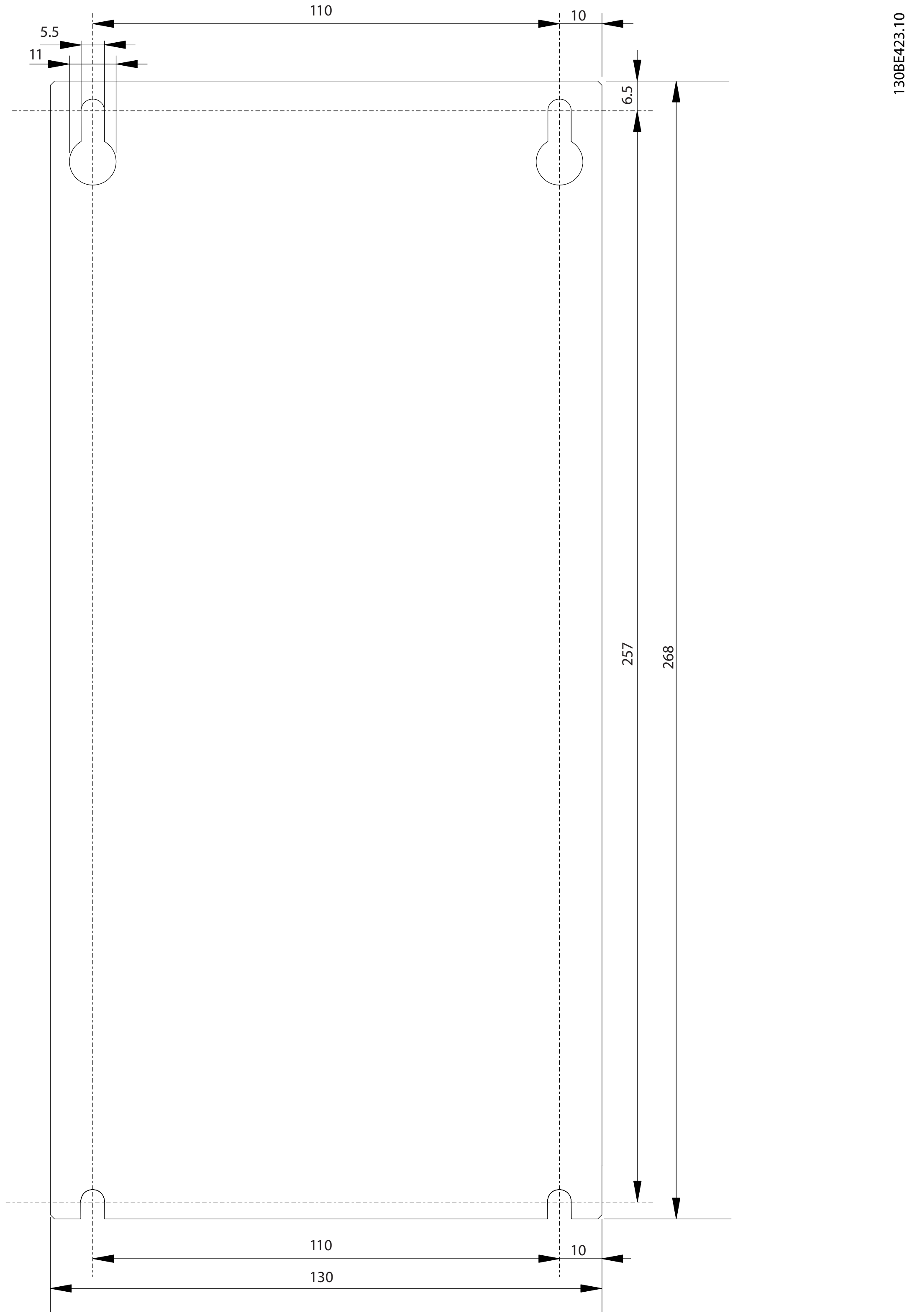


Illustration 6.29 Dimensions: Mounting Plate

6.2.2 Clearance

- The SABs can be mounted next to each other but require a minimum space of 100 mm at the top and bottom for cooling.
- In addition to its own dimensions, the SAB needs 100 mm space between the SAB decoupling plate and the cable duct for connecting cables.

