ABB DRIVES FOR WATER

ACQ80-07 drives (75 to 200 kW)

Hardware manual

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Hardware manual

3AXD50000946440 Rev B
EN
Original instructions
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1

Safety instructions

Contents of this chapter

This chapter contains the safety instructions which you must obey when you install, start-up, operate and do maintenance work on the drive. If you ignore the safety instructions, injury, death or damage can occur.

Use of warnings and notes

Warnings tell you about conditions which can cause injury or death, or damage to the equipment. They also tell you how to prevent the danger. Notes show a particular condition or fact, or give information.

The manual uses these warning symbols:

WARNING!
Electricity warning tells about hazards from electricity which can cause injury or death, or damage to the equipment.

WARNING!
General warning tells about conditions other than those caused by electricity, which can cause injury or death, or damage to the equipment.

WARNING!
Electrostatic sensitive devices warning tells you about the risk of electrostatic discharge which can cause damage to the equipment.

General safety in installation, start-up and maintenance

These instructions are for all persons who do work on the drive.

WARNING!
Obey these instructions. If you ignore them, injury or death, or damage to the equipment can occur.

- Keep the drive in its package until you install it. After unpacking, protect the drive from dust, debris and moisture.
- Use the required personal protective equipment: safety shoes with metal toe cap, safety glasses, protective gloves and long sleeves, etc. Some parts have sharp edges.
- Use a lifting device to lift a heavy drive. Use the designated lifting points. Refer to the dimension drawings.
- Obey the local laws and regulations that apply to lifting, such as the requirements for planning the lift, the capacity and condition of the lifting equipment, and personnel training.
- Attach the drive cabinet to the floor to prevent it from falling over. The cabinet has a high center of gravity. When you pull out heavy components or power modules, there is a risk of overturning. Attach the cabinet also to the wall when necessary.

- Do not stand or walk on the cabinet roof. Make sure that nothing presses against the roof, side or back plates or door. Do not store anything on the roof while the drive is in operation.
- Be careful when handling a tall module. The module overturns easily because it is heavy and has a high center of gravity. Whenever possible, secure the module with chains. Do not leave an unsupported module unattended especially on a sloping floor.

- Beware of hot surfaces. Some parts, such as heatsinks of power semiconductors, and brake resistors, can be hot for a period after operation.
- Before the start-up, vacuum clean the area around the drive to prevent the drive cooling fan from drawing dust inside the drive.
- Make sure that debris from drilling, cutting and grinding does not go into the drive during installation. Electrically conductive debris inside the drive can cause damage or malfunction.
- Make sure that there is sufficient cooling. Refer to the technical data.
- Keep the drive cabinet doors closed when the drive has electrical power. If the doors of the drive cabinet are open, there is a risk of a potentially fatal electric shock, arc flash or high-energy arc blast exists.
- If you must do work on a drive that is connected to the power supply, obey the local laws and regulations on live electrical work. This includes, but is not limited to, electric shock and arc protection.
- Before you adjust the drive operation limits, make sure that the motor and all driven equipment can operate throughout the set operation limits.
- Before you activate the automatic fault reset or automatic restart functions of the drive control program, make sure that no dangerous situations can occur. These functions reset the drive automatically and continue operation after a fault or break in the power supply. If these functions are activated, the installation must be clearly marked as defined in IEC/EN/UL 61800-5-1, subclause 6.5.3, for example, "THIS MACHINE STARTS AUTOMATICALLY".
- The maximum number of drive power-ups is five in ten minutes. Too frequent power-ups can damage the charging circuit of the DC capacitors.
- If the drive has connected safety circuits (for example, Safe torque off or emergency stop), validate them at start-up. Refer to separate instructions for the safety circuits.
- Beware of hot air flow from the cooling outlets.
- Do not cover the air inlet or air outlet when the drive operates.

Note:

- If you select an external source for the start command and it is on, the drive starts immediately after a fault reset unless you configure the drive for pulse start. Refer to the firmware manual.
- If the drive is in remote control mode, you cannot stop or start the drive with the control panel.
- Only authorized persons are permitted to repair a faulty drive.

Electrical safety in installation, start-up and maintenance

Electrical safety precautions

These electrical safety precautions are for all persons who do work on the drive, motor cable or motor.

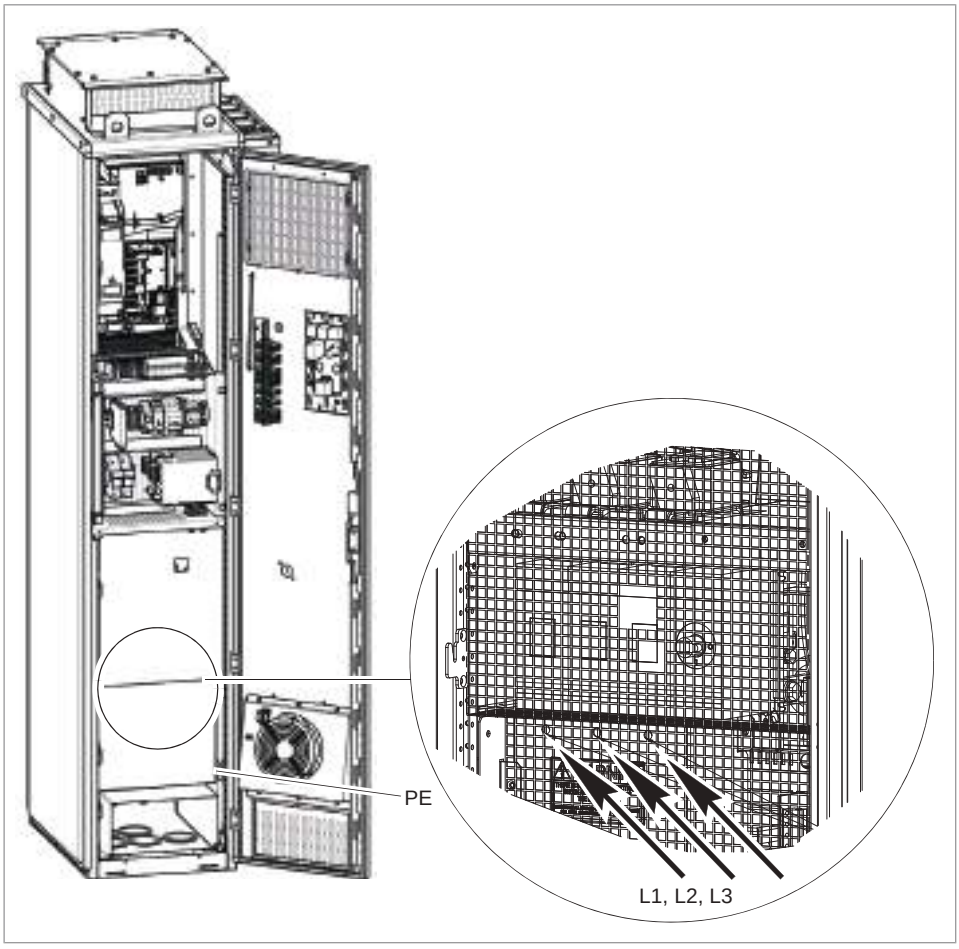
WARNING!
Obey these instructions. If you ignore them, injury or death, or damage to the equipment can occur.

If you are not a qualified electrical professional, do not do installation or maintenance work.

Do these steps before you begin any installation or maintenance work.

1. Prepare for the work.
   - Make sure that you have a work order.
   - Do an on-site risk assessment or job hazard analysis.
   - Make sure that you have the correct tools available.
   - Make sure that the workers are qualified.
   - Select the correct personal protective equipment (PPE).
   - Stop the drive and motor(s).
2. Clearly identify the work location and equipment.
3. Disconnect all possible voltage sources. Make sure that connection is not possible. Lock out and tag out.
   - Open the main disconnecting device of the drive.
   - Open the charging switch if it is present.
   - Open the disconnector of the supply transformer. (The main disconnecting device in the drive cabinet does not disconnect the voltage from the AC input power busbars of the drive cabinet.)
   - Open the auxiliary voltage switch-disconnector (if it is present), and all other possible disconnecting devices that isolate the drive from dangerous voltage sources.
   - If a permanent magnet motor connects to the drive, disconnect the motor from the drive with a safety switch or by other means.
   - Open the main isolating device of the drive.
   - Disconnect all dangerous external voltages from the control circuits.
   - After you disconnect power from the drive, wait 5 minutes to let the intermediate circuit capacitors discharge before you continue.
4. Protect other energized parts in the work location against contact and take special precautions when close to bare conductors.
5. Measure that the installation is de-energized. Use a quality voltage tester. If the measurement requires removal or disassembly of shrouding or other cabinet structures, obey the local laws and regulations applicable to live electrical work. This includes, but is not limited to, electric shock and arc protection.
   - Before and after you measure the installation, verify the operation of the voltage tester on a known voltage source.
   - Make sure that the voltage between the drive input power terminals (L1, L2, L3) and the grounding (PE) busbar is zero.

Measuring points of frames R6…R9 are shown below.



- Make sure that the voltage between the drive output terminals (U, V, W) and the grounding (PE) busbar is zero.
- Make sure that the voltage between the drive DC terminals (UDC+ and UDC-) and the grounding (PE) terminal is zero.

6. Install temporary grounding as required by the local regulations.
7. Ask for a permit to work from the person that is responsible for the electrical installation work.

Additional instructions and notes

WARNING!
Obey these instructions. If you ignore them, injury or death, or damage to the equipment can occur.

If you are not a qualified electrical professional, do not do installation or maintenance work.

- Keep the cabinet doors closed when the drive has electrical power. If the doors the drive cabinet are open, there is a risk of a potentially fatal electric shock, arc flash or high-energy arc blast exists.
- Make sure that the electrical power network, motor/generator, and environmental conditions agree with the drive data.
- Do not do insulation or voltage withstand tests on the drive.

- If you have a cardiac pacemaker or other electronic medical device, do not go near the area near motor, drive, and the drive power cabling when the drive is in operation. The equipment produces electromagnetic fields that can cause interference in electronic medical devices. This can cause a health hazard.
- ABB does not recommend attaching the cabinet by arc welding. If you have to, obey the welding instructions in the drive manuals.

Note:

- When the drive is connected to the input power, the motor cable terminals and the DC bus are at a dangerous voltage.
  After you disconnect the drive from the input power, these remain at a dangerous voltage until the intermediate circuit capacitors discharge.
- External wiring can supply dangerous voltages to the relay outputs of the control units of the drive.
- The Safe torque off function does not remove the voltage from the main and auxiliary circuits. The function is not effective against deliberate sabotage or misuse.

Printed circuit boards

WARNING!
Use ESD wristband when you handle printed circuit boards. Do not touch the boards unnecessarily. The boards are sensitive to electrostatic discharge.

Grounding

These instructions are for all persons who are responsible for the grounding of the drive.

WARNING!
Obey these instructions. If you ignore them, injury or death, or equipment malfunction can occur, and electromagnetic interference can increase.

If you are not a qualified electrical professional, do not do grounding work.

- Always ground the drive, the motor and adjoining equipment. This is necessary for personnel safety.
- Make sure that the conductivity of the protective earth (PE) conductors is sufficient and that other requirements are met. Refer to the electrical planning instructions of the drive. Obey the applicable national and local regulations.
- When you use shielded cables, make a 360° grounding of the cable shields at the cable entries to reduce electromagnetic emission and interference.
- In a multiple-drive installation, connect each drive separately to the protective earth (PE) busbar of the power supply.

General safety in operation

These instructions are for all persons that operate the drive.

WARNING!
Obey these instructions. If you ignore them, injury or death, or damage to the equipment can occur.

- Keep the cabinet doors closed when the drive has electrical power. If the doors the drive cabinet are open, there is a risk of a potentially fatal electric shock, arc flash or high-energy arc blast exists.
- If you have a cardiac pacemaker or other electronic medical device, do not go near the area near motor, drive, and the drive power cabling when the drive is in operation. The equipment produces electromagnetic fields that can cause interference in electronic medical devices. This can cause a health hazard.
- Give a stop command to the drive before you reset a fault. If you have an external source for the start command and the start is on, the drive starts immediately after the fault reset, unless you configure the drive for pulse start. Refer to the firmware manual.
- Before you activate the automatic fault reset or automatic restart functions of the drive control program, make sure that no dangerous situations can occur. These functions reset the drive automatically and continue operation after a fault or break in the power supply. If these functions are activated, the installation must be clearly marked as defined in IEC/EN/UL 61800-5-1, subclause 6.5.3, for example, "THIS MACHINE STARTS AUTOMATICALLY".

Note:

- If the drive is in remote control mode, you cannot stop or start the drive with the control panel.

Additional instructions for permanent magnet motor drives

Safety in installation, start-up, maintenance

These are additional warnings for permanent magnet motor drives. The other safety instructions in this chapter are also valid.

WARNING!
Obey these instructions. If you ignore them, injury or death, or damage to the equipment can occur.

If you are not a qualified electrical professional, do not do installation or maintenance work.

- Do not do work on the drive when a rotating permanent magnet motor is connected to it. A rotating permanent magnet motor energizes the drive including its input and output power terminals.

Before installation, start-up and maintenance work on the drive:

- Stop the drive.
- Disconnect the motor from the drive with a safety switch or by other means.
- If you cannot disconnect the motor, make sure that the motor cannot rotate during work. Make sure that no other system, like hydraulic crawling drives, can rotate the motor directly or through any mechanical connection such as belt, nip, rope, etc.
- Do the steps in section Electrical safety precautions (page 19).
- Install temporary grounding to the drive output terminals (T1/U, T2/V, T3/W). Connect the output terminals together as well as to the PE.

During the start-up:

- Make sure that the motor cannot run at overspeed, for example, when it is driven by the load. Motor overspeed causes an overvoltage that can cause damage to the capacitors in the intermediate circuit of the drive.

Safety in operation

WARNING!
Make sure that the motor cannot run at overspeed, for example, when it is driven by the load. Motor overspeed causes an overvoltage that can cause damage to the capacitors in the intermediate circuit of the drive.

2

Introduction to the manual

Contents of this chapter

This chapter describes the intended audience and contents of the manual. It contains a flowchart of steps in examining the delivery, installing and commissioning the drive. The flowchart refers to chapters/sections in this manual and other manuals.

Target audience

This manual is intended for people who plan the installation, install, commission, and do maintenance work on the drive, or create instructions for the end user of the drive concerning the installation and maintenance of the drive.

Read the manual before you do work on the drive. You are expected to know the fundamentals of electricity, wiring, electrical components, and electrical schematic symbols.

Categorization by frame size and option code

The frame size identifies information which concerns only a certain frame size of the drive. The frame size is shown on the type designation label. All frame sizes are listed in the technical data.

The option code (A123) identifies information which concerns only a certain optional selection. The options included in the drive are listed on the type designation label.

Quick installation flowchart

Task	See
Plan the electrical installation and acquire the accessories needed (cables, fuses, etc.). Check the ratings, required cooling air flow, input power connection, compatibility of the motor, motor connection, and other technical data.	Guidelines for planning the electrical installation (page 65) Technical data (page 157)
⬇	
Check the installation site.	Ambient conditions (page 191)
⬇	
Unpack and check the units (only intact units may be started up). Examine that all necessary option modules and equipment are present and correct. Mount the drive.	Mechanical installation (page 51) If the drive has been non-operational for more than one year, the converter DC link capacitors need to be reformed (Reforming the capacitors (page 154))
⬇	
Route the cables.	Routing the cables (page 82)
⬇	
Check the insulation of the supply cable, the motor and the motor cable.	Measuring the insulation resistance of the motor and motor cable (page 93)
⬇	
Connect the power cables. Connect the control cables.	Connecting the power cables (page 94), Connecting the control cables (page 102)
⬇	
Check the installation.	Installation checklist (page 131)
⬇	
Start the drive up.	Start-up (page 133)
⬇	
Operate the drive: start, stop, speed control etc.	Start-up (page 133) and the firmware manual

Terms and abbreviations

Term/ Abbreviation	Description
ACS-AP-S	Standard assistant control panel
ACS-AP-W	Industrial assistant control panel with Bluetooth interface
ACS-BP-S	Basic control panel
CAIO-01	CAIO-01 optional bipolar analog input and unipolar analog output extension module
CBAI-01	Bipolar analog IO extension module
CCU	Type of control unit

Term/ Abbreviation	Description
CHDI-01	115/230 V digital input extension module
CMF	Common mode filtering
CMOD-01	Multifunction extension module (external 24 V AC/DC and digital I/O extension)
CMOD-02	Multifunction extension module (external 24 V AC/DC and isolated PTC interface)
CPTC-02	Multifunction extension module (external 24 V and ATEX/UKEX-certified PTC interface)
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
FBIP-21	BACnet/IP adapter module
FCAN	Optional CANopen® adapter module
FCNA-01	Optional ControlNet™ adapter module
FDCO-01	DDCS communication module with two pairs of 10 Mbit/s DDCS channels
FDNA-01	Optional DeviceNet™ adapter module
FECA-01	Optional EtherCAT® adapter module
FENA-21	Optional Ethernet adapter module for EtherNet/IP™, Modbus TCP and PROFINET IO protocols, 2-port
FEPL-01	Optional Ethernet POWERLINK adapter module
FPBA-01	Optional PROFIBUS DP® adapter module
Frame, frame size	Physical size of the drive or power module
IGBT	Insulated gate bipolar transistor
IT system	Type of supply network that has no (low-impedance) connection to ground. See IEC 60364-5.
STO	Safe torque off (IEC/EN 61800-5-2)
TN system	Type of supply network that provides a direct connection to ground

Related documents

Name	Code (English)
Drive manuals and guides	
ACQ80 standard control program firmware manual	3AXD50000170654
ACQ80-07 (75 to 500 kW) drives hardware manual	3AXD50000946440
ACQ80-07 (75 to 500 kW) drives quick installation and startup guide	3AXD50000946433
Converter module lifting device for drive cabinets hardware manual	3AXD50000210268
ACS-AP-I, -S, -W and ACH-AP-H, -W Assistant control panels user’s manual	3AUA0000085685
ACS -BP-S basic control panel, User's manual	3AXD50000032527
Option manuals and guides	
CPTC-02 ATEX-certified thermistor protection module, Ex II (2) GD (+L537+Q971) user's manual	3AXD50000030058
FCAN-01 CANopen adapter module user's manual	3AFE68615500
FCNA-01 ControlNet adapter module user's manual	3AUA0000141650
FDNA-01 DeviceNet™ adapter module user's manual	3AFE68573360
FECA-01 EtherCAT adapter module user's manual	3AUA0000068940
FENA-01/-11/-21 Ethernet adapter module user's manual	3AUA0000093568
FEPL-02 Ethernet POWERLINK adapter module user's manual	3AUA0000123527

Name	Code (English)
FMBT-21 Modbus/TCP adapter module user’s manual	3AXD50000158607
FPBA-01 PROFIBUS DP adapter module user's manual	3AFE68573271
FSCA-01 RS-485 adapter module user's manual	3AUA0000109533
Tool and maintenance manuals and guides	
Drive Composer Start-up and maintenance PC tool user’s manual	3AUA0000094606
Converter module capacitor reforming instructions	3BFE64059629

You can find manuals on the Internet. See below for the relevant code/link. For more documentation, go to www.abb.com/drives/documents.