6.2.3 Terminal Locations

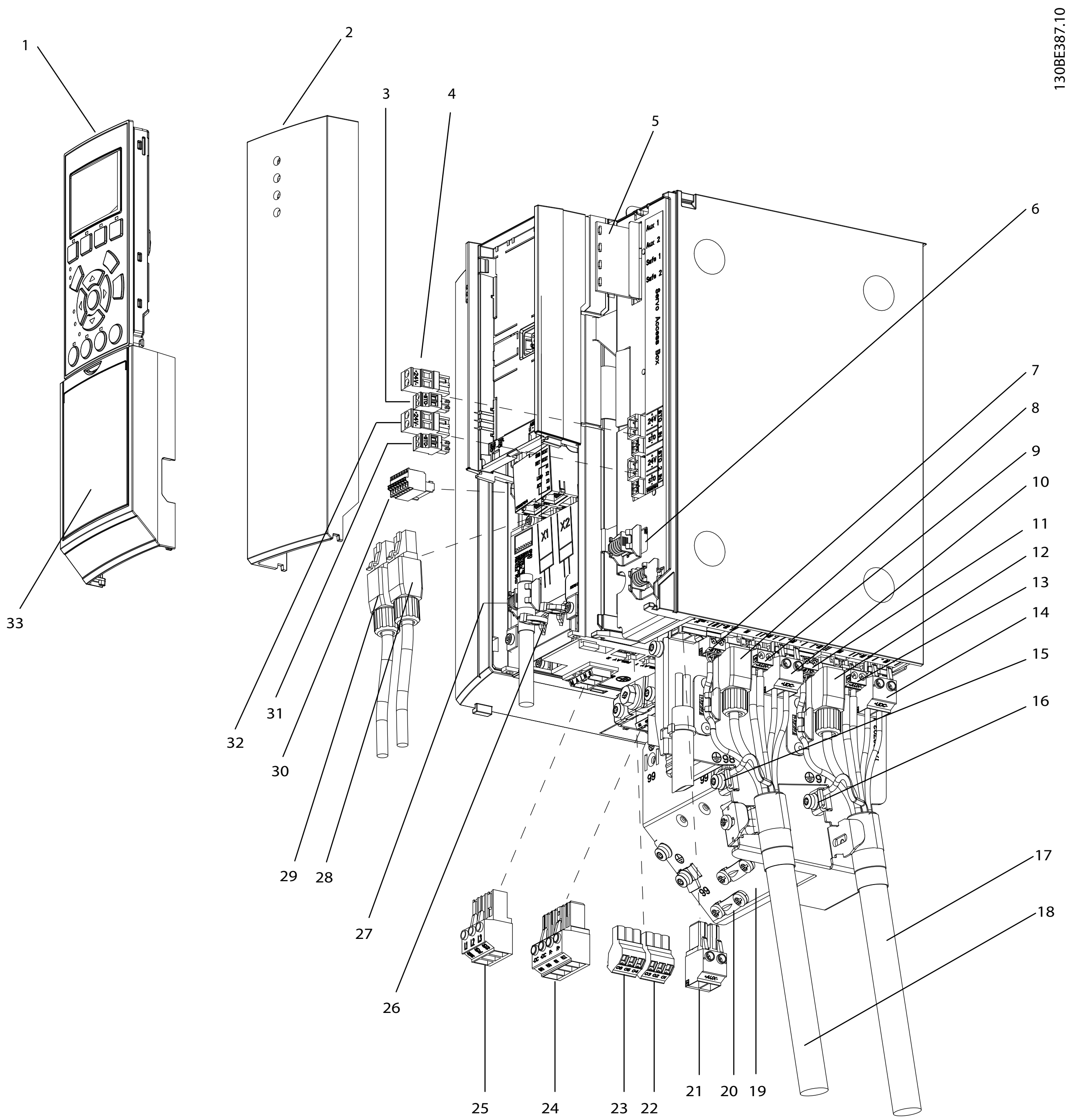


Illustration 6.30 Explosion Drawing of the Servo Access Box

Number	Description/connector name	Name on corresponding connector	Number	Description/connector name	Name on corresponding connector
1	Local control panel (LCP)	–	18	Hybrid cable line 2	–
2	Front cover	–	19	Decoupling plate	–
3	STO 1 IN: STO (Used for STO input voltage 1)	+STO–	20	Shielded cable grounding clamp and strain relief	–
4	STO 1 IN: 24 V (Used for bridging when the STO function is not required, see *chapter 6.2.3.1 STO Connectors*)	+24V–	21	24/48 V IN (Auxiliary input terminal)	+AUX–
5	LEDs for status of auxiliary output and STO	–	22	Relay 1	Relay 1
6	Decoupling clamp for STO cable	–	23	Relay 2	Relay 2
7	ISD Line 2: STO 2 (STO output to hybrid cable line 2)	+STO–	24	Brake	R– (81), R+ (82)
8	ISD Line 2: NET 2 X4 (Ethernet output to hybrid cable line 2)	RJ45 connector (without label)	25	Mains (Input terminal)	L1 (91), L2 (92), L3 (93)
9	ISD Line 2: AUX 2 (Auxiliary output to hybrid cable line 2)	+AUX–	26	Fixture for Ethernet inputs	–
10	ISD Line 2: UDC 2 (UDC output to hybrid cable line 2)	+UDC–	27	Decoupling clamp for encoder cable	–
11	ISD Line 1: STO 1 (STO output to hybrid cable line 1)	+STO–	28	X1 (Ethernet input line 1)	RJ45 connector (not included)
12	ISD Line 1: NET 1 X3 (Ethernet output to hybrid cable line 1)	RJ45 connector (without label)	29	X2 (Ethernet input line 2)	RJ45 connector (not included)
13	ISD Line 1: AUX 1 (Auxiliary output to hybrid cable line 1)	+AUX–	30	GND, 24 V, GX, /RS422 TXD, RS422 TXD, /RS422 RXD, RS422 RXD (Encoder terminal)	Not labeled
14	ISD Line 1: UDC 1 (UDC output to hybrid cable line 1)	+UDC–	31	STO 2 IN: STO (Used for STO input voltage 2)	+STO–
15	Grounding PE clamp for hybrid cable line 2	–	32	STO 2 IN: 24 V (Used for bridging when the STO function is not required, see *chapter 6.2.3.1 STO Connectors*)	+24V–
16	Grounding PE clamp for hybrid cable line 1	–	33	Cover	–
17	Hybrid cable line 1	–	–	–	–

Table 6.13 Legend to *Illustration 6.30*

6.2.3.1 STO Connectors

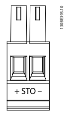
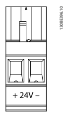
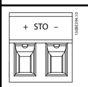
Item	Position on SAB	Description	Drawing/ pins	Ratings
STO 1 IN: STO	Front	Used for STO input voltage 1.	 Pins (left to right): STO+ STO-	Nominal voltage: 24 V DC ±10% Nominal current: Depends on the number of servo drives in the application. Maximum current: 1 A Maximum cross-section: 1.5 mm²
STO 2 IN: STO	Front	Used for STO input voltage 2.		
STO 1 IN: 24 V	Front	These connectors can only be used to make a bridge to STO 1 IN: STO and STO 2 IN: STO if the STO function is not required in the application. This connector cannot be used for any other function.	 Pins (left to right): 24+ 24-	Nominal voltage: 24 V DC ±10% Nominal current: 1 A Maximum cross-section: 1.5 mm²
STO 2 IN: 24 V	Front			
ISD Line 1: STO 1	Underside	Used for STO output voltage 1.	 Pins (left to right): STO+ STO-	Nominal voltage: 24 V DC ±10% Nominal current: Depends on the number of servo drives in the application. Maximum current: 1 A Maximum cross-section: 0.5 mm²
ISD Line 2: STO 2	Underside	Used for STO output voltage 2.		

Table 6.14 STO Connectors

6.2.3.2 Mains Connectors

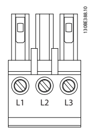
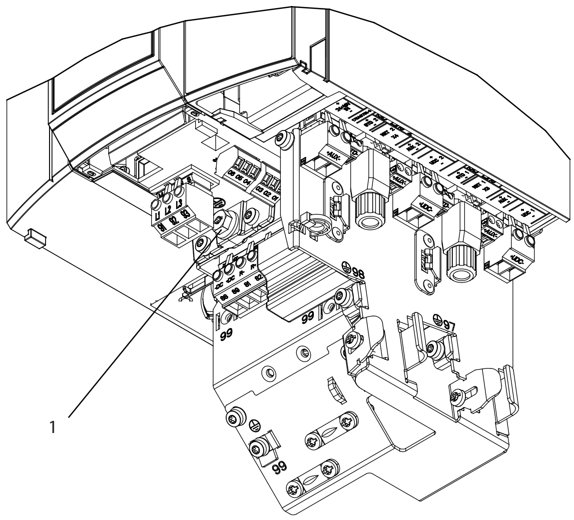
Item	Description	Drawing/ pins	Ratings
AC mains supply	Used to connect L1/L2/L3	 Pins (left to right): L1 L2 L3	Nominal voltage: 400–480 V AC Nominal current: 12.5 A Maximum cross-section: 4 mm²
Mains PE (terminal 95)	The PE screw is used to connect the protective earth, see *Illustration 6.31*.	–	Minimum cross-section: 10 mm²

Table 6.15 Mains Connectors



1	PE screw (terminal 95)

Illustration 6.31 PE Screw

6.2.3.3 Brake Connector

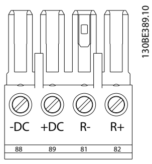
Item	Description	Drawing/pins	Ratings
Brake	Used for connecting a brake resistor	 –DC (88) = Do not use +DC (89) = Do not use R– (81) = Brake – R+ (82)= Brake +	Nominal voltage: 565–778 V DC Maximum brake current: 14.25 A Maximum cross-section: 4 mm^2

Table 6.16 Brake Connector

NOTICE

The maximum length of the brake cable is 20 m (shielded).