ACQ80-07 manuals

See also,

- Video of ACQ80 solar pump drive.
- QR code on the drive. Scan the QR code to navigate to ABB Access web page and find up-to-date product online data.

3

Operation principle and hardware description

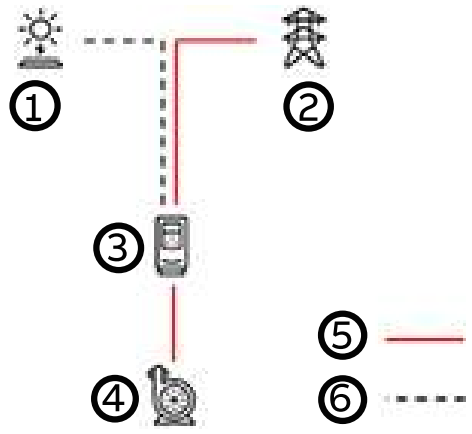
Contents of this chapter

This chapter briefly describes the operation principle and construction of the drive.

Operation principle

The ACQ80-07 is a solar pump drive for controlling asynchronous AC induction motors and permanent magnet synchronous motors. The drive is optimized for cabinet installation.

- **Block diagram**

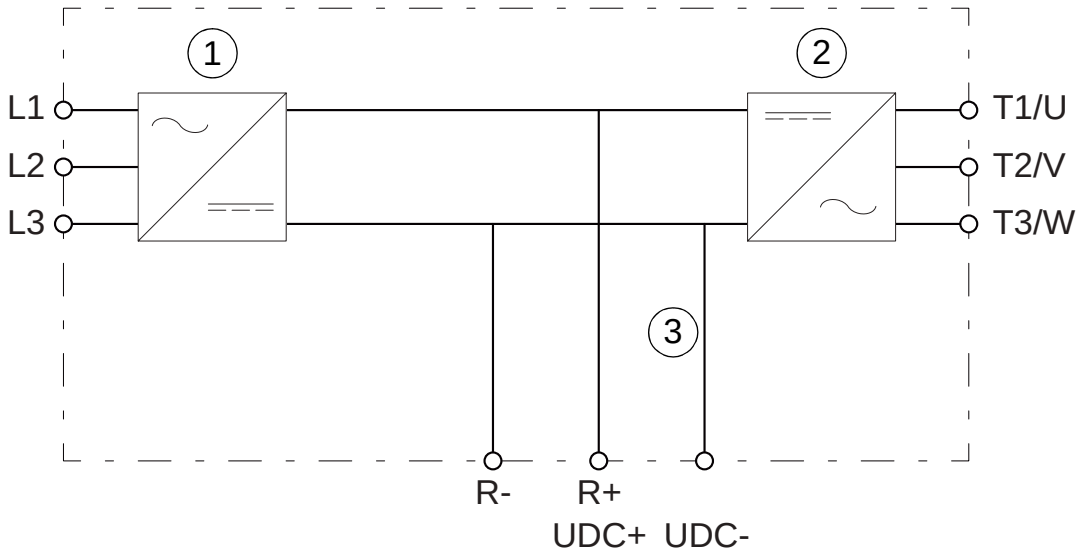


1	Solar panels. The panels provide DC power to the drive.

2	Grid power. The grid provides AC power to the drive. To get maximum water flow throughout the day and to reduce grid power consumption, both the grid and solar panel can be connected.
3	ACQ80 drive. The drive comes with built-in Maximum Power Point Tracking (MPPT) logic. The MPPT logic supports the drive to control the pump motor with variable DC power from the solar panels.
4	Pump motor. The motor is powered by ACQ80 drive.
5	AC power.
6	DC power.

Note: ACQ80 drive is intended to be used for speed control of three-phase AC pump motors and is powered from either AC grid or DC solar array or both AC and DC power together. ABB recommends not to use it as an island grid forming inverter or to supply generic single phase or three-phase loads, other than the three-phase AC pump motors.

Simplified main circuit diagram

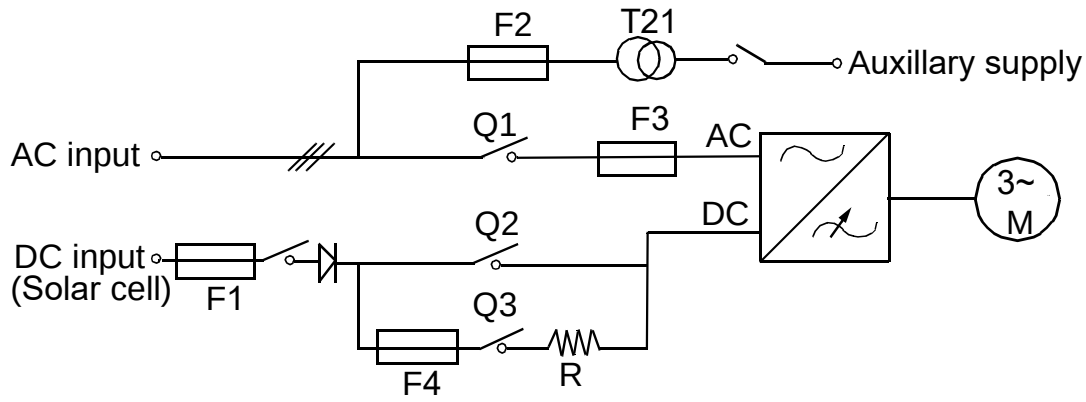


1	Rectifier. Converts alternating current and voltage to direct current and voltage.
2	Inverter. Converts direct current and voltage to alternating current and voltage.
3	DC connection (UDC+, UDC-).

Product overview

The ACQ80-07 is a drive module for controlling AC induction motors, synchronous reluctance motors and permanent magnet synchronous motors in open loop control.

The single-line circuit of the drive is shown below.



Q1	AC line contactor
Q2 and Q3	DC line contactor
T21	Auxiliary voltage transformer supplying 24 V and 230/115 V control voltage for, eg, cabinet fan(s), control devices and I/O extension adapter module.
F1 and F4	DC Fuses
F2 and F3	AC Fuses

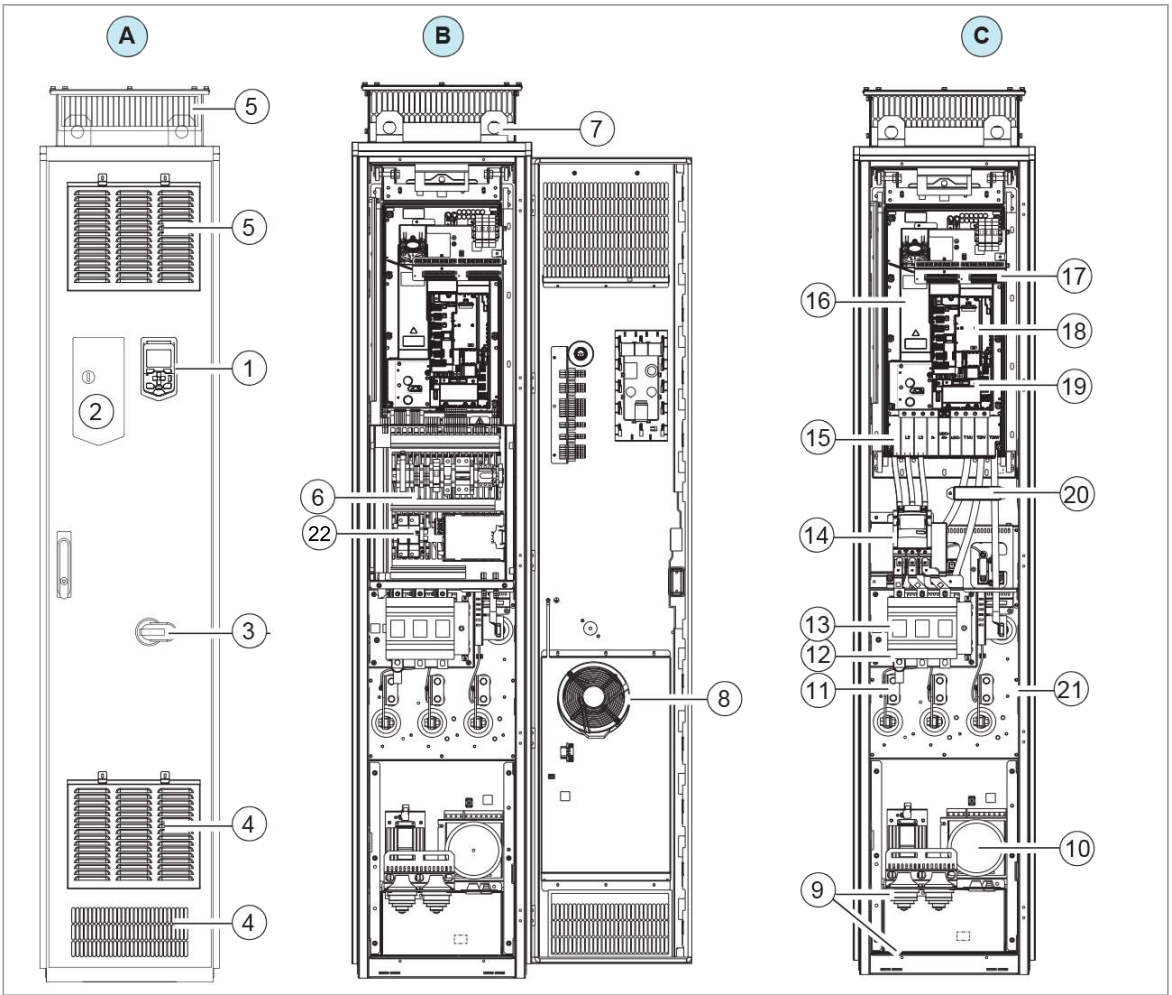
Layout

General information on the cabinet layout

IP42 (option +B054) and **IP54 (standard offer)**

Cabinet layout – R6 and R7 (bottom entry and exit of cables)

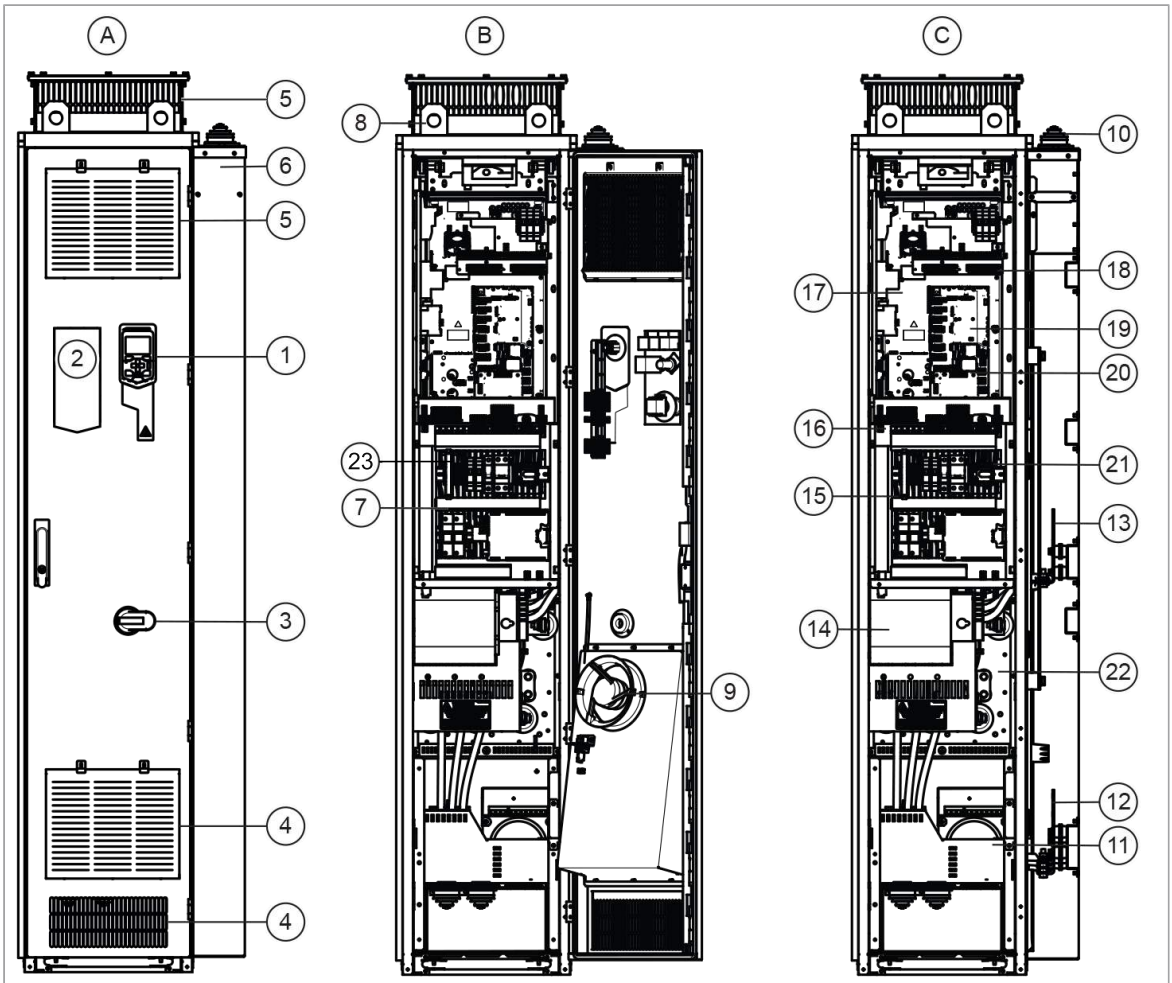
The cabinet layout of frame R7 with du/dt filter (option +E205) is shown below. Degree of protection IP42 (UL Type 1 Filtered [option +B054]). Frame R6 looks similar.



A	Cabinet door closed	11	Motor cable connection terminals **Note:** For drives with no du/dt filter (option +E205), the motor cables are connected to the drive module terminals.
B	Cabinet door open	12	Input cable connection terminals
C	Cabinet door open, mounting plate and cabinet shrouds removed	13	Main switch with AC fuses (Q1)
1	Drive control panel	14	Main contactor (Q2, option +F250)
2	Operating switch	15	Power cable connection terminals of the drive module behind the shroud
3	Main switch handle	16	Drive module
4	Gratings for cooling air in	17	Additional I/O terminal block (option +L504)
5	Gratings for cooling air out	18	Drive control unit
6	Mounting plate, see section Mounting plate – R6 to R9 (page 36)	19	NETA-21 (not shown) (option +K496 and +K497)
7	Lifting lugs	20	Common mode filter (option +E208)
8	Cabinet door fan	21	du/dt filter (option +E205)
9	Power and control cable entries	22	DC circuit

10	Auxiliary voltage transformer T21	-	-

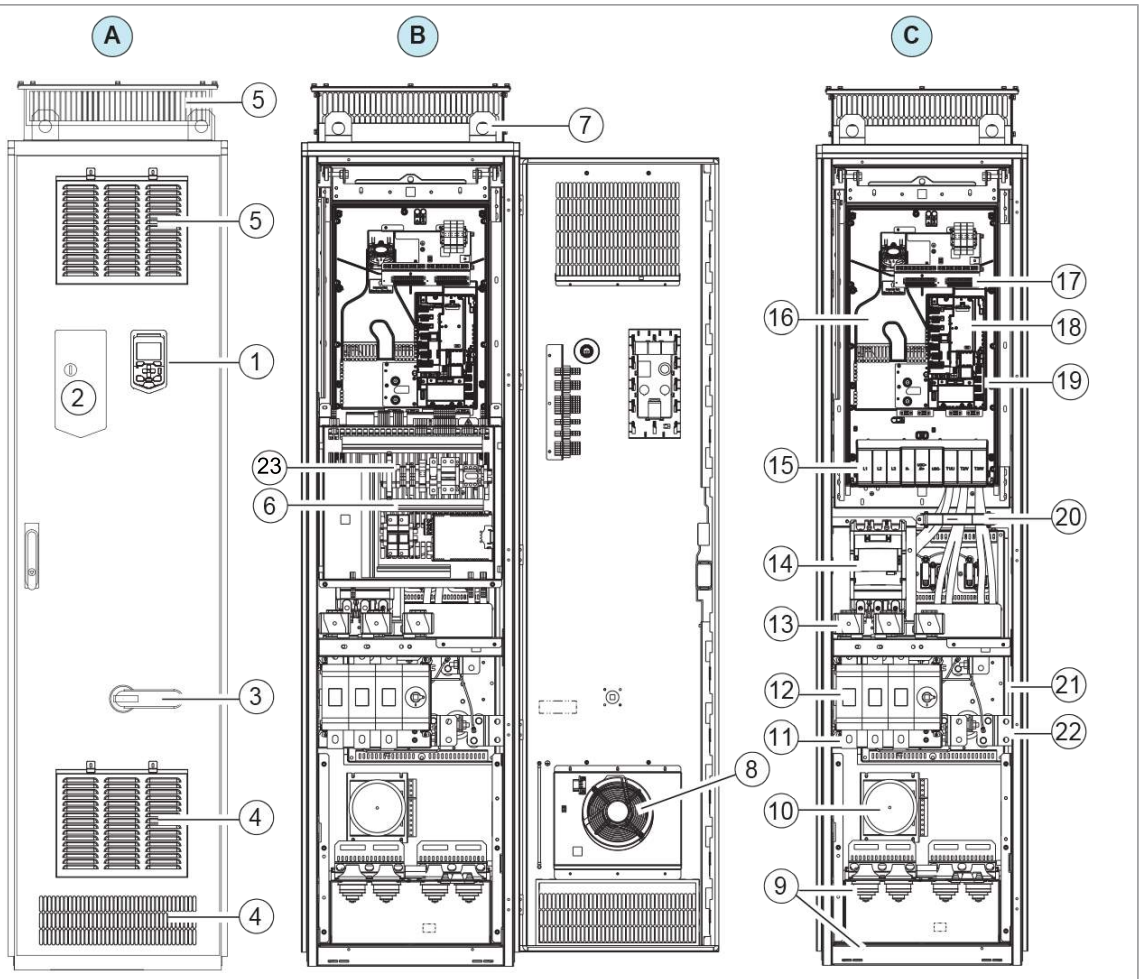
Cabinet layout – R6 and R7 (top entry and exit of cables, options +H351 and +H353)



A	Cabinet door closed	11	Auxiliary voltage transformer T21
B	Cabinet door open	12	Motor cable connection terminals
C	Cabinet door open and motor cable cubicle cover removed	13	Input cable connection terminals
1	Drive control panel	14	Main switch with AC fuses (Q1)
2	Operating switch	15	Main contactor (Q2, option +F250) behind the mounting plate
3	Main switch handle	16	Power cable connection terminals of the drive module behind the shroud
4	Gratings for cooling air in	17	Drive module
5	Gratings for cooling air out	18	Additional I/O terminal block (option +L504)
6	Cubicle for cabling	19	Drive control unit
7	Mounting plate, see section Mounting plate – R6 to R9 (page 36)	20	NETA-21 (not shown) (option +K496 and +K497)
8	Lifting lugs	21	Common mode filter (option +E208) behind the mounting plate
9	Cabinet door fan	22	du/dt filter (option +E205)
10	Power and control cable entries	23	DC circuit

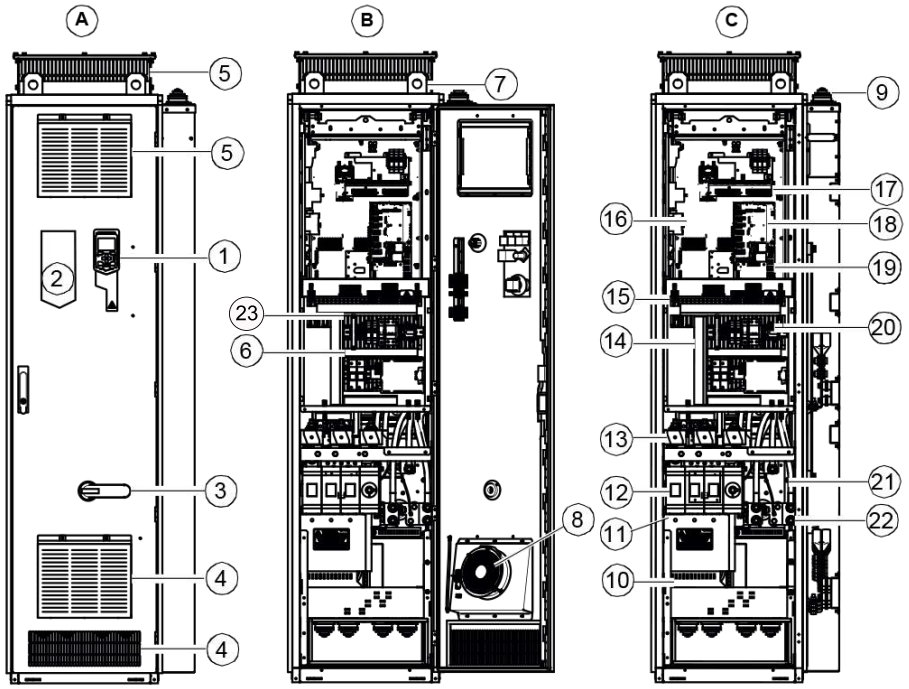
Cabinet layout – R8 and R9 (bottom entry and exit of cables)

The cabinet layout of frame R9 with du/dt filter (option +E205) is shown below. Degree of protection IP42 (UL Type 1 Filtered [option +B054]). Frame R8 looks similar.



A	Cabinet door closed	11	Input cable connection terminals
B	Cabinet door open	12	Main switch-disconnector (Q1)
C	Cabinet door open, mounting plates and cabinet shrouds removed	13	AC fuses
1	Drive control panel	14	Main contactor (Q2, option +F250)
2	Operating switch	15	Power cable connection terminals of the drive module behind the shroud
3	Main switch handle	16	Drive module
4	Gratings for cooling air in	17	Additional I/O terminal block (option +L504)
5	Gratings for cooling air out	18	Drive control unit
6	Mounting plate, see section Mounting plate – R6 to R9 (page 36)	19	NETA-21 (not shown) (option +K496 and +K497)
7	Lifting lugs	20	Common mode filter (option +E208)
8	Cabinet door fan	21	du/dt filter (option +E205)
9	Power and control cable entries	22	Motor cable connection terminals **Note:** For drives with no du/dt filter (option +E205), the motor cables are connected to the drive module terminals.
10	Auxiliary voltage transformer T21	23	DC circuit

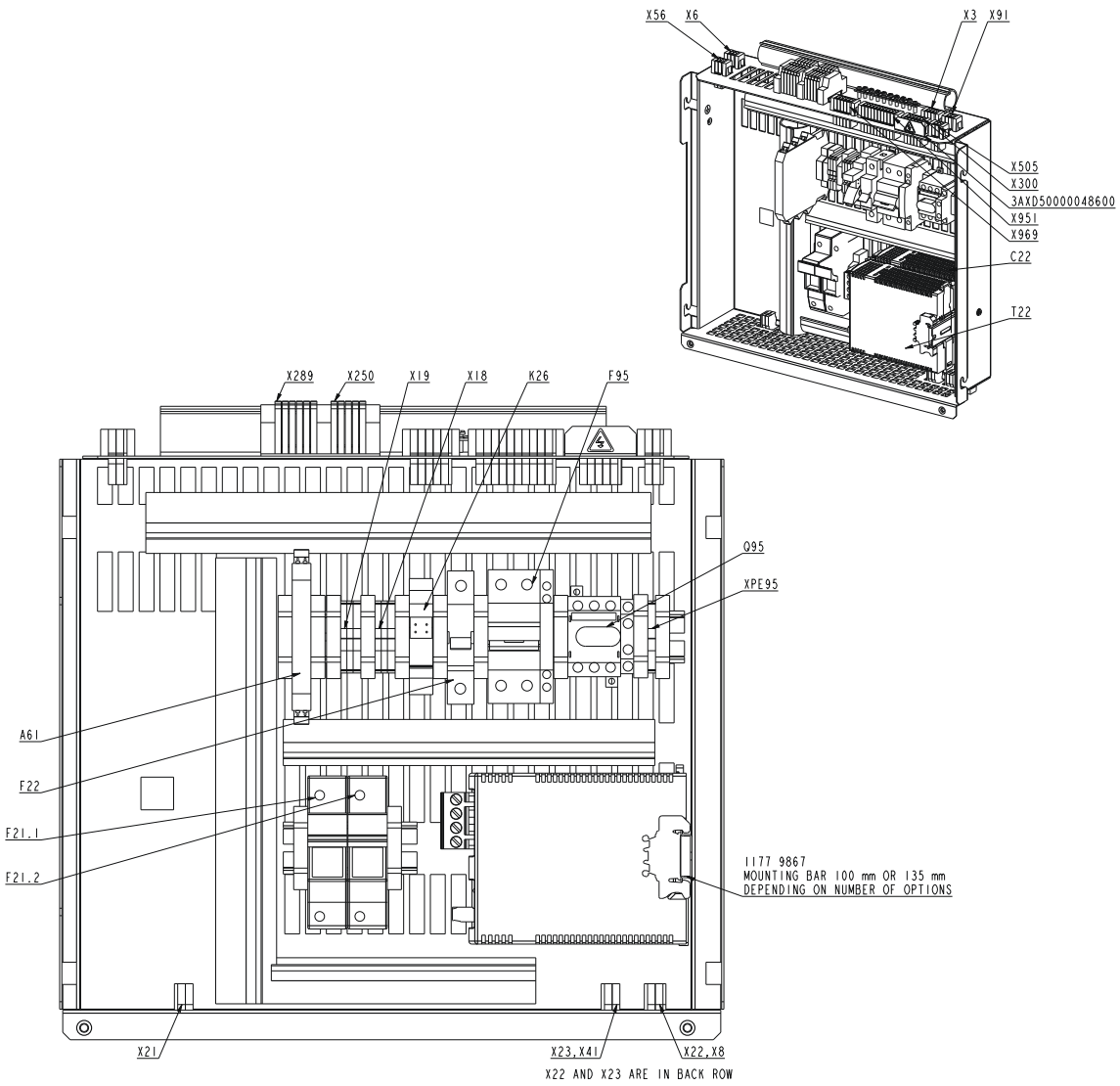
Cabinet layout – R8 and R9 (top entry and exit of cables, options +H351 and +H353)



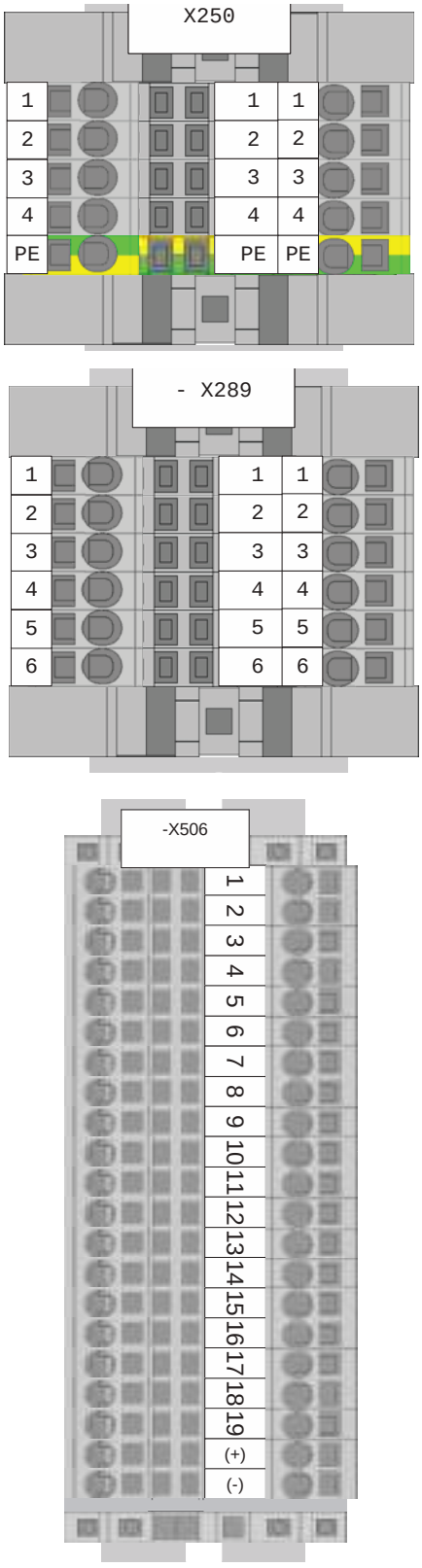
A	Cabinet door closed	11	Input cable connection terminals
B	Cabinet door open	12	Main switch-disconnector (Q1)
C	Cabinet door open, mounting plates and cabinet shrouds removed	13	AC fuses
1	Drive control panel	14	Main contactor (Q2, option +F250)
2	Operating switch	15	Power cable connection terminals of the drive module behind the shroud
3	Main switch handle	16	Drive module
4	Gratings for cooling air in	17	Additional I/O terminal block (option +L504)
5	Gratings for cooling air out	18	Drive control unit
6	Mounting plate, see section Mounting plate – R6 to R9 (page 36)	19	NETA-21 (not shown) (option +K496 and +K497)
7	Lifting lugs	20	Common mode filter (option +E208)
8	Cabinet door fan	21	du/dt filter (option +E205)
9	Power and control cable entries	22	Motor cable connection terminals **Note:** For drives with no du/dt filter (option +E205), the motor cables are connected to the drive module terminals.
10	Auxiliary voltage transformer T21	23	DC circuit

Mounting plate – R6 to R9

The components and terminals on the mounting plate of frames R6 to R9 are shown below. The layout of frames R6 and R7 is similar.



+G300	switch-disconnector and miniature circuit breaker for cabinet heater (option +G300)	X3	External main contactor control
A61	Emergency stop relay for options +Q951 and +Q963	X250	Indication of main contactor status
Q95, F95	Switch-disconnector and miniature circuit breaker for cabinet heater (option +G300)	X289	Indication of the status of the molded case circuit breaker (option +F289)
F21	Auxiliary transformer fuses	X300	Connection terminals for cabinet heater (option +G300)
F22	Auxiliary transformer's secondary side miniature circuit breaker	X951	Connection of external emergency stop button (options +Q951 and Q963)
T22, C22	24VDC power supply and buffer with emergency stop options (+Q951 and +Q963), also with line contactor option (+F250).	X969	Connection of external Safe torque off button
X251, X4, X6, X56, X53, X51, X55, X18 and X19: for internal use.			

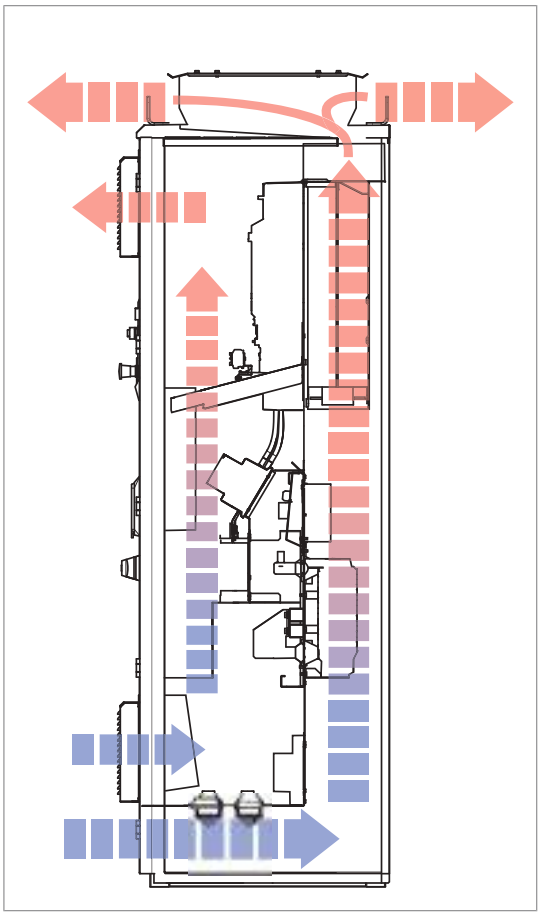


Terminals for	
X250	Auxiliary contacts of line contactor (option +F250)
X289	Auxiliary contacts of molded case circuit breaker (option +F289)
X951	Push buttons for emergency stop option +Q951 or +Q963. See section Connecting the emergency stop push buttons (options +Q951 and +Q963) (page 108).
X969	External STO customer connection for safety option +Q951 or +Q963. See section Connecting the Safe torque off circuit (page 109).
X601	Starter for auxiliary motor fan (options +M601...M605). See section Wiring the starter for auxiliary motor fan (options +M601...M605).
X506	Pt100 relays (options +L506, +2L506, +3L506 and +5L506)

Cooling air flow

The figure below shows cooling air flow through the cabinet.

Frames R6…R9 (Side view)



Door switches and lights

	Label in English	Label in local language	Description
1	READY	-	Ready pilot light (option +G327)
2	RUN	-	Run pilot light (option+G328)
3	FAULT	-	Fault pilot light (option +G329)
4	MAIN CONTACTOR OFF ON 	-	Operating switch with option +F250 0 – Opens the main contactor (Q2) and disables starting of the drive 1 – Closes the main contactor (Q2)
5	EMERGENCY STOP RESET	-	Emergency stop indication light and reset push button with options +Q951 and +Q963
6	EMERGENCY STOP	-	Emergency stop push button with options +Q951 and +Q963

Main switch-disconnector Q1

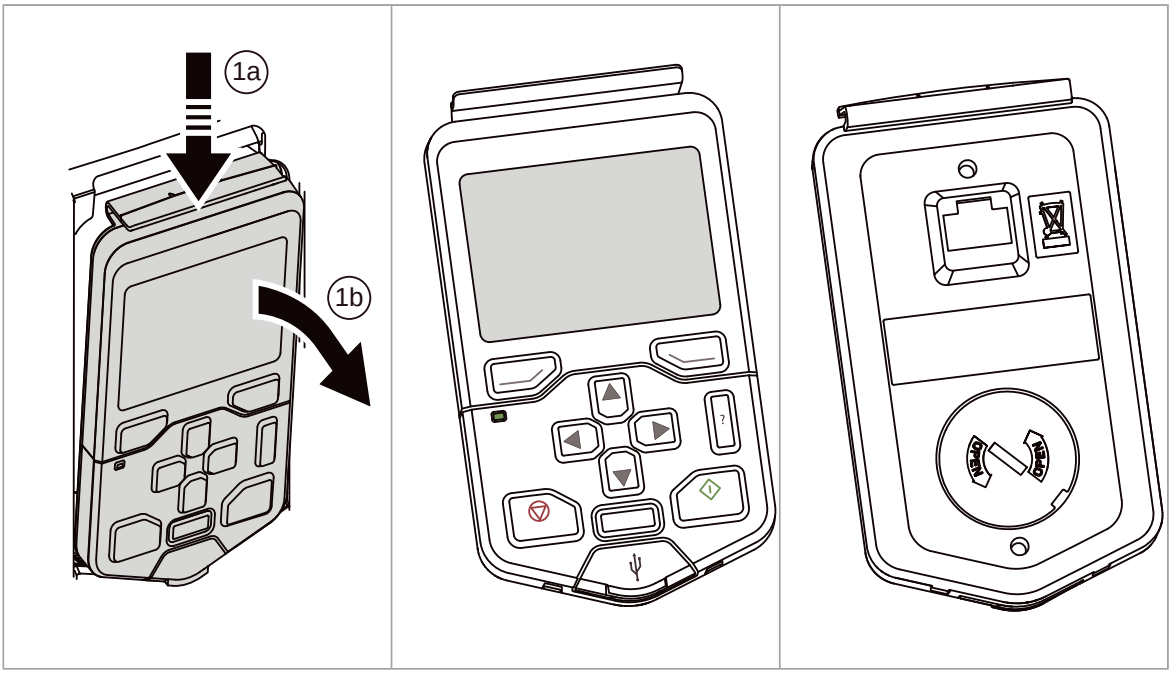
The switch-disconnector handle switches the main voltage to the drive on and off.