6.2.3.4 Relay Connectors

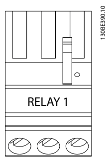
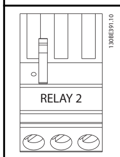
Item	Description	Drawing/pins	Ratings
Relay 1	Used for a customer-defined reaction. For example, the relay can be triggered if the SAB issues a warning.	 Pins (left to right): 1: Common 2: Normally open 3: Normally closed	Pin 1: Common Pin 2: 240 V AC Pin 3: 240 V AC Nominal current: 2 A Maximum cross-section: 2.5 mm^2
Relay 2		 Pins (left to right): 4: Common 5: Normally open 6: Normally closed	Pin 4: Common Pin 5: 400 V AC Pin 6: 240 V AC Nominal current: 2 A Maximum cross-section: 2.5 mm^2

Table 6.17 Relay Connectors

6.2.3.5 Encoder Connectors

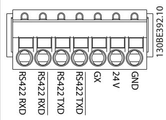
Item	Description	Drawing/pins	Ratings
Encoder connector	Used to connect SSI or BiSS encoders.	 Pins (left to right on SAB label): RS422 RXD /RS422 RXD RS422 TXD /RS422 TXD GX 24 V GND	Maximum cross-section: 0.5 mm^2. See *Table 6.19.*

Table 6.18 Encoder Connectors

NOTICE

The maximum length of the encoder cable is 25 m (shielded).

Number	Description	Notes		Rating/ parameter
		SSI	BiSS	
1	RS422 RXD	Positive data		Bus speed: SSI: 0.5 Mbit with 25 m cable BiSS: Fulfills the RS485 specification
2	/RS422 RXD	Negative data		
3	RS422 TXD	Positive clock		
4	/RS422 TXD	Negative clock		
5	GX	Isolated ground If encoders are powered externally, the ground of the external supply must be connected to GX.		–
6	24 V	24 V DC ±10% (used for powering the encoder)		Maximum current: 250 mA
7	GND	Ground for pin 6		–

Table 6.19 Pin Assignment for SSI and BiSS Encoders

6.2.3.6 Ethernet Connectors

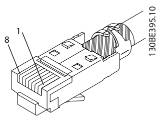
Connector name	Description	Drawing/pins	Ratings
Ethernet X1	Connection to fieldbus	 Pins: 1: TD+ 2: TD– 3: RD+ 6: RD–	Fulfill the 100BASE-T specification
Ethernet X2	Connection to fieldbus		
Ethernet X3	Connection to servo line 1		
Ethernet X4	Connection to servo line 2		

Table 6.20 Ethernet Connectors

NOTICE

The maximum length of the X1 and X2 shielded Ethernet cables is 30 m.

6.2.3.7 AUX Connectors

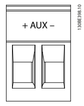
Connector name	Description	Drawing/ pins	Ratings
ISD Line 1: AUX 1	Used to connect the AUX output from the SAB to the hybrid cable.	 Pins (left to right): AUX+ AUX–	Nominal voltage: 24–48 V DC±10% Nominal current: Depends on the number of servo drives in the application Maximum current: 15 A Maximum cross-section: 2.5 mm²
ISD Line 2: AUX 2			

Table 6.21 AUX Connectors

6.2.3.8 24/48 V IN Connector

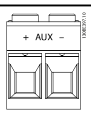
Connector name	Description	Drawing/ pins	Ratings
24/48 V IN Connector	Used for 24–48 V DC input to the SAB.	 Pins (left to right): AUX+ AUX–	Nominal voltage: 24–48 V DC ±10% Nominal current: Depends on the number of servo drives in the application Maximum current: 34 A Maximum cross-section: 4 mm²

Table 6.22 24/48 V IN Connector

NOTICE

The maximum cable length is 3 m.