Control panel

The control panel is the user interface of the drive. It provides the essential controls such as Start/Stop/Direction/Reset/Reference, and the parameter settings for the control program.

One control panel can be used to control several drives through a panel link.

The control panel can be removed by pulling it forward from the top edge and disconnecting the panel cable. The panel is reinstalled in reverse order. For the use of the control panel, see the firmware manual or *ACS-AP-I, -S, -W and ACS-BP-S, -W Assistant control panels user's manual* (3AUA0000085685 [English]).



Control by PC tools

There is a USB connector on the front of the panel that can be used to connect a PC to the drive. When a PC is connected to the control panel, the control panel keypad is disabled.

Common mode filter

The drive of frames R6 to R9 can be optionally equipped with a common mode filter (option +E208). The filter contains ferrite rings mounted around the drive AC conductors. The filter protects the motor bearings by reducing the bearing currents.

More information on when the option is required: See section Examining the compatibility of the motor and drive (page 66).

Descriptions of options

Note: All options are not available for all drive types, are not compatible with some other options, or require additional engineering.

Degree of protection

Definitions

According to IEC/EN 60529, the degree of protection is indicated by an IP code where the first numeral means protection against ingress of solid foreign objects, and the second numeral protection against ingress of water. The IP codes of the standard cabinet and options covered in this manual are defined below.

IP code	The equipment is protected ...	
	First numeral	Second numeral
IP42	against ingress of solid foreign objects > 1 mm	against dripping (15° tilting) water
IP54	dust-protected	against splashing water

* meaning for protection of persons: against access to hazardous parts with finger

IP42 (UL Type 1 Filtered) (option +B054)

This option provides the degree of protection of IP42 (UL type 1). The air inlet gratings are covered with a metallic mesh between the inner and outer metallic gratings.

IP54 (UL Type 12) (Standard)

This option provides the degree of protection of IP54 (UL type 12). It provides the cabinet air inlets with filter housings containing folded board air filter mats between the inner and outer metallic gratings. An additional fan and filtered outlets on the cabinet roof are also included.

Cooling air inlet through bottom of cabinet (option +C128)

See section Air inlet through the bottom of the cabinet (option +C128) (page 61).

UL Listed (option +C129)

The cabinet contains the following accessories and features:

- top entry and exit with US cable conduit entries (plain plate without ready-made holes)
- all components UL/CSA Listed/Recognized
- maximum supply voltage 600 V
- US-type main switch and fuses.

Channeled air outlet (option +C130)

This option provides a collar for connection to an air outlet duct. The collar is located on the cabinet roof. Depending on the equipment installed in each cubicle, the channeled air outlet either replaces, or adds to, the standard roof arrangement.

With option +B055, this option also provides the cabinet air inlets with filter housings containing folded board air filter mats between the inner and outer metallic gratings.

See also section Air outlet duct on the cabinet roof (option +C130) (page 62).

Plinth height (options +C164 and +C179)

The standard height of the cabinet plinth is 50 mm. These options specify a plinth height of 100 mm (+C164) or 200 mm (+C179).

Empty cubicles on right (options +C196...C198)

The option adds an empty 400, 600 or 800 mm wide cubicle to the right end of the line-up. The cubicle is equipped with blank power cable entries both at the top and the bottom.

The cubicle is equipped with blank panel entries (full panel or two-half panels) on the back.

Empty cubicles on left (options +C199...C201)

The option adds an empty 400, 600 or 800 mm wide cubicle to the left end of the line-up. The cubicle is equipped with blank power cable entries both at the top and the bottom.

The cubicle is equipped with blank panel entries (full panel or two-half panels) on the back.

d*u*/d*t* filter (option +E205)

The d*u*/d*t* filter protects the motor insulating system by reducing the voltage rise speed at the motor terminals. The filter also protects the motor bearings by reducing the bearing currents.

More information on when the option is required: See section Examining the compatibility of the motor and drive (page 66).

Common mode filter (option +E208)

The common mode filter contains ferrite rings mounted around the AC output busbars in the drive module. The filter protects the motor bearings by reducing the bearing currents.

More information on when the option is required: See section Examining the compatibility of the motor and drive (page 66).

Molded case circuit breaker (MCCB, option +F289)

This option replaces the standard main switch with a molded case circuit breaker. The breaker has built-in protection functions against overload and short-circuit. It is operated with a direct rotary handle on the cabinet door.

For North American market only.

Cabinet heater with external supply (option +G300)

The option contains:

- heating elements in the cubicles or supply/inverter modules
- load switch for providing electrical isolation during service
- miniature circuit breaker for overcurrent protection
- terminal block for external power supply.

The heater prevents condensation inside the cabinet when the drive is not in operation. The power output of the heating elements increases when the surrounding air temperature is low and decreases when the surrounding air temperature is high. The customer must stop the heating when it is not needed by disconnecting the heater supply voltage.

The customer must supply the heater from an external 110…240 V AC power source.

For the actual wiring, see the circuit diagrams delivered with drive.

Terminals for external control voltage (option +G307)

The option provides terminals for connecting an external uninterruptible control voltage to the control unit and control devices when the drive is not powered.

See also:

- Supplying power for the auxiliary circuits (page 89)
- circuit diagrams delivered with drive for the actual wiring.

Output for motor space heater (option +G313)

The option contains:

- load switch for providing electrical isolation during service
- miniature circuit breaker for overcurrent protection
- terminal block for heater and external heater supply connection.

When the drive is running, the heater is switched off. Otherwise, the heater is controlled by the external supply voltage.

The power and voltage of the heater depend on the motor.

See also:

- Supplying power for the auxiliary circuits (page 89)
- circuit diagrams delivered with drive for the actual wiring.

Ready/Run/Fault lights (options +G327...G329)

These options provide "ready" (+G327, white), "run" (+G328, green) and "fault" (+G329, yellow) lights installed on the cabinet door.

Top cable entry/exit (options +H351 and +H353)

The top entry (+H351) and top exit (+H353) options provide power and control cable entries at the roof of the cabinet. The entries are equipped with grommets and 360° grounding hardware.

The options +H351 and +H353 add an additional 128 mm (5.04 in) wide cable channel to the cabinet width in frames R6...R9.

European cable entry (option +H357)

The standard configuration is equipped with European cable entry. This option provides European cable entry if option +C129 has been pre-selected. +H357 is not compatible with option with +H358.

Cable conduit entry (option +H358)

The option provides US/UK conduit plates (plain 3 mm thick steel plates without any ready-made holes).

Connectivity for wired remote monitoring (option +K496)

This option provides a gateway to connect the drive to ABB Ability™ via a local Ethernet network. Includes NETA-21 remote monitoring tool and FMBT-21 Modbus/TCP adapter module.

See the appropriate manual for more information.

Manual	Code (English)
NETA-21 remote monitoring tool user's manual	3AUA0000096939
NETA-21 remote monitoring tool installation and start-up guide	3AUA0000096881
FMBT-21 Modbus/TCP adapter module user's manual	3AXD50000158607
FMBT-21 Modbus/TCP adapter module quick installation and start-up guide	3AXD50000158560

Connectivity for wireless remote monitoring (option +K497)

This option provides a gateway to connect the drive to ABB Ability™ via a wireless 4G network. Includes NETA-21 remote monitoring tool, FMBT-21 Modbus/TCP adapter module and modem.

See the appropriate manual for more information.

Manual	Code (English)
NETA-21 remote monitoring tool user's manual	3AUA0000096939
NETA-21 remote monitoring tool installation and start-up guide	3AUA0000096881
FMBT-21 Modbus/TCP adapter module user's manual	3AXD50000158607
FMBT-21 Modbus/TCP adapter module quick installation and start-up guide	3AXD50000158560
InRouter 615-S commissioning guide	3AXD50000837939

Additional terminal block X504 (option +L504)

The standard terminal blocks of the drive control unit are wired to the additional terminal block at the factory for customer control wiring. The terminals are spring loaded.

Note: The optional modules inserted in the slots of the control unit are not wired to the additional terminal block. The customer must connect the optional module control wires directly to the modules.

Cables accepted by the terminals of the additional I/O terminal block:

- solid wire 0.2 … 2.5 mm^2 (24…12 AWG)
- stranded wire with ferrule 0.25 … 2.5 mm^2 (24…12 AWG)
- stranded wire without ferrule 0.2 … 2.5 mm^2 (24…12 AWG).

Thermal protection with Pt100 relays (option +nL506)

Pt100 temperature monitoring relays are used for overtemperature supervision of motors equipped with Pt100 sensors. For example, there can be three sensors to measure the temperature of the motor windings and two sensors for the bearings. As the temperature rises, the sensor resistance increases linearly. At an adjustable wake-up level, the monitoring relay de-energizes its output.

The standard Pt100 relay options include two (+2L506), three (+3L506) or five (+5L506) relays.

By default, the relays are wired internally to digital input DI6 of the drive control unit. The loss of the input is set to trigger an external fault. The options include a terminal block for sensor connection. The output indication on the terminal block can be wired by the customer, for example, to an external monitoring circuit. See the circuit diagrams delivered with the drive.

See also

- firmware manual for parameter settings
- Pt100 relay alarm and trip limit setting instructions in the start-up instructions
- circuit diagrams delivered with the drive for the actual wiring.

Starter for auxiliary motor fan (options +M600...M605)

What the option contains

The option provides switched and protected connections for 3-phase auxiliary motor fans. Each fan connection is equipped with:

- fuses
- a manual motor starter switch with an adjustable current limit
- a contactor controlled by the drive, and
- terminal block X601 for customer connections.

Description

The output for the auxiliary fan is wired from the 3-phase supply voltage to terminal block X601 through a motor starter switch and a contactor. The contactor is operated by the drive. The 230 V AC control circuit is wired through a jumper on the terminal block; the jumper can be replaced by an external control circuit.

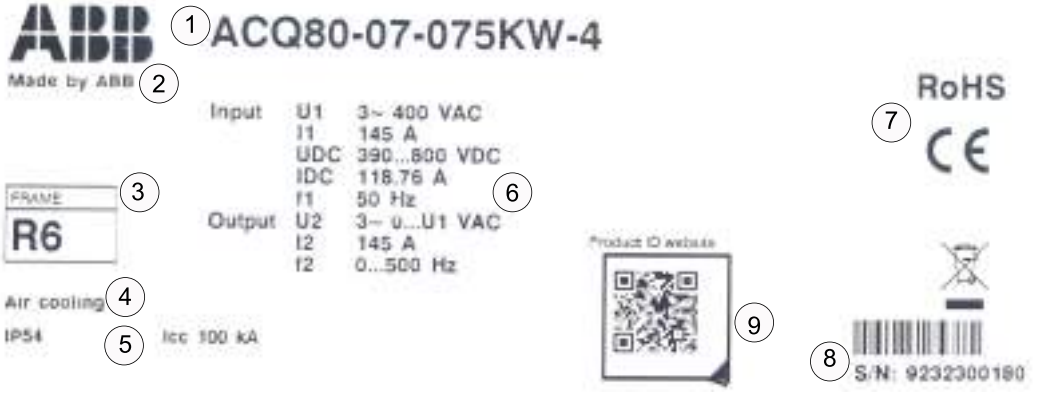
The starter switch has an adjustable trip current limit, and can be opened to permanently switch the fan off.

The statuses of both the starter switch and the fan contactor are wired to the terminal block.

See the circuit diagrams delivered with the drive for the actual wiring.

Type designation label

The type designation label includes an IEC rating, appropriate markings, a type designation and a serial number, which allow identification of each unit. The type designation label is located on the front cover. An example label is shown below.



1	Type designation, see section Type designation key below.
2	Manufacturer
3	Frame size
4	Cooling method
5	Degree of protection
6	Ratings, see section Electrical ratings (page 157), Electrical power network specification (page 189) and Motor connection data (page 189).
7	Valid markings
8	Serial number. The first digit of the serial number refers to the manufacturing plant. The next four digits refer to the unit's manufacturing year and week, respectively. The remaining digits complete the serial number so that there are no two units with the same number.
9	Link to product information

Type designation key

Type designation key

The type designation contains information on the specifications and configuration of the drive. The first digits from left express the basic drive type. The optional selections are given next, separated by plus signs. Codes that start with zero (eg. +0A123) indicate the absence of a specified feature. The main selections are described below. Not all selections are available for all types. For more information, refer to the ordering instructions available on request.

Basic code

Code	Description
ACQ80	Product series
Size	
-xxxxA	See the ratings table.
Voltage range	

Code	Description
4	380…480 V. This is indicated in the type designation label as typical input voltage level (3~400/480 V AC).

Option codes

Code	Description
B054	IP42 (UL Type 1 Filtered)
B055	IP54 (UL Type 12)
C128	Air inlet through bottom of cabinet. See section Air inlet through the bottom of the cabinet (option +C128) (page 61).
C129	UL Listed (evaluated to both U.S. and Canadian safety requirements). See section UL Listed (option +C129) (page 42).
C130	Channeled air outlet. See section Channeled air outlet (option +C130) (page 42).
C164	Plinth height 100 mm. See section Plinth height (options +C164 and +C179) (page 42).
C179	Plinth height 200 mm. See section Plinth height (options +C164 and +C179) (page 42).
C196	Empty 400 mm wide cubicle on right. See section Empty cubicles on right (options +C196…C198) (page 42).
C197	Empty 600 mm wide cubicle on right. See section Empty cubicles on right (options +C196…C198) (page 42).
C198	Empty 800 mm wide cubicle on right. See section Empty cubicles on right (options +C196…C198) (page 42).
C199	Empty 400 mm wide cubicle on left. See section Empty cubicles on left (options +C199…C201) (page 42).
C200	Empty 600 mm wide cubicle on left. See section Empty cubicles on left (options +C199…C201) (page 42).
C201	Empty 800 mm wide cubicle on left. See section Empty cubicles on left (options +C199…C201) (page 42).
C218	Chemical gases contamination class 3C3 compliant printed circuit boards with option +C218 according to IEC 60721-3-3:2002. Chemical gases contamination class C4 compliant printed circuit boards with option +C218 according to IEC 60721-3-3:2019 and ISO 9223. Applies to these gases: H_2S, NH_3, NO_2 and SO_2.
E205	d*u*/d*t* filtering
E208	Common mode filtering
F250	Main (line) contactor
F289	MCCB circuit breaker
G300	Cabinet and module heating elements (external supply). See section Cabinet heater with external supply (option +G300) (page 43).
G307	Terminals for connecting external control voltage (230 V AC or 115 V AC, eg. UPS). See section Terminals for external control voltage (option +G307) (page 43).
G313	Output for motor space heater (external supply)
G327	Ready light on door, white
G328	Run light on door, green
G329	Fault light on door, yellow
H351	Power cabling entry from top. See section Top cable entry/exit (options +H351 and +H353) (page 44).

Code	Description
H353	Power cabling exit from top. See section Top cable entry/exit (options +H351 and +H353) (page 44).
H358	Cable gland plates (3 mm steel, undrilled)
J429	ACS-AP-W control panel (with Bluetooth)
K451	FDNA-01 DeviceNet™ adapter module
K454	FPBA-01 PROFIBUS DP® adapter module
K457	FCAN-01 CANopen® adapter module
K458	FSCA-01 RS-485 (Modbus/RTU) adapter module
K462	FCNA-01 ControlNet™ adapter module
K469	FECA-01 EtherCAT® adapter module
K470	FEPL-02 Ethernet POWERLINK adapter module
K475	FENA-21 Ethernet adapter module for EtherNet/IP™, Modbus TCP and PROFINET IO protocols, 2-port
K490	FEIP-21 Ethernet adapter module for EtherNet/IP™
K491	FMBT-21 Ethernet adapter module for Modbus TCP
K496	Connectivity for wired remote monitoring. Includes NETA-21 remote monitoring tool with Ethernet connection, FMBT-21 Modbus/TCP adapter module (+K491). See section Connectivity for wired remote monitoring (option +K496) (page 44).
K497	Connectivity for wireless remote monitoring. Includes NETA-21 remote monitoring tool, FMBT-21 Modbus/TCP adapter module (+K491) and 4G modem. See section Connectivity for wireless remote monitoring (option +K497) (page 45).
L500	CBAI-01 bipolar analog IO adapter module
L501	CMOD-01 External 24 V AC/DC and digital I/O extension (2×RO and 1×DO)
L504	Additional I/O terminal block. See section Additional terminal block X504 (option +L504) (page 45).
L506	Thermal protection with Pt100 relays (2, 3, 5 or 8 pcs). See section Thermal protection with Pt100 relays (option +nL506) (page 45).
L512	CHDI-01 115/230 V digital input module (six digital inputs and two relay outputs).
L523	CMOD-02 External 24 V and isolated PTC interface
L525	FAIO-01 analog I/O extension module
L537	FPTC-02 ATEX-certified thermistor protection module
M600	Starter for auxiliary motor fan, trip limit 1 … 1.6 A
M601	Starter for auxiliary motor fan, trip limit 1.6 … 2.5 A
M602	Starter for auxiliary motor fan, trip limit 2.5 … 4 A
M603	Starter for auxiliary motor fan, trip limit 4 … 6.3 A
M604	Starter for auxiliary motor fan, trip limit 6.3 … 10 A
M605	Starter for auxiliary motor fan, trip limit 10…16 A
P912	Seaworthy packaging
P931	Extended warranty (36 months from delivery)
P932	Extended warranty (60 months from delivery)
Q951	Emergency stop (category 0) with safety relays, by opening the main breaker/contactor
Q963	Emergency stop (category 0) with safety relays, by activating the Safe torque off function
Q971	ATEX-certified safe disconnection function
Q986	FSPS-21 PROFIsafe safety functions module

Code	Description
R700	Printed documents in English

4

Mechanical installation

Contents of this chapter

This chapter describes the mechanical installation procedure of the drive.

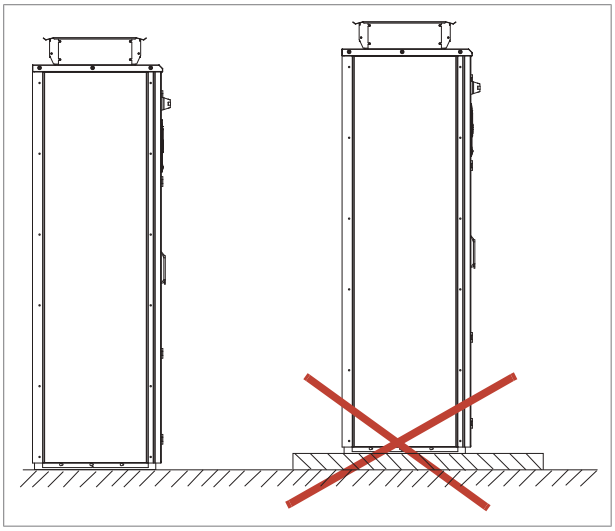
Examining the installation site

Examine the installation site. Make sure that:

- The installation site is sufficiently ventilated or cooled to remove heat from the drive. Refer to the technical data.
- The ambient conditions of the drive meet the specifications. Refer to the technical data.
- The material behind, above, and below the drive is non-flammable.
- There is sufficient free space above the drive for cooling, maintenance work, and operation of the pressure relief (if present).
- The floor that the drive cabinet is installed on is of non-flammable material, as smooth as possible, and strong enough to hold the weight of the unit. Examine the flatness of the floor with a spirit level. The maximum permitted deviation from a level surface is 5 mm (0.2 in) for every 3 meters (10 ft). If it is necessary, level the installation site, as the cabinet does not have adjustable feet.
- The drive cabinet should be IP42 or IP54 and mounted below a solar array or in a closed room so that water never goes into or falls on the drive cabinet.
- A lightning pole is installed near the site (1–2 m [3–7 ft] from the solar structure). This is recommended even if the location is not prone to lightning. Make sure that the height of the lightning pole is more than the total height of the site structure.

- Use two separate earth pits. Use a dedicated earth pit for the lightning rod to ensure isolation from other earthing. Use the second pit for the drive, drive cabinet, pump motor and solar array.
- The length of the cable between the motor and drive is less than 300 m (985 ft). Use a motor choke for cable lengths between 300 m (985 ft) to 350 m (1150 ft). Use a sine filter for cable lengths of more than 350 m (1150 ft).

Do not install the drive on an elevated platform or in a recess. The module extraction/installation ramp included with the drive is only suitable for a maximum height difference of 50 mm (2 in), that is, the standard plinth height of the drive.



Necessary tools

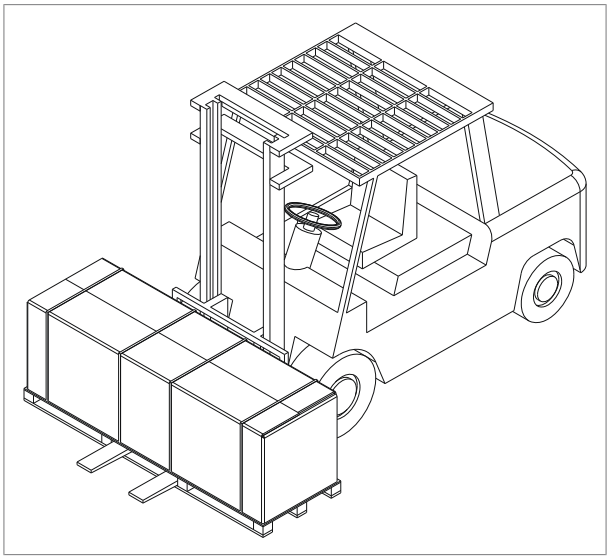
The tools required for moving the unit to its final position, fastening it to the floor and wall and tightening the connections are listed below:

- crane, fork-lift or pallet truck (check load capacity!), slate/spud bar, jack and rollers
- Pozidriv and Torx screwdrivers
- torque wrench
- set of wrenches or sockets.

Moving and unpacking the drive

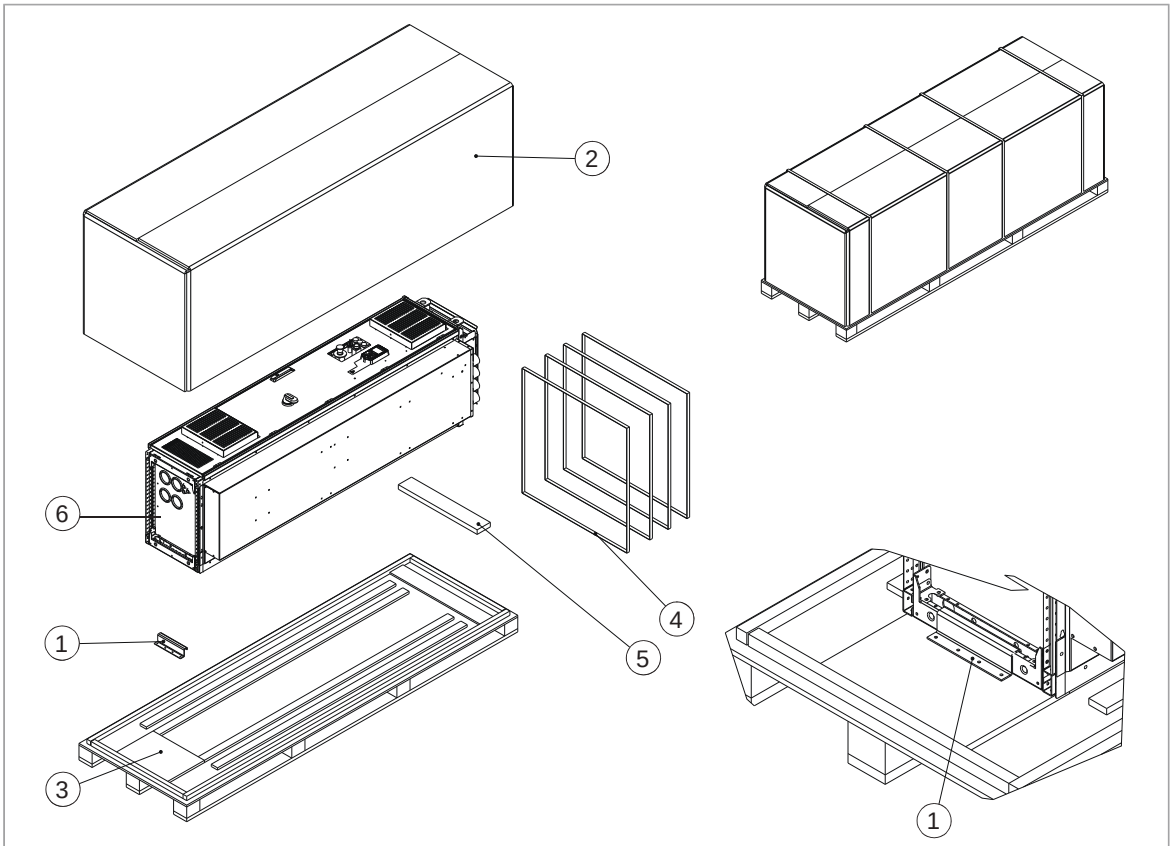
Move the drive preferably in the original package to installation site as shown below to avoid damaging the cabinet surfaces and door devices. When you use a pallet truck, check its load capacity before you move the drive.

Horizontal package (frames R6…R9):



Unpacking the transport package

This drawing shows the layout of the horizontal transport package.



1	Bracket for attaching the drive to the wooden pallet	5	Timber
2	Cardboard packing hood	6	Drive cabinet
3	Wooden pallet	7	Plinth (delivered in a separate package)
4	Straps	-	-

Unpack the horizontal transport package as follows:

1. Cut the straps (4).
2. Remove the hood (2).
3. Undo the screws that attach the bracket (1) to the wooden pallet.
4. Remove the plastic wrapping.

Unpack the vertical transport package as follows:

1. Undo the screws that attach the wooden parts of the transport crate to each other.
2. Remove the wooden parts.
3. Remove the clamps with which the drive cabinet is mounted onto the transport pallet by undoing the fastening screws.
4. Remove the plastic wrapping.

Examining the delivery

The drive delivery contains:

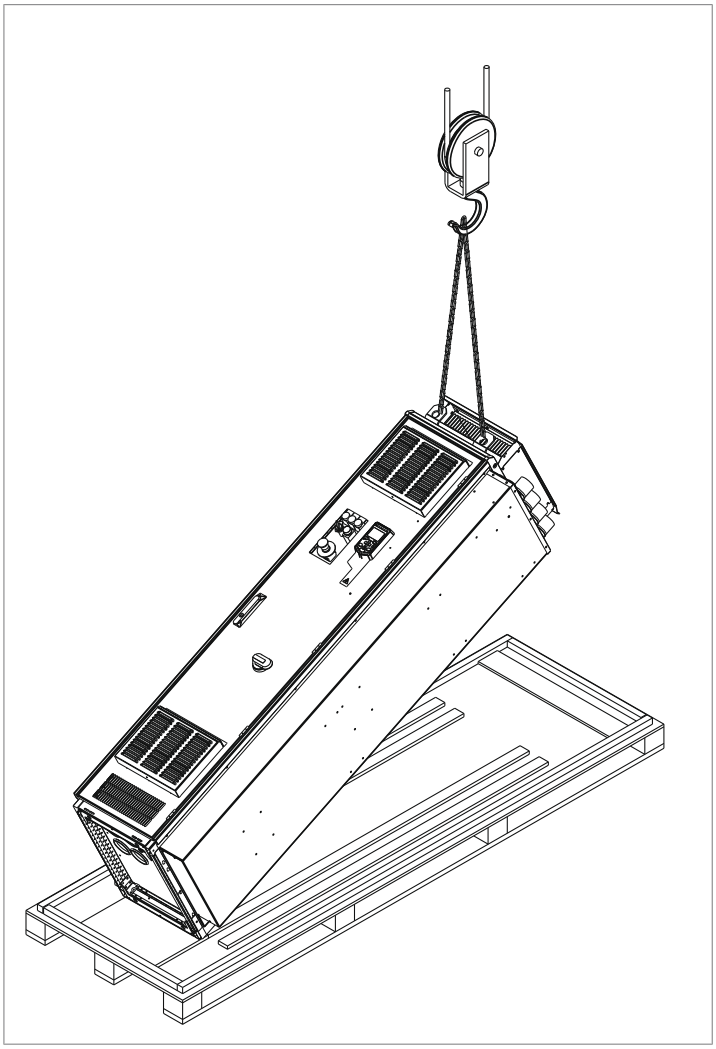
- drive cabinet line-up
- optional modules (if ordered) installed onto the control unit(s) at the factory
- delivery documents.

Make sure that there are no signs of damage. Before attempting installation and operation, see the information on the type designation labels of the drive to verify that the delivery is of the correct type.

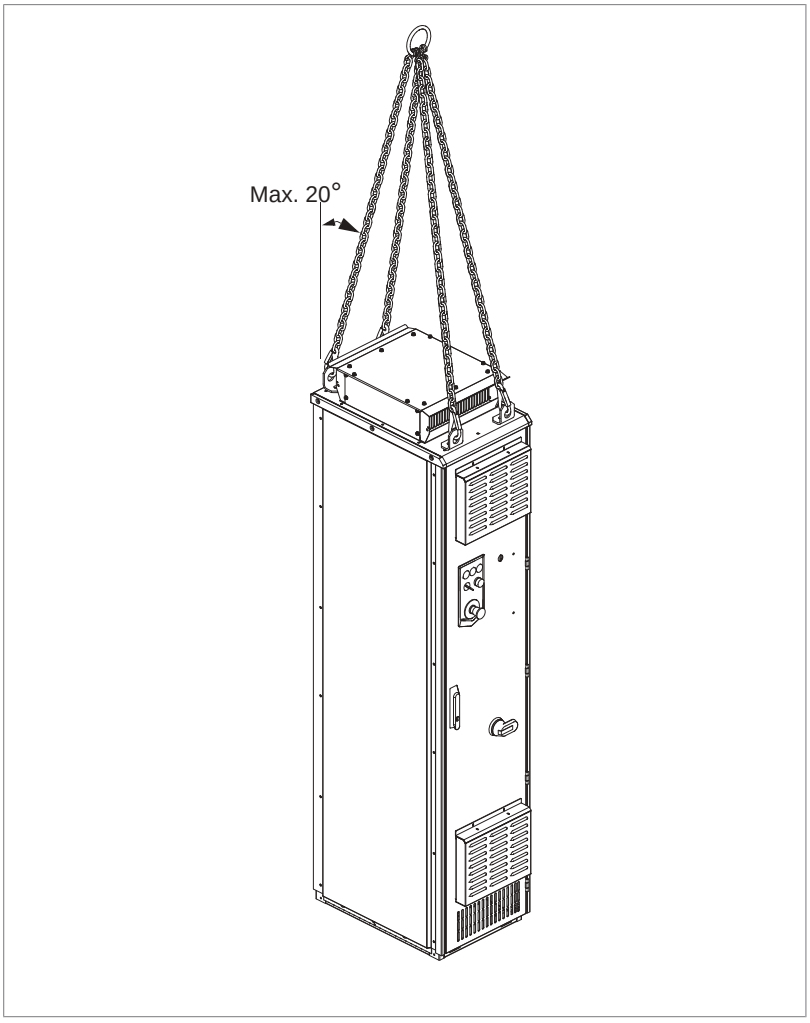
Lifting the cabinet

Obey the local laws and regulations that apply to lifting, such as the requirements for planning the lift, the capacity and condition of the lifting equipment, and personnel training.

Lift the drive cabinet up using its lifting lugs.



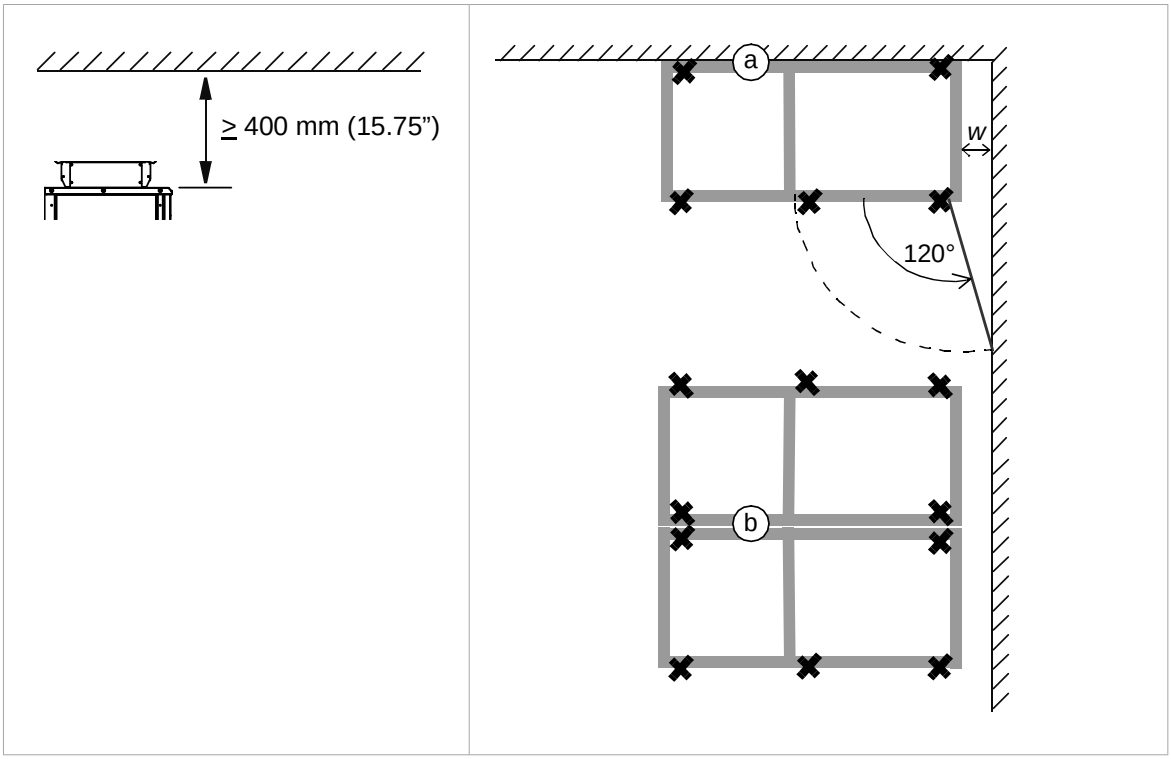
Lift the cabinet to its position. Maximum allowed angle of the lifting slings is 20°.



Attaching the cabinet to the floor and wall or roof

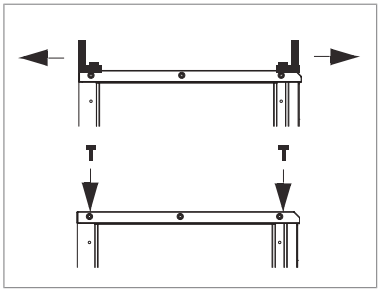
General rules

- The drive must be installed in an upright vertical position.
- Leave 400 mm (15.75”) of free space above the basic roof level of the cabinet for cooling.
- The cabinet can be installed with its back against a wall (a), or back-to-back with another unit (b).
- Leave some space (*w*) at the side where the cabinet outmost hinges are to allow the doors to open sufficiently. The doors must open 120° to allow module replacement.



Note 1: Any height adjustment must be done before attaching the cabinet sections to the floor or to each other. Height adjustment can be done by using metal shims between the cabinet bottom and floor.

Note 2: Depending on the size of the cabinet, it has either bolt-on lifting eyes, or lifting bars with lifting holes. Bolt-on lifting eyes need not be removed unless the holes are used for attaching the cabinet. If the cabinet is delivered with lifting bars, remove them and store them for decommissioning. Plug any unused holes using the existing bolts and sealing rings included. Tighten to 70 N·m (52 lbf·ft).

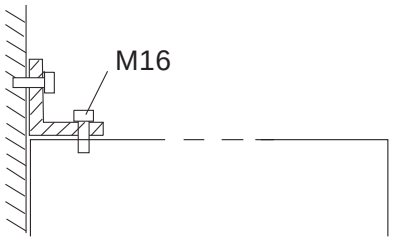
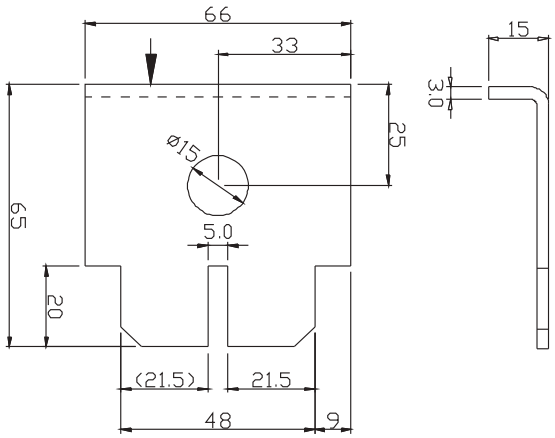


WARNING!
Do not stand or walk on the cabinet roof. Make sure that nothing presses against the roof, side or back plates or door. Do not store anything on the roof while the drive is in operation.