6.2.3.9 UDC Connectors

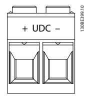
Connector name	Description	Drawing/ pins	Ratings
ISD Line 1: UDC 1	Used to connect the DC-link voltage from the SAB to the hybrid cable.	 Pins (left to right): UDC+ UDC–	Nominal voltage: 565–778 V DC Nominal current: Depends on the number of servo drives in the application Maximum current: 15 A Maximum cross-section: 2.5 mm²
ISD Line 2: UDC 2			

Table 6.23 UDC Connectors

6.2.3.10 Hybrid Cable PE

Item	Description	Drawing/pins	Ratings
Hybrid cable PE	Used to connect the PE wire from the hybrid cable to the decoupling plate.	See callout 15 in *Illustration 6.30.*	Maximum cross-section: 2.5 mm²

Table 6.24 Hybrid Cable PE

6.2.4 Characteristic Data

Definition	Value and unit
Input	
Input voltage	400–480 V ±10%
Efficiency	98.5% at 400 V
Input current	12.5 A continuous 20 A intermittent
Output	
Output voltage ISD Line 1: UDC 1 & ISD Line 2: UDC 2	565–679 V ±10%[2)]
Output voltage ISD Line 1: STO 1 & ISD Line 2: STO 2	24 V ±10%
Output voltage ISD Line 1: AUX 1 & ISD Line 2: AUX 2	24–48 V ±10%
Output current ISD Line 1: AUX 1 & ISD Line 2: AUX 2	15 A[1)]
Output current UDC	15 A[1)]
Output current ISD Line 1: STO 1 & ISD Line 2: STO 2	1 A[1)]
Output power	8 kW at 400 V 9.7 kW at 480 V
Housing	
Dimensions (W x H x D)	130 x 268 x 80 mm
Weight	8.3 kg

Table 6.25 Servo Access Box Characteristic Data

1) Depends on the number of servo drives connected in the application. The current per servo drive is 6.7 mA.

6.2.5 General Specifications and Environmental Considerations

Protection rating	IP20 (UL rating: Open type)
Vibration test	Random vibration: 1.14 g (2h/axis according to EN 60068-2-64) Sinusoidal vibration: 0.7 g (2h/axis according to EN 60068-2-6)
Maximum relative humidity	Storage/transport and stationary use: 5–93% (non-condensing)
Ambient temperature range	5–50 °C operating temperature (24-hour average maximum 45 °C) Transport: -25 to +70 °C Storage: -25 to +55 °C
Installation elevation	Maximum 1000 m above sea level
EMC standard for emission and immunity	EN 61800-3

Table 6.26 General Specifications and Environmental Conditions SAB

6.2.6 Mains Supply

Refer to *chapter 4.4 Mains Input* for information on the mains supply for the SAB.

6.2.7 Derating

The cooling capability is decreased at lower air pressure. Below 1000 m altitude no derating is necessary. Above 1000 m, the ambient temperature or the maximum output current has to be derated.

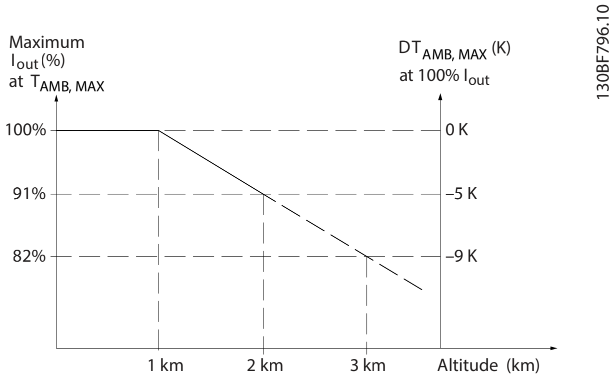


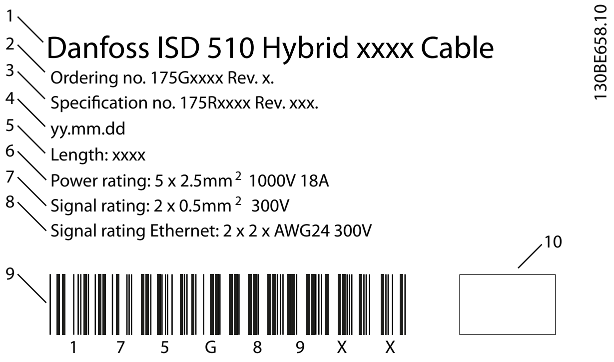
Illustration 6.32 Derating SAB

6.2.8 Connection Tightening Torques

Decoupling plate screws: 2 Nm

6.3 Cable

All cables supplied by Danfoss have a nameplate as per the example in *Illustration 6.33*.