Attaching the cabinet (non-marine units)

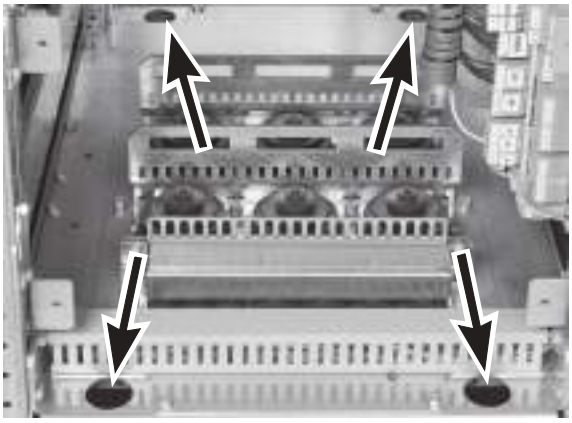
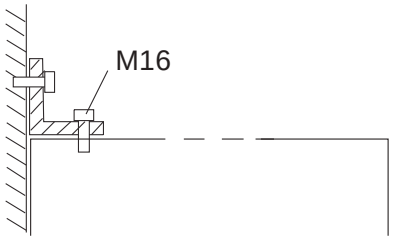
Alternative 1 – Clamping

1. Insert the clamps (included) into the twin slots along the front and rear edges of the cabinet frame body and fasten them to the floor with a bolt. The recommended maximum distance between the clamps in the front edge is 800 mm (31.5”).
2. If floor mounting at the back is not possible, attach the top of the cabinet to the wall with L-brackets (not included in the delivery) bolted to the lifting eye/bar holes, and suitable hardware.

Clamping bottom to floor	Attaching top to wall
	
	

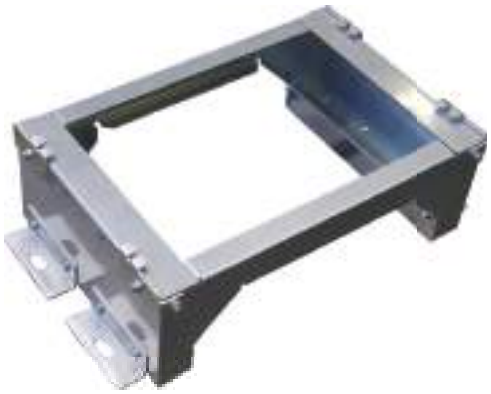
Alternative 2 – Using the holes inside the cabinet

1. Attach the cabinet to the floor through the bottom fastening holes with size M10…M12 (3/8”…1/2”) bolts. The recommended maximum distance between the front edge fastening points is 800 mm (31.5”).
2. If the back fastening holes are not accessible, attach the top of the cabinet to the wall with L-brackets (not included in the delivery) bolted to the lifting eye/bar holes.

Attaching bottom to floor	Attaching cabinet top to wall
	

Alternative 3 – Cabinets with plinth options +C164 and +C179

1. Attach the plinth to the floor with the brackets included in the plinth package.



2. Lift the cabinet onto the plinth and attach it to the plinth with the L-brackets delivered with the plinth.

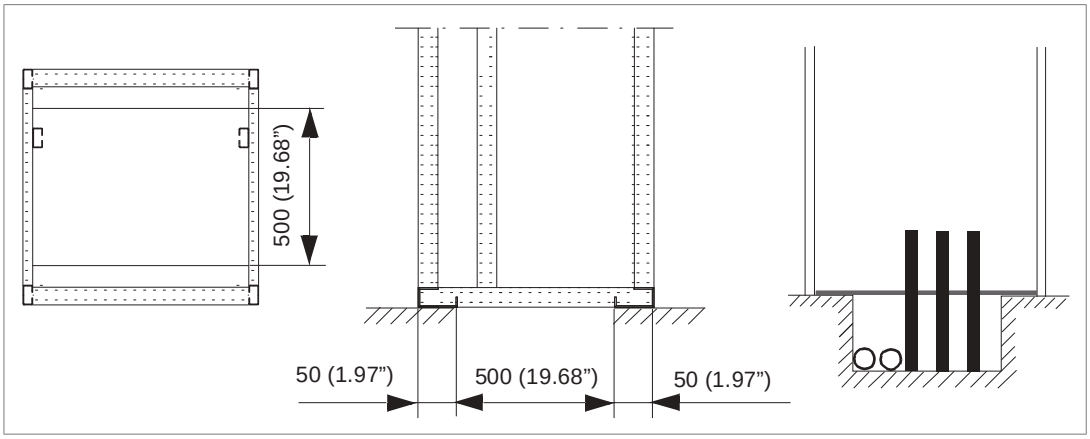
3. Attach the brackets of the front cover plate to the plinth with screws (Hex M8×20 full thread or equal) and M8 washers and nuts.
4. Attach the front cover plate to the brackets.
5. Attach each side cover plate with 3 screws (combi screw M5×12, Torx T20 or equal).

Miscellaneous

Cable duct in the floor below the cabinet

A cable duct can be constructed below the 500 mm wide middle part of the cabinet. The cabinet weight lies on the two 50 mm wide transverse sections which the floor must carry.

Prevent the cooling air flow from the cable duct to the cabinet by bottom plates. To ensure the degree of protection for the cabinet, use the original bottom plates delivered with the unit. With user-defined cable entries, take care of the degree of protection, fire protection and EMC compliance.



Arc welding

ABB does not recommend attaching the cabinet by arc welding. However, if arc welding is the only option, connect the return conductor of the welding equipment to the cabinet frame at the bottom within 0.5 meters (1'6") of the welding point.

Note: The cabinet frame is zinc-plated.

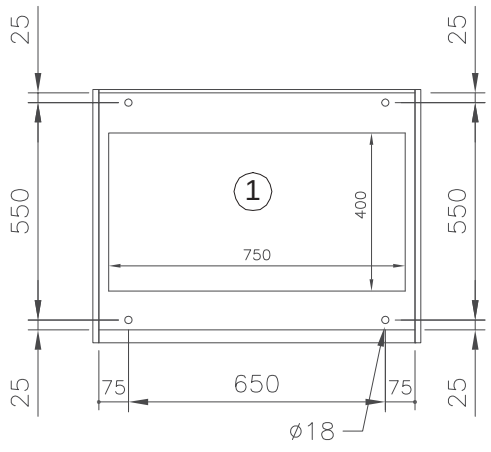
WARNING!
Make sure that the return wire is connected correctly. Welding current must not return via any component or cabling of the drive. If the welding return wire is connected incorrectly, the welding circuit can damage electronic circuits in the cabinet.

WARNING!
Do not inhale the welding fumes.

Air inlet through the bottom of the cabinet (option +C128)

Drives with air inlet through the bottom of the cabinet (option +C128) are intended for installation on an air duct in the floor.

An example of the air inlets in the cabinet bottom plate is shown below. Refer also to the dimension drawings delivered with the drive.



1	Air inlet area

Support the plinth of the cabinet all round.

The air duct must be able to supply a sufficient volume of cooling air. See technical data for the minimum air flow values.

WARNING!
Make sure that the incoming air is sufficiently clean. If not, dust goes into the cabinet. The outlet filter on the cabinet roof prevents dust from going out. The collected dust can cause drive malfunction and danger of fire.

Air outlet duct on the cabinet roof (option +C130)

The option adds air outlet ducts to each cubicle of the cabinet line-up. The outlet diameter (and quantity) of the ducts depend on the cubicle width. The ducts used are from the Veloduct series by FläktGroup.

Cubicle width (mm)	Outlet duct				Channel
	Veloduct type	Outer diameter (mm)	Inner diameter (mm)	Cross-sectional area (m^2)	Recommended inner diameter (mm)
300	BDEA-6-020	200	194	0.030	200.0 … 200.7
400	BDEA-6-031	310	304	0.073	315.0 … 315.9
500	BDEA-6-031	310	304	0.073	315.0 … 315.9
600	BDEA-6-040	400	394	0.122	400.0 … 401.0
700	BDEA-6-040	400	394	0.122	400.0 … 401.0
800	2 × BDEA-6-031	310	304	0.145	315.0 … 315.9
1000	2 × BDEA-6-031	310	304	0.145	315.0 … 315.9

The ventilation system must keep the static pressure in the air outlet duct sufficiently below the pressure of the room where the drive is located in order that the cabinet fans can produce the required air flow through the cabinet. Make sure that no dirty or moist air is able to flow backward to the drive in any case, even during off-time or while servicing the drive or the ventilation system.

Calculating the required static pressure difference

The required static pressure difference between the exit air duct and the drive installation room can be calculated as follows:

$\Delta p_s = (1.5…2) \cdot p_d$

where

$p_d = 0.5 \cdot \rho \cdot v_m^2$

$v_m = q / A_c$

p_d	Dynamic pressure
ρ	Air density (kg/m^3)
v_m	Average air velocity in the exit duct(s) (m/s)
q	Rated air flow of the drive (m^3/s)
A_c	Cross-sectional area of the exit duct(s) (m^2)

Example

The cabinet has 3 exit openings of 315 mm diameter. The rated air flow of the cabinet is 4650 m^3/h =1.3 m^3/s.

$A_c = 3 \cdot 0.315^2 \cdot \pi / 4 = 0.234\ m^2$

$v_m = 1.3 / 0.234 = 5.5\ m/s$

$p_d = 0.5 \cdot \rho \cdot v_m^2 = 0.5 \cdot 1.1 \cdot 5.5^2 = 17\ Pa$

The required pressure in the exit air duct is then 1.5…2 · 17 Pa = 26…34 Pa below the pressure in the room.

5

Guidelines for planning the electrical installation

Contents of this chapter

This chapter contains guidelines for planning the electrical installation of the drive.

Limitation of liability

The installation must always be designed and made according to applicable local laws and regulations. ABB does not assume any liability whatsoever for any installation which breaches the local laws and/or other regulations. Furthermore, if the recommendations given by ABB are not followed, the drive may experience problems that the warranty does not cover.

Selecting the supply disconnecting device

The drive is equipped with a main disconnecting device as standard. Depending on the size of the drive, and the selected options, the type of disconnecting device may vary. Examples: switch-disconnector, withdrawable air circuit breaker, etc.

Selecting the main contactor or breaker

You can order the drive with a main contactor (option +F250) or a molded case circuit breaker (option +F289).

Examining the compatibility of the motor and drive

Use asynchronous AC induction motors, permanent magnet synchronous motors or ABB synchronous reluctance motors (SynRM motors) with the drive.

Select the motor size and drive type from the rating table on basis of the AC line voltage and motor load. You can find the rating table in the appropriate hardware manual. You can also use the DriveSize PC tool.

Make sure that the motor can be used with an AC drive. See Requirements tables (page 66). For basics of protecting the motor insulation and bearings in drive systems, see Protecting the motor insulation and bearings (page 66).

Note:

- Consult the motor manufacturer before using a motor with nominal voltage that differs from the AC line voltage connected to the drive input.
- The voltage peaks at the motor terminals are relative to the supply voltage of the drive, not to the drive output voltage.

Protecting the motor insulation and bearings

The drive employs modern IGBT inverter technology. Regardless of frequency, the drive output comprises pulses of approximately the drive DC bus voltage with a very short rise time. The pulse voltage can almost double at the motor terminals, depending on the attenuation and reflection properties of the motor cable and the terminals. This can cause additional stress on the motor and motor cable insulation.

Modern variable speed drives with their fast rising voltage pulses and high switching frequencies can generate current pulses that flow through the motor bearings. This can gradually erode the bearing races and rolling elements.

d*u*/d*t* filters protect motor insulation system and reduce bearing currents. Common mode filters mainly reduce bearing currents. Insulated N-end (non-drive end) bearings protect the motor bearings.

Requirements tables

These tables show how to select the motor insulation system and when a drive d*u*/d*t* and common mode filters and insulated N-end (non-drive end) motor bearings are required. Ignoring the requirements or improper installation may shorten motor life or damage the motor bearings and voids the warranty.

Requirements for ABB motors, P_n < 100 kW (134 hp)

See also Abbreviations (page 70).

Motor type	Nominal AC line voltage	Requirement for	
		Motor insulation system	ABB d*u*/d*t* and common mode filters, insulated N-end motor bearings
			P_n < 100 kW and frame size < IEC 315
			P_n < 134 hp and frame size < NEMA 500
Random-wound M2_, M3_ and M4_	$U_n \leq 500$ V	Standard	-
	500 V < $U_n \leq$ 600 V	Standard	+ d*u*/d*t*
		Reinforced	-
	600 V < $U_n \leq$ 690 V (cable length ≤ 150 m)	Reinforced	+ d*u*/d*t*
	600 V < $U_n \leq$ 690 V (cable length > 150 m)	Reinforced	-
Form-wound HX_ and AM_	380 V < $U_n \leq$ 690 V	Standard	N/A
Old [1] form-wound HX_ and modular	380 V < $U_n \leq$ 690 V	Check with the motor manufacturer.	+ N + d*u*/d*t* with voltages over 500 V + CMF
Random-wound HX_ and AM_ [2]	0 V < $U_n \leq 500$ V	Enamelled wire with fiber glass taping	+ N + CMF
	500 V < $U_n \leq$ 690 V		+ N + d*u*/d*t* + CMF
HDP	Consult the motor manufacturer.		

[1] manufactured before 1.1.1998
[2] For motors manufactured before 1.1.1998, check for additional instructions with the motor manufacturer.

Requirements for ABB motors, $P_n \geq 100$ kW (134 hp)

See also Abbreviations (page 70).

Motor type	Nominal AC line voltage	Requirement for		
		Motor insulation system	ABB du/dt and common mode filters, insulated N-end motor bearings	
			100 kW ≤ P_n < 350 kW or IEC 315 ≤ frame size < IEC 400	P_n ≥ 350 kW or frame size ≥ IEC 400
			134 hp ≤ P_n < 469 hp or NEMA 500 ≤ frame size ≤ NEMA 580	P_n ≥ 469 hp or frame size > NEMA 580
Random-wound M2_, M3_ and M4_	$U_n \leq 500$ V	Standard	+ N	+ N + CMF
	500 V < $U_n \leq 600$ V	Standard	+ N + du/dt	+ N + du/dt + CMF
		Reinforced	+ N	+ N + CMF
	600 V < $U_n \leq 690$ V (cable length ≤ 150 m)	Reinforced	+ N + du/dt	+ N + du/dt + CMF
	600 V < $U_n \leq 690$ V (cable length > 150 m)	Reinforced	+ N	+ N + CMF
Form-wound HX_ and AM_	380 V < $U_n \leq 690$ V	Standard	+ N + CMF	P_n < 500 kW: +N + CMF
				$P_n \geq 500$ kW: +N + du/dt + CMF
Old[1] form-wound HX_ and modular	380 V < $U_n \leq 690$ V	Check with the motor manufacturer.	+ N + du/dt with voltages over 500 V + CMF	
Random-wound HX_ and AM_ [2]	0 V < $U_n \leq 500$ V	Enamelled wire with fiber glass taping	+ N + CMF	
	500 V < $U_n \leq 690$ V		+ N + du/dt + CMF	
HDP	Consult the motor manufacturer.			

1) manufactured before 1.1.1998
2) For motors manufactured before 1.1.1998, check for additional instructions with the motor manufacturer.

Requirements for non-ABB motors, P_n < 100 kW (134 hp)

See also Abbreviations (page 70).

Motor type	Nominal AC line voltage	Requirement for	
		Motor insulation system	ABB d*u*/d*t* and common mode filters, insulated N-end motor bearings
			P_n < 100 kW and frame size < IEC 315
			P_n < 134 hp and frame size < NEMA 500
Random-wound and form-wound	$U_n \leq 420$ V	Standard: $\hat{U}_{LL}$ = 1300 V	-
	420 V < $U_n \leq$ 500 V	Standard: $\hat{U}_{LL}$ = 1300 V	+ d*u*/d*t*
		Reinforced: $\hat{U}_{LL}$ = 1600 V, 0.2 µs rise time	-
	500 V < $U_n \leq$ 600 V	Reinforced: $\hat{U}_{LL}$ = 1600 V	+ d*u*/d*t*
		Reinforced: $\hat{U}_{LL}$ = 1800 V	-
	600 V < $U_n \leq$ 690 V	Reinforced: $\hat{U}_{LL}$ = 1800 V	+ d*u*/d*t*
		Reinforced: $\hat{U}_{LL}$ = 2000 V, 0.3 µs rise time [1)]	-

1) If the intermediate DC circuit voltage of the drive is increased from the nominal level due to long term resistor braking cycles, check with the motor manufacturer if additional output filters are needed.

Requirements for non-ABB motors, $P_n \geq 100$ kW (134 hp)

See also Abbreviations (page 70).

Motor type	Nominal AC line voltage	Requirement for		
		Motor insulation system	ABB du/dt and common mode filters, insulated N-end motor bearings	
			100 kW ≤ P_n < 350 kW or IEC 315 ≤ frame size < IEC 400	P_n ≥ 350 kW or frame size ≥ IEC 400
			134 hp ≤ P_n < 469 hp or NEMA 500 ≤ frame size ≤ NEMA 580	P_n ≥ 469 hp or frame size > NEMA 580
Random-wound and form-wound	$U_n \leq 420$ V	Standard: $\hat{U}_{LL}$ = 1300 V	+ N or CMF	+ N + CMF
	420 V < $U_n \leq 500$ V	Standard: $\hat{U}_{LL}$ = 1300 V	+ du/dt + (N or CMF)	+ N + du/dt + CMF
		Reinforced: $\hat{U}_{LL}$ = 1600 V, 0.2 µs rise time	+ N or CMF	+ N + CMF
	500 V < $U_n \leq 600$ V	Reinforced: $\hat{U}_{LL}$ = 1600 V	+ du/dt + (N or CMF)	+ N + du/dt + CMF
		Reinforced: $\hat{U}_{LL}$ = 1800 V	+ N or CMF	+ N + CMF
	600 V < $U_n \leq 690$ V	Reinforced: $\hat{U}_{LL}$ = 1800 V	+ du/dt + N	+ N + du/dt + CMF
		Reinforced: $\hat{U}_{LL}$ = 2000 V, 0.3 µs rise time [1)]	+ N + CMF	+ N + CMF

1) If the intermediate DC circuit voltage of the drive is increased from the nominal level due to long term resistor braking cycles, check with the motor manufacturer if additional output filters are needed.

Abbreviations

Abbr.	Definition
U_n	Nominal AC line voltage
$\hat{U}_{LL}$	Peak line-to-line voltage at motor terminals which the motor insulation must withstand
P_n	Motor nominal power
du/dt	du/dt filter at the output of the drive
CMF	Common mode filter of the drive
N	N-end bearing: insulated motor non-drive end bearing
n.a.	Motors of this power range are not available as standard units. Consult the motor manufacturer.

Availability of d*u*/d*t* filter and common mode filter by drive type

Product type	Availability of du/dt filter	Availability of common mode filter (CMF)
ACQ80-07	+E205	+E208

Additional requirements for explosion-safe (EX) motors

If you use an explosion-safe (EX) motor, obey the rules in the requirements table above. In addition, consult the motor manufacturer for any further requirements.

Additional requirements for ABB motors of types other than M2_, M3_, M4_, HX_ and AM_

Use the selection criteria given for non-ABB motors.

Additional requirements for ABB high-output and IP23 motors

The rated output power of high output motors is higher than what is stated for the particular frame size in EN 50347 (2001).

This table shows the requirements for protecting the motor insulation and bearings in drive systems for ABB random-wound motor series (for example, M3AA, M3AP and M3BP).

Nominal AC supply voltage	Requirement for			
	Motor insulation system	ABB d*u*/d*t* and common mode filters, insulated N-end motor bearings		
		P_n < 100 kW	100 kW ≤ P_n < 200 kW	P_n ≥ 200 kW
		P_n < 140 hp	140 hp ≤ P_n < 268 hp	P_n ≥ 268 hp
U_n ≤ 500 V	Standard	-	+ N	+ N + CMF
500 V < U_n ≤ 600 V	Standard	+ d*u*/d*t*	+ d*u*/d*t* + N	+ d*u*/d*t* + N + CMF
	Reinforced	-	+ N	+ N + CMF
600 V < U_n ≤ 690 V	Reinforced	+ d*u*/d*t*	+ d*u*/d*t* + N	+ d*u*/d*t* + N + CMF

Additional requirements for non-ABB high-output and IP23 motors

The rated output power of high-output motors is higher than what is stated for the particular frame size in EN 50347 (2001).

If you plan to use a non-ABB high-output motor or an IP23 motor, consider these additional requirements for protecting the motor insulation and bearings in drive systems:

- If motor power is below 350 kW: Equip the drive and/or motor with the filters and/or bearings according to the table below.
- If motor power is above 350 kW: Consult the motor manufacturer.

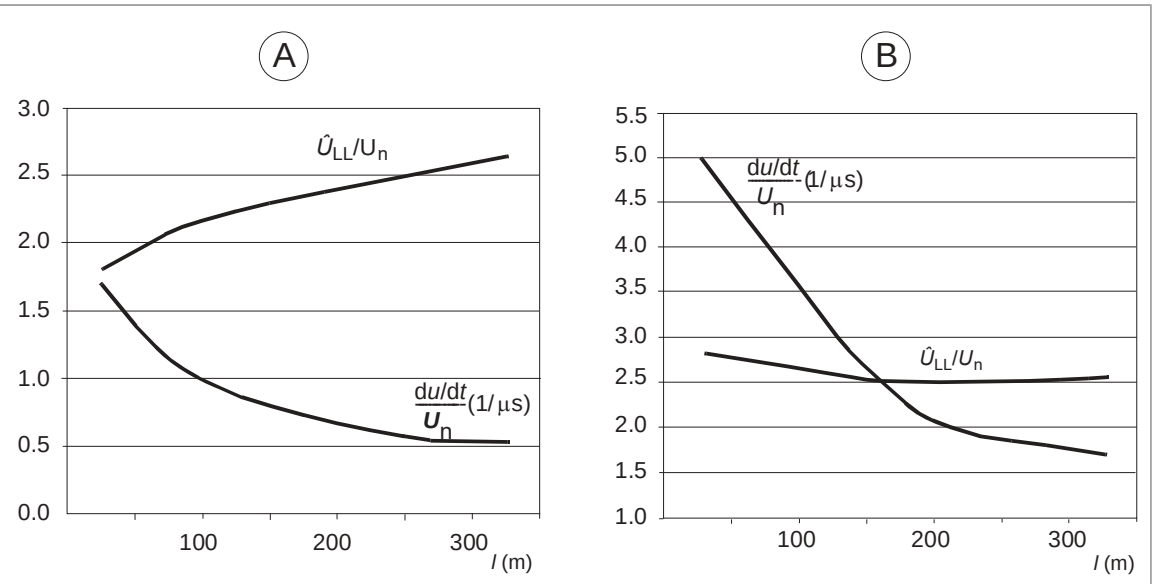
Nominal AC supply voltage	Requirement for		
	Motor insulation system	ABB d*u*/d*t* and common mode filters, insulated N-end motor bearings	
		P_n < 100 kW or frame size < IEC 315	100 kW < P_n < 350 kW or IEC 315 < frame size < IEC 400
		P_n < 134 hp or frame size < NEMA 500	134 hp < P_n < 469 hp or NEMA 500 < frame size < NEMA 580
$U_n \leq 420$ V	Standard: $\hat{U}_{LL}$ = 1300 V	+ N or CMF	+ N or CMF
420 V < U_n < 500 V	Standard: $\hat{U}_{LL}$ = 1300 V	+ d*u*/d*t* + (N or CMF)	+ N + d*u*/d*t* + CMF
	Reinforced: $\hat{U}_{LL}$ = 1600 V, 0.2 microsecond rise time	+ N or CMF	+ N or CMF
500 V < $U_n \leq 600$ V	Reinforced: $\hat{U}_{LL}$ = 1600 V	+ d*u*/d*t* + (N or CMF)	+ N + d*u*/d*t* + CMF
	Reinforced: $\hat{U}_{LL}$ = 1800 V	+ N or CMF	+ N + CMF
600 V < $U_n \leq 690$ V	Reinforced: $\hat{U}_{LL}$ = 1800 V	+ N + d*u*/d*t*	+ N + d*u*/d*t* + CMF
	Reinforced: $\hat{U}_{LL}$ = 2000 V, 0.3 microsecond rise time [1)]	+ N + CMF	+ N + CMF

1) If the intermediate DC circuit voltage of the drive is increased from the nominal level due to long term resistor braking cycles, check with the motor manufacturer if additional output filters are needed.

Additional data for calculating the rise time and the peak line-to-line voltage

The diagrams below show the relative peak line-to-line voltage and rate of change of voltage as a function of the motor cable length. If you need to calculate the actual peak voltage and voltage rise time considering the actual cable length, proceed as follows:

- Peak line-to line voltage: Read the relative $\hat{U}_{LL}/U_n$ value from the diagram below and multiply it by the nominal supply voltage (U_n).
- Voltage rise time: Read the relative values $\hat{U}_{LL}/U_n$ and (d*u*/d*t*)/U_n from the diagram below. Multiply the values by the nominal supply voltage (U_n) and substitute into equation $t = 0.8 \cdot \hat{U}_{LL}/(du/dt)$.



A	Drive with d*u*/d*t* filter
B	Drive without d*u*/d*t* filter
l	Motor cable length
U_n	Nominal AC line voltage
$\hat{U}_{LL}/U_n$	Relative peak line-to-line voltage
(d*u*/d*t*)/U_n	Relative d*u*/d*t* value
Note: $\hat{U}_{LL}$ and d*u*/d*t* values are approximately 20% higher with resistor braking.	

Additional note for sine filters

A sine filter also protects the motor insulation system. The peak phase-to-phase voltage with a sine filter is approximately 1.5 · U_n.

Selecting the power cables

General guidelines

Select the input power and motor cables according to local regulations.

- **Current:** Select a cable capable of carrying the maximum load current and suitable for the prospective short-circuit current provided by the supply network. The method of installation and ambient temperature affect the cable current carrying capacity. Obey local regulations and laws.
- **Temperature:** For an IEC installation, select a cable rated for at least 70 °C (158 °F) maximum permissible temperature of conductor in continuous use.
  For North America, select a cable rated for at least 75 °C (167 °F).
  Important: For certain product types or option configurations higher temperature rating may be required. See the technical data for details.
- **Voltage:** 600 V AC cable is accepted for up to 500 V AC. 750 V AC cable is accepted for up to 600 V AC. 1000 V AC cable is accepted for up to 690 V AC.

To comply with the EMC requirements of the CE mark, use one of the preferred cable types. See Preferred power cable types (page 74).

Symmetrical shielded cable reduces electromagnetic emission of the whole drive system as well as the stress on motor insulation, bearing currents and wear.

Metal conduit reduces electromagnetic emission of the whole drive system.

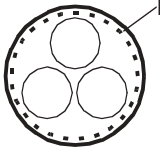
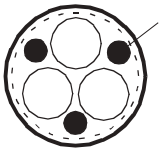
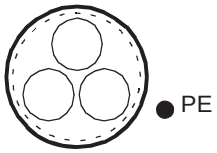
Typical power cable sizes

See the technical data.

Power cable types

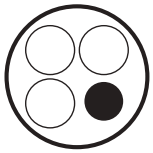
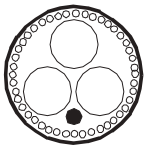
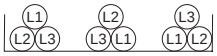
Preferred power cable types

This section shows the preferred cable types. Make sure that the selected cable type also complies with local/state/country electrical codes.

Cable type	Use as input power cabling	Use as motor cabling and as brake resistor cabling
 Symmetrical shielded (or armored) cable with three phase conductors and concentric PE conductor as shield (or armor)	Yes	Yes
 Symmetrical shielded (or armored) cable with three phase conductors and symmetrically constructed PE conductor and a shield (or armor)	Yes	Yes
 Symmetrical shielded (or armored) cable with three phase conductors and a shield (or armor), and separate PE conductor/cable [1)]	Yes	Yes

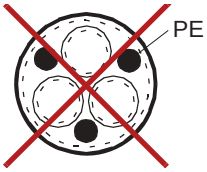
1) A separate PE conductor is required if the conductivity of the shield (or armor) is not sufficient for the PE use.

Alternate power cable types

Cable type	Use as input power cabling	Use as motor cabling and as brake resistor cabling
 Four-conductor cable in plastic jacket (three phase conductors and PE)	Yes with phase conductor smaller than 10 mm² (8 AWG) Cu.	Yes with phase conductor smaller than 10 mm² (8 AWG) Cu, or motors up to 30 kW (40 hp). **Note:** Shielded or armored cable, or cabling in metal conduit is always recommended to minimize radio frequency interference.
 Four-conductor armored cable (three phase conductors and PE)	Yes	Yes with phase conductor smaller than 10 mm² (8 AWG) Cu, or motors up to 30 kW (40 hp)
 Shielded (Al/Cu shield or armor) [1] four-conductor cable (three phase conductors and a PE)	Yes	Yes with motors up to 100 kW (135 hp). A potential equalization between the frames of motor and driven equipment is required.
 A single-core cable system: three phase conductors and PE conductor on cable tray  Preferable cable arrangement to avoid voltage or current unbalance between the phases	Yes **WARNING!** If you use unshielded single-core cables in an IT network, make sure that the non-conductive outer sheath (jacket) of the cables have good contact with a properly grounded conductive surface. For example, install the cables on a properly grounded cable tray. Otherwise voltage may become present on the non-conductive outer sheath of the cables, and there is even a risk of an electric shock.	No

[1] Armor may act as an EMC shield, as long as it provides the same performance as a concentric EMC shield of a shielded cable. To be effective at high frequencies, the shield conductivity must be at least 1/10 of the phase conductor conductivity. The effectiveness of the shield can be evaluated based on the shield inductance, which must be low and only slightly dependent on frequency. The requirements are easily met with a copper or aluminum shield/armor. The cross-section of a steel shield must be ample and the shield helix must have a low gradient. A galvanized steel shield has a better high-frequency conductivity than a non-galvanized steel shield.

Not allowed power cable types

Cable type	Use as input power cabling	Use as motor cabling and as brake resistor cabling
 Symmetrical shielded cable with individual shields for each phase conductor	No	No

Selecting AC power cables

The below table gives the copper cable types with concentric copper shield for the drives with nominal current. The value separated by plus sign means the diameter of PE conductor.

See page Terminal and entry data for the power cables for the cable entry sizes allowed for the selected drive frame size.

ACQ80-07-...	Frame size	Cu cable type [1]
		mm²
030kW-4	R4	3×25 + 16
037kW-4	R4	3×35 + 16
045kW-4	R4	3×50 + 25
055kW-4	R5	3×70 + 35
075kW-4	R6	3×95 + 50
090kW-4	R7	3×120 + 70
110kW-4	R7	3×150 + 70
132kW-4	R8	2×(3×70+35)
160kW-4	R8	2×(3×95+50)
200kW-4	R9	2×(3×120+70)

[1] The cable sizing is based on max. 6 cables laid on a cable ladder side by side, ambient temperature 30 °C, PVC insulation, surface temperature 70 °C (EN 60204-1 and IEC 60364- 5-52/2001). For other conditions, size the cables according to local safety regulations, appropriate input voltage and the load current of the drive. See page 168 for the accepted cable sizes of the drive.

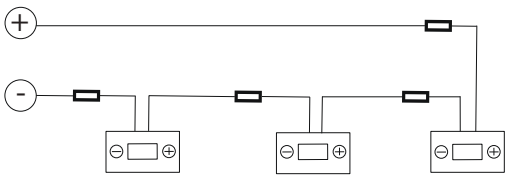
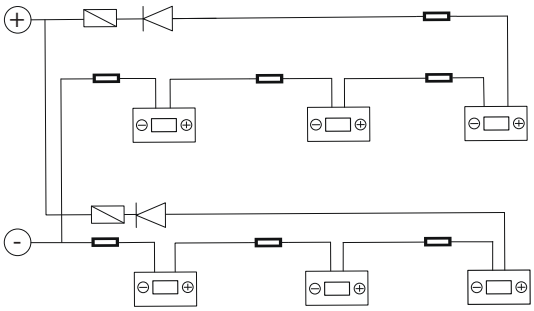
Selecting DC power cables

Consider the following conditions when selecting DC power cables:

- Make sure the DC cable can handle 1000 V open circuit voltage(VOC).

WARNING! Open joints in DC power cable wiring can cause damage of equipment or injury or loss of life of personal.

- Use blocking and bypass diodes as per the solar module manufacturer's recommendation and local regulatory.

String connection	Parallel connection
	

	Solar cell
	MC4 connector
	Diode
	Contactor

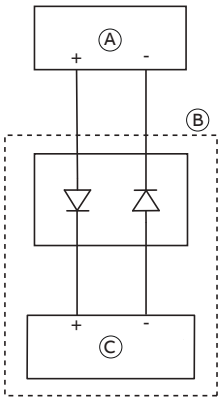
For more information on DC cables and cable bending rule, blocking and bypass diodes, see DC cable recommendation provided by solar cell manufacturer.

- The maximum length of DC cables between solar cell modules and drive must be decided based on the voltage drop specified by solar cell manufacturer or cable manufacturer.
- The drive needs 560 VDC as Voltage at maximum power ($V_{mp)}$ with motor rated current to operate a 400 VAC motor at nominal speed.
  For information on calculation of required solar cell voltage and short-circuit current (Isc) for a motor at nominal conditions, see page 158
- Unshielded single-core DC cable can be used inside the cabinet. If the DC cables are running outside the cabinet, use shielded three-core cables. The shield is connected only at one end. Maximum length is four meters.
- Consider DC power cable sizing same as the AC power cable sizing.

DC cable sizing

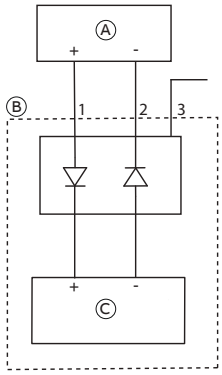
Obey the basic cabling guidelines given for AC drive systems. The most economical power cable for DC systems has an even number of conductors. You can also use a shielded three-core cable. The 2+1 or 1+2 principle of cabling (see in below figures) can be used when three-core cables are installed in large drive systems. Where several power cables are needed, this principle allows power sharing evenly between the cables.

Single core run:



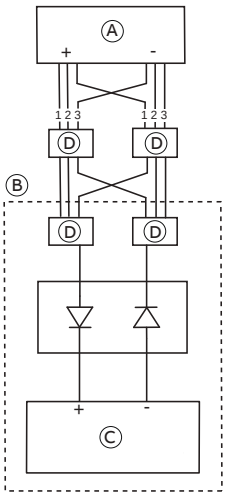
A	Solar cell
B	Cabinet
C	Solar pump drive

Three core - single run:



1,2,3	Three core cable
A	Solar cell
B	Cabinet
C	Solar pump drive

Three core - multiple run:



1,2,3	Three core cable
A	Solar cell
B	Cabinet
C	Solar pump drive
D	Terminal block

The excitation cable is a heavy source of interference because of the abrupt commutation. Make sure that shielded excitation cables are used to avoid any interference.

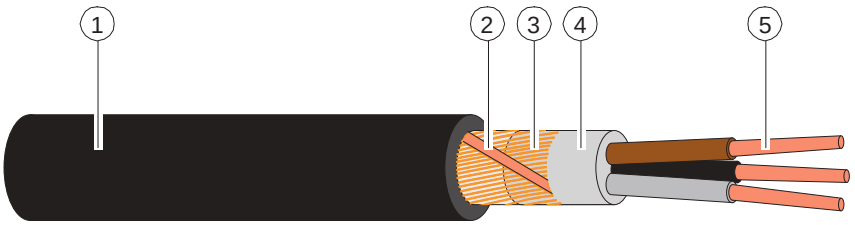
Do not use single-core cables for DC drives.

Make sure that the motors with stator serial winding has a grounding brush on the shaft to avoid bearing problems.

Power cable shield

If the cable shield is used as the sole protective earth (PE) conductor, make sure that its conductivity agrees with the PE conductor requirements.

To effectively suppress radiated and conducted radio-frequency emissions, the cable shield conductivity must be at least 1/10 of the phase conductor conductivity. The requirements are easily met with a copper or aluminum shield. The minimum requirement of the motor cable shield of the drive is shown below. It consists of a concentric layer of copper wires with an open helix of copper tape or copper wire. The better and tighter the shield, the lower the emission level and bearing currents.



1	Insulation jacket
2	Helix of copper tape or copper wire
3	Copper wire shield
4	Inner insulation
5	Cable core

Grounding requirements

This section gives general requirements for grounding the drive. When you plan the grounding of the drive, obey all the applicable national and local regulations.

The conductivity of the protective earth conductor(s) must be sufficient.