1	Cable type
2	Ordering code
3	Revision of specification
4	Manufacturing date
5	Length
6	Power rating
7	Signal rating
8	Signal rating for Ethernet
9	Barcode
10	Manufacturer logo

Illustration 6.33 Example of a Cable Nameplate

WARNING

HIGH VOLTAGE

The VLT® Integrated Servo Drive ISD 510 System contains components that operate at high voltage when connected to the electrical supply network.
A hazardous voltage is present on the servo drives and the SAB whenever they are connected to the mains network.
There are no indicators on the servo drive or SAB that indicate the presence of mains supply.
Incorrect installation, commissioning, or maintenance can lead to death or serious injury.

- **Installation, commissioning, and maintenance must only be performed by qualified personnel.**

NOTICE

Do not use force to connect or fit the connector. This causes permanent damage to connector and cables.

Before working on the power connector (connecting and disconnecting M23), disconnect the mains supply and wait for discharge time to elapse (see *chapter 1.6 Safety*).

The interlocking of the hybrid feed-in cable and loop cable with the servo drive is indicated by the marking OPEN on the cable connector.

The advanced servo drive is delivered with M8, M12, and M23 caps. These caps protect the servo drive connectors during transportation and storage. Furthermore, they are a part of the IP protection (IP67 for M8 and M12 covers; IP40 for M23 covers) and must remain fitted if the respective connectors are not used. To achieve IP67 on the M23 connector, use the M23 blind cap.

Connector	Tightening torque [Nm]
M8	0.2
M12	0.4
M23	0.8

Table 6.27 Tightening Torques

6.3.1 Feed-In Cable

Shielded/ unshielded	Maximum cable length	Description
Shielded	40 m[1)]	Hybrid cable (overall shield with additional fieldbus and safety section shield).

Table 6.28 Feed-In Cable

1) Maximum 100 m total length for each line of servo drives.

There are 2 types of connector for the feed-in cable:

- M23 angled connector
- M23 straight connector

See *chapter 5.5.1.1 Feed-In Cable* for ordering numbers.

6.3.1.1 Clearances

Illustration 6.35 and *Illustration 6.36* show the dimensions of 2 types of M23 cable connectors installed on the servo drive. A size 2 servo drive is used in this example and the dimensions of other sizes differ.

The M23 angled connector can be adjusted or tilted up to 120°, as illustrated in *Illustration 6.34*.

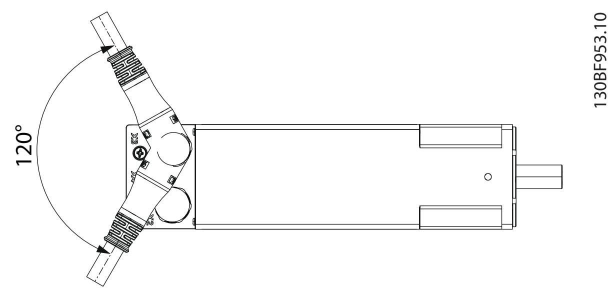


Illustration 6.34 Adjustable Angle of the Angled Connector

Each connector type requires specific installation spaces or area in order to ease the installation and to meet the minimum allowable bending radius of cable.

NOTICE

Exceeding the minimum allowable bending radius of cable causes damage on connectors on both the servo drive and the cable itself.

There are 2 possible types of cable installation. The minimum allowable bending radius R_{min} for each installation type is:

- Permanently flexible: 12 x cable diameter = 187.2 mm
- Permanently installed: 5 x cable diameter = 78 mm

The maximum number of bending cycles is 5 million at 7.5 x cable diameter (15.6 mm).

Illustration 6.35 shows the servo drive with the straight connector installed on a size 2 servo drive. *Illustration 6.36* shows the servo drive with the angled connector installed on a size 2 servo drive. The illustrations show the minimum distance from the servo drive to next object, and the minimum allowable bending radius R_{min} for permanently installed cable.

For cable installation, allow the height of the connector plus an additional 30 mm for the cable.

Required installation distances

The minimum distance is measured from the electronic housing as this is the same for all motor variants.

Straight connector

The minimum distance for the straight connector is calculated as follows:
0.5 x cable diameter + connector height + R_{min} = 7.8 mm + 112 mm + 78 mm = 197.8 mm ≈ 200 mm

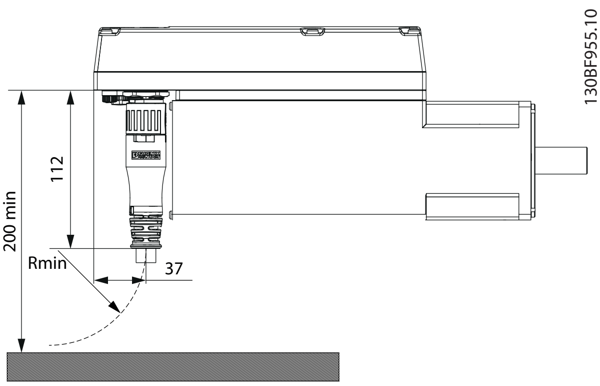


Illustration 6.35 Required Installation Distance and Minimum Bending Radius for M23 Straight Connector

Angled connector

The minimum distance for the angled connector is calculated as follows:
0.5 x cable diameter + connector length measured from electronic housing + R_{min} = 7.8 mm + 51.4 mm + 78 mm = 137.8 mm ≈ 140 mm

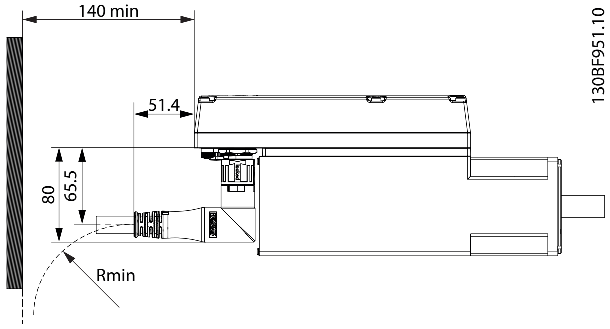


Illustration 6.36 Required Installation Distance and Minimum Bending Radius for M23 Angled Connector

6.3.2 Loop Cable

Shielded/ unshielded	Maximum cable length	Description
Shielded	25 m[1)]	Hybrid cable (overall shield with additional fieldbus and safety section shield).

Table 6.29 Loop Cable

1) Maximum 100 m total length for each line of servo drives.

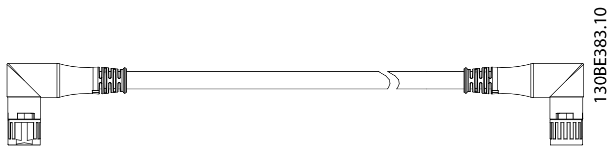


Illustration 6.37 Loop Cable

See *chapter 5.5.1.2 Loop Cable* for ordering numbers.

See *chapter 6.1.2.1 Connectors on the Servo Drives* for pin assignment.

6.3.3 Fieldbus Extension Cable

There are 2 types of fieldbus extension cable for ring redundancy:

- M23 angled connector to M12 straight connector
- M23 straight connector to M12 straight connector

See *chapter 5.5.2 Fieldbus Cables* for ordering numbers.

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6.3.4 LCP Cable

There are 2 types of cable for the LCP module:

- To connect the LCP to the servo drive.
- To connect the LCP to the SAB.

See *chapter 5.5.3 LCP Cable* for ordering numbers.

6.3.5 Sensor and Encoder Cable

Contact Danfoss for further information regarding cables for connection to the M8 and M12 connectors. The pin assignment can be found in *chapter 6.1.2.1 Connectors on the Servo Drives*. Always use shielded cables.

- Maximum length: 25 m (shielded)
- Maximum cross-section: 0.5 mm^2

6.3.6 Ethernet Cable

See *chapter 6.2.3.6 Ethernet Connectors* for pin assignment.

	Specification
Ethernet standard	Standard Ethernet (in accordance with IEEE 802.3), 100Base-TX (Fast Ethernet)
Cable type	S/FTP (shielded foiled twisted pair), ISO (IEC 11801 or EN 50173), CAT 5e or 6
Damping	23.2 dB (at 100 Mhz and 100 m each)
Crosstalk damping	24 dB (at 100 Mhz and 100 m each)
Return loss	10 dB (100 m each)
Surge impedance	100 Ω
Maximum cable length	100 m between switches or network devices

Table 6.30 Ethernet Cable Recommendations

NOTICE

Ground the Ethernet cable through the RJ45 connector. Do not ground it on the strain relief.

7 Appendix

7.1 Glossary

A side
The A side is the shaft side of the servomotor.

Ambient temperature
The temperature in the immediate vicinity of the servo system or component.

Automation Studio™
Automation Studio™ is a registered trademark of B&R. It is the integrated software development environment for B&R controllers.

Axial force
The force in newton acting on the rotor axis in the axial direction.

Bearings
The ball bearings of the servomotor.

Beckhoff®
Beckhoff® is a registered trademark of and licensed by Beckhoff Automation GmbH, Germany.

B&R
Multi-national company, specializing in factory and process automation software and systems for a wide range of industrial applications.

B side
The rear side of the servo drive with the plug-and-socket connectors.

Brake
Mechanical holding brake on the servo drive.

CANopen®
CANopen® is a registered community trademark of CAN in Automation e.V.

CE
European test and certification mark.

CiA DS 402
Device profile for drives and motion control.
CiA® is a registered community trademark of CAN in Automation e.V.

Clamping set
A mechanical device, which, for example, can be used to secure gears to a motor shaft.

Connector (M23)
Servo drive hybrid connector.

Cooling
The servo drives are cooled by natural convection (without fans).

DC-link
Each servo drive has its own DC-link, consisting of capacitors.

DC-link voltage
A DC voltage shared by several servo drives connected in parallel.

DC voltage
A direct constant voltage.

DDS Toolbox
A Danfoss pc software tool used for parameter setting and diagnostics of the servo drives and the SAB.

EPSG
Ethernet POWERLINK® Standardization Group.

ETG
EtherCAT® Technology Group

EtherCAT®
EtherCAT® (Ethernet for Control Automation Technology) is an open high-performance Ethernet-based fieldbus system. EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

Illustration 7.1 EtherCAT® Logo

Ethernet POWERLINK®
Ethernet POWERLINK® is a deterministic real-time protocol for standard Ethernet. It is an open protocol managed by the Ethernet POWERLINK® Standardization Group (EPSG). It was introduced by Austrian automation company B&R in 2001.

Feed-in cable
Hybrid connection cable between the SAB and servo drive.

Feedback system
The feedback system measures the rotor position.

Fieldbus
Communication bus between controller and servo axis and SAB; in general between controller and field nodes.

Firmware
Software in the unit; runs on the control board.

Function block
Device functionalities are accessible via the engineering environment software.

IGBT
The insulated-gate bipolar transistor is a 3-terminal semiconductor device, primarily used as an electronic switch to combine high efficiency and fast switching.

Installation elevation
Installation elevation above normal sea level, typically associated with a derating factor.

ISD
Integrated servo drive.

ISD devices
Refers to both the servo drives and the SAB.

ISD servomotor
Designates the ISD servomotor (without the drive electronics).

LCP
Local control panel.

Loop cable
Hybrid connection cable between 2 servo drives, with 2 M23 connectors.

M8 connectors
Fully functional real-time Ethernet port (X3) on the B side of the advanced servo drive.
Connector (X5) for connection of the LCP to the B side of the advanced servo drive.

M12 connector
Connector (X4) for connecting I/O and/or encoder on the B side of the advanced servo drive.

M23 connectors
Connectors (X1 & X2) for connecting the hybrid feed-in and loop cables on the B side of the standard and advanced servo drive.

Motor shaft
Rotating shaft on the A side of the servo motor, typically without a key groove.

Multi-turn encoder
Describes a digital absolute encoder, in which the absolute position remains known after several revolutions.

PLC
A programmable logic controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factor assembly lines.

PELV
Protected extra low voltage is an electricity supply voltage in a range which carries a low risk of dangerous electrical shock.

PLCopen®
The name PLCopen® is a registered trademark and, together with the PLCopen® logos, is owned by the association PLCopen®. PLCopen® is a vendor and product-independent worldwide association, that defines a standard for industrial control programming.

POU
Program organization unit. This can be a program, function block, or function.

PWM
Pulse width modulation.

Radial force
The force in newton acting at 90° to the longitudinal direction of the rotor axis.

RCCB
Residual current circuit breaker.

Resolver
A feedback device for servomotors, typically with 2 analog tracks (sine and cosine).

Safety (STO)
A servo drive safety circuit that switches off the voltages of the driver components for the IGBTs.

Scope
Is part of the DDS Toolbox software and is used for diagnosis. It enables internal signals to be depicted.

Servo Access Box (SAB)
Generates the DC-link supply for the VLT® Integrated Servo Drive ISD 510 System and can host up to 64 servo drives.

SIL 2
Safety Integrated Level II.

Single-turn encoder
Describes a digital absolute encoder, in which the absolute position for 1 revolution remains known.

SSI
Synchronous serial interface.

Standstill (servo drive)
Power is on, there is no error in the axis, and there are no motion commands active on the axis.

STO
Safe Torque Off function. On activation of STO, the servo drive is no longer able to produce torque in the motor.

TwinCAT®
TwinCAT® is a registered trademark of and licensed by Beckhoff Automation GmbH, Germany. It is the integrated software development environment for controllers from Beckhoff.

U_{AUX}
Auxiliary supply, provides power to the control electronics of the servo drives and SAB.

Wireshark®
Wireshark® is a network protocol analyzer released under the GNU General Public License version 2.

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