Unless local wiring regulations state otherwise, the cross-sectional area of the protective earth conductor must agree with the conditions that require automatic disconnection of the supply required in 411.3.2 of IEC 60364-4-41:2005 and be capable of withstanding the prospective fault current during the disconnection time of the protective device. The cross-sectional area of the protective earth conductor must be selected from the table below or calculated according to 543.1 of IEC 60364-5-54.

The table shows the minimum cross-sectional area of the protective earth conductor related to the phase conductor size according to IEC/UL 61800-5-1 when the phase conductor(s) and the protective earth conductor are made of the same metal. If they are different metals, the cross-sectional area of the protective earth conductor must be determined in a manner which produces a conductance equivalent to that which results from the application of this table.

Cross-sectional area of the phase conductors S (mm²)	**Minimum cross-sectional area of the corresponding protective earth conductor S_p (mm²)**
S ≤ 16	S [1)]
16 < S ≤ 35	16
35 < S	S/2

1) For the minimum conductor size in IEC installations, refer to Additional grounding requirements – IEC.

If the protective earth conductor is not part of the input power cable or input power cable enclosure, the minimum permitted cross-sectional area is:

- 2.5 mm² if the conductor is mechanically protected,
  or
- 4 mm² if the conductor is not mechanically protected. If the equipment is cord-connected, the protective earth conductor must be the last conductor to be interrupted if there is a failure in the strain relief mechanism.

Additional grounding requirements – IEC

This section gives grounding requirements according to standard IEC/EN 61800-5-1.

Because the normal touch current of the drive is more than 3.5 mA AC or 10 mA DC:

- the minimum size of the protective earth conductor must comply with the local safety regulations for high protective earth conductor current equipment, and
- you must use one of these connection methods:
  1. a fixed connection and:
     - a protective earth conductor with a minimum cross-sectional area of 10 mm^2 Cu or 16 mm^2 Al (as an alternative when aluminum cables are permitted),
       or
     - a second protective earth conductor of the same cross-sectional area as the original protective earth conductor,
       or
     - a device that automatically disconnects the supply if the protective earth conductor is damaged.
  2. a connection with an industrial connector according to IEC 60309 and a minimum protective earth conductor cross-section of 2.5 mm^2 as part of a multi-conductor power cable. Sufficient strain relief must be provided.

If the protective earth conductor is routed through a plug and socket, or similar means of disconnection, it must not be possible to disconnect it unless power is simultaneously removed.

Note: You can use power cable shields as protective earth conductors only when their conductivity is sufficient.

Additional grounding requirements – UL (NEC)

This section gives grounding requirements according to standard UL 61800-5-1.

The protective earth conductor must be sized as specified in Article 250.122 and table 250.122 of the National Electric Code, ANSI/NFPA 70.

For cord-connected equipment, it must not be possible to disconnect the protective earth conductor before power is removed.

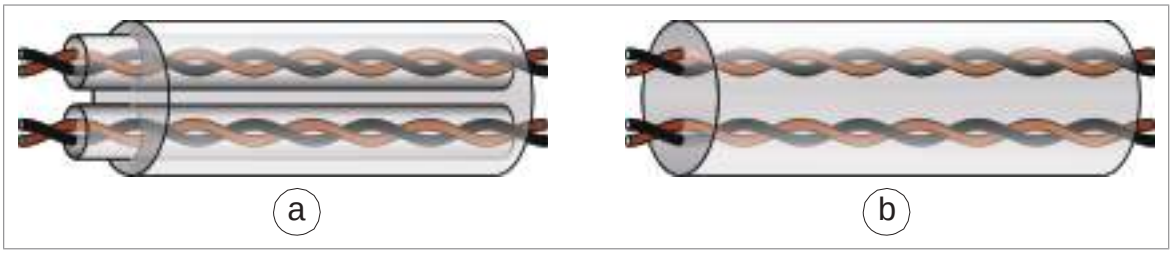
Selecting the control cables

Shielding

Only use shielded control cables.

Use a double-shielded twisted pair cable for analog signals. ABB recommends this type of cable also for the pulse encoder signals. Use one individually shielded pair for each signal. Do not use common return for different analog signals.

A double-shielded cable (a) is the best alternative for low-voltage digital signals, but single-shielded (b) twisted pair cable is also acceptable.



Signals in separate cables

Run analog and digital signals in separate, shielded cables. Do not mix 24 V DC and 115/230 V AC signals in the same cable.

Signals that can be run in the same cable

If their voltage does not exceed 48 V, relay-controlled signals can be run in the same cables as digital input signals. The relay-controlled signals should be run as twisted pairs.

Relay cable

The cable type with braided metallic shield (for example ÖLFLEX by LAPPKABEL, Germany) has been tested and approved by ABB.

Control panel to drive cable

Use EIA-485, Cat 5e (or better) cable with male RJ-45 connectors. The maximum length of the cable is 100 m (328 ft).

PC tool cable

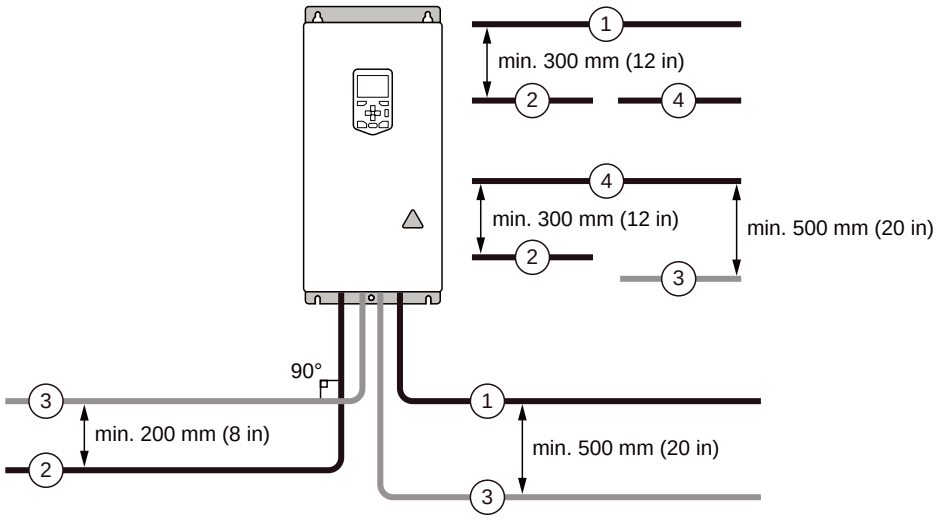
Connect the Drive Composer PC tool to the drive through the USB port of the control panel. Use a USB Type A (PC) - Type Mini-B (control panel) cable. The maximum length of the cable is 3 m (9.8 ft).

Routing the cables

General guidelines – IEC

- Route the motor cable away from other cables. Motor cables of several drives can be run in parallel installed next to each other.
- Install the motor cable, input power cable and control cables on separate trays.
- Avoid long parallel runs of motor cables with other cables.
- Where control cables must cross power cables, make sure that they are arranged at an angle as near to 90 degrees as possible.
- Do not run extra cables through the drive.
- Make sure that the cable trays have good electrical bonding to each other and to the grounding electrodes. Aluminum tray systems can be used to improve local equalizing of potential.

The following figure illustrates the cable routing guidelines with an example drive.



1	Motor cable
2	Input power cable
3	Control cable
4	Brake resistor or chopper cable (if any)

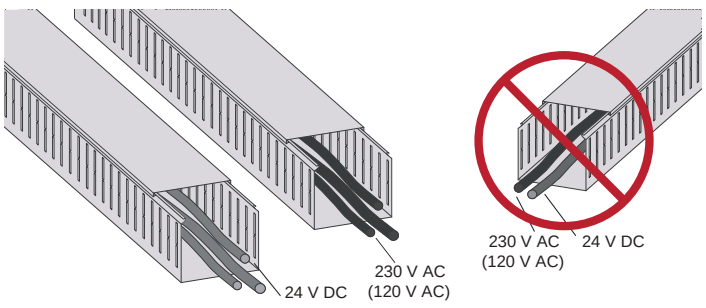
Continuous motor cable shield/conduit and metal enclosure for equipment on the motor cable

To minimize the emission level when safety switches, contactors, connection boxes or similar equipment are installed on the motor cable between the drive and the motor:

- Install the equipment in a metal enclosure.
- Use either a symmetrical shielded cable, or install the cabling in a metal conduit.
- Make sure that there is a good and continuous galvanic connection in the shield/conduit between drive and motor.
- Connect the shield/conduit to the protective ground terminal of the drive and the motor.

Separate control cable ducts

Put 24 V DC and 230 V AC (120 V AC) control cables in separate ducts, unless the 24 V DC cable is insulated for 230 V AC (120 V AC) or insulated with an insulation sleeving for 230 V AC (120 V AC).



Protecting the drive, input power cable, motor and motor cable in short circuit situations and against thermal overload

Protecting the drive and input power cable in short-circuit situations

The drive is equipped with internal AC fuses (1) as standard. The fuses restrict drive damage and prevent damage to adjoining equipment in case of a short-circuit inside the drive.

Protect the input cable with fuses or circuit breaker (2) according to local safety regulations, appropriate input voltage and the rated current of the drive (see chapter).

Protecting the motor and motor cable in short-circuits

The drive protects the motor cable and motor in a short-circuit situation when:

- the motor cable is sized correctly
- the motor cable type complies with the motor cable selection guidelines by ABB
- the cable length does not exceed the allowed maximum length specified for the drive
- the setting of parameter 99.10 Motor nominal power in the drive is equal with the value given on the motor rating plate.

The electronic power output short-circuit protection circuitry meets the requirements of IEC 60364-4-41:2005 + AMD1:2017.

Protecting the drive and the power cables against thermal overload

The drive protects itself and the input and motor cables against thermal overload when the cables are sized according to the nominal current of the drive. No additional thermal protection devices are needed.

WARNING!
If the drive is connected to multiple motors, use a separate circuit breaker or fuses for protecting each motor cable and motor against overload. The drive overload protection is tuned for the total motor load. It may not trip due to an overload in one motor circuit only.

Protecting the motor against thermal overload

According to regulations, the motor must be protected against thermal overload and the current must be switched off when overload is detected. The drive includes a motor thermal protection function that protects the motor and switches off the current when necessary. Depending on a drive parameter value, the function either monitors a calculated temperature value (based on a motor thermal model) or an actual temperature indication given by motor temperature sensors.

The motor thermal protection model supports thermal memory retention and speed sensitivity. The user can tune the thermal model further by feeding in additional motor and load data.

The most common temperature sensor types are PTC or Pt100.

For more information, see the firmware manual.

Protecting the motor against overload without thermal model or temperature sensors

Motor overload protection protects the motor against overload without using motor thermal model or temperature sensors.

Motor overload protection is required and specified by multiple standards including the US National Electric Code (NEC) and the common UL/IEC 61800-5-1 standard in conjunction with UL/IEC 60947-4-1. The standards allow for motor overload protection without external temperature sensors.

The protection feature of the drive allows the user to specify the class of operation in the same manner as the overload relays are specified in standards UL/IEC 60947-4-1 and NEMA ICS 2.

The motor overload protection supports thermal memory retention and speed sensitivity.

For more information, see drive firmware manual.

Protecting the drive against ground faults

The drive is equipped with an internal ground fault protective function to protect the unit against ground faults in the motor and motor cable. This function is not a personnel safety or a fire protection feature. See the firmware manual for more information.

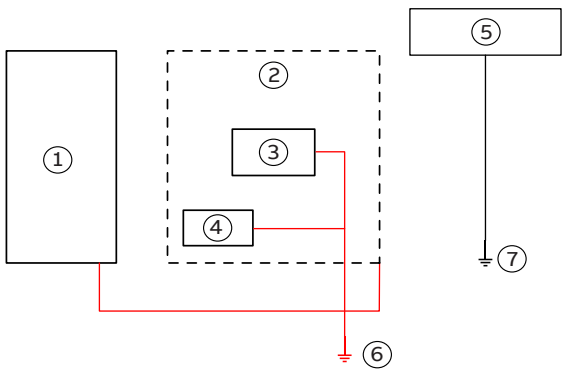
Residual current device compatibility

The drive is suitable for use with residual current devices of Type B.

Note: As standard, the drive contains capacitors connected between the main circuit and the frame. These capacitors and long motor cables increase the ground leakage current and may cause nuisance faults in residual current devices.

Earth connection (grounding) recommendation

Ground the solar cell or if it does not have ground, connect the solar cell body to the ground. See below figure.



1	Solar cells
2	Drive cabinet
3	Drive

4	Metal Oxide Varistor (MOV)
5	Lightening pole
6	Earth pit 1
7	Earth pit 2

Implementing the emergency stop function

You can order the drive with an emergency stop function (option).

See the appropriate option manual for more information.

Implementing the Safe torque off function

See chapter The Safe torque off function (page 205).

Implementing the power loss ride-through function

If the incoming supply voltage is cut off, the drive will continue to operate by utilizing the kinetic energy of the rotating motor. The drive will be fully operational as long as the motor rotates and generates energy to the drive.

If the drive is equipped with a main contactor (option +F250), it restores the drive input power after a short break. The power supply for the contactor control circuit is buffered. It keeps the contactor closed in short power-loss situations. If the drive is equipped an external uninterruptible auxiliary power supply (option +G307), it keeps the main contactor closed in power-loss situations.

Note: If the power loss lasts so long that the drive trips on undervoltage, a fault reset and a fresh start command is required to continue operation.

Implement the power-loss ride-through function as follows:

1. Enable the power-loss ride-through function of the drive (parameter 30.31).
2. Enable the automatic restart of the motor after a short power supply break:
   - Set the start mode to automatic (parameter 21.01 or 21.19, depending on the motor control mode being used).
   - Define the automatic restart time (parameter 21.18).

WARNING!
Make sure that a flying restart of the motor will not cause any danger. If you are in doubt, do not implement the power loss ride-through function.

Using power factor compensation capacitors with the drive

Power factor compensation is not needed with AC drives. However, if a drive is to be connected in a system with compensation capacitors installed, note the following restrictions.

WARNING!
Do not connect power factor compensation capacitors or harmonic filters to the motor cables (between the drive and the motor). They are not meant to be used with AC drives and can cause permanent damage to the drive or themselves.

If there are power factor compensation capacitors in parallel with the input of the drive:

1. Do not connect a high-power capacitor to the power line while the drive is connected. The connection will cause voltage transients that may trip or even damage the drive.
2. If capacitor load is increased/decreased step by step when the AC drive is connected to the power line, make sure that the connection steps are low enough not to cause voltage transients that would trip the drive.
3. Make sure that the power factor compensation unit is suitable for use in systems with AC drives, ie, harmonic generating loads. In such systems, the compensation unit should typically be equipped with a blocking reactor or harmonic filter.

Using a safety switch between the drive and the motor

ABB recommends to install a safety switch between the permanent magnet motor and the drive output. The switch is needed to isolate the motor from the drive during maintenance work on the drive.

Implementing an ATEX-certified motor thermal protection

With option +Q971, the drive provides ATEX-certified safe motor disconnection without contactor using the drive Safe torque off function. To implement the thermal protection of a motor in explosive atmosphere (Ex motor), you must also:

- use an ATEX-certified Ex motor
- order an ATEX-certified thermistor protection module for the drive (option +L537), or acquire and install an ATEX-compliant protection relay
- do the necessary connections.

For more information, see:

User's manual	Manual code (English)
CPTC-02 ATEX-certified thermistor protection module, Ex II (2) GD (option +L537+Q971) user's manual	3AXD50000030058
CPTC-02 ATEX-certified thermistor protection module, instructions for pairing the module with an ATEX-certified drive	3AXD10001243391

Controlling a contactor between drive and motor

The control of the output contactor depends on how you use the drive, that is, which motor control mode and which motor stop mode you select.

If you have the vector control mode and motor ramp stop selected, open the contactor as follows:

1. Give a stop command to the drive.
2. Wait until the drive decelerates the motor to zero speed.
3. Open the contactor.

If you have the vector control mode and motor coast stop selected, or scalar control mode selected, open the contactor as follows:

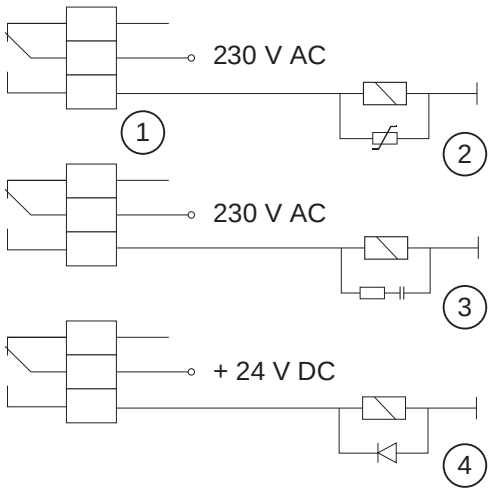
1. Give a stop command to the drive.
2. Open the contactor.

WARNING!
When the vector control mode is in use, never open the output contactor while the drive controls the motor. The vector control operates extremely fast, much faster than it takes for the contactor to open its contacts. When the contactor starts opening while the drive controls the motor, the vector control will try to maintain the load current by immediately increasing the drive output voltage to the maximum. This will damage, or even burn, the contactor completely.

Protecting the contacts of relay outputs

Inductive loads (relays, contactors, motors) cause voltage transients when switched off.

Install the protective component as close to the inductive load as possible. Do not install protective components at the relay outputs.



1	Relay output
2	Varistor
3	RC filter
4	Diode

Implementing a motor temperature sensor connection

WARNING!
IEC 61800-5-1 requires double or reinforced insulation between live parts and accessible parts when:

- the accessible parts are not conductive, or
- the accessible parts are conductive, but not connected to the protective earth.

Obey this requirement when you plan the connection of the motor temperature sensor to the drive.

You have these implementation alternatives:

1. If there is double or reinforced insulation between the sensor and the live parts of the motor: You can connect the sensor directly to the analog/digital input(s) of the drive. See the control cable connection instructions. Make sure that the voltage is not more than the maximum allowed voltage over the sensor.
2. If there is basic insulation between the sensor and the live parts of the motor, or if the insulation type is not known: You can connect a sensor to a digital input of the drive via an external relay. The sensor and the relay must form a double or reinforced insulation between the motor's live parts and the digital input of the drive. Make sure that the voltage does not exceed the maximum allowed voltage over the sensor.

Supplying power for the auxiliary circuits

The user must supply these options from external power sources:

- +G300: Cabinet heaters
- +G307: Connection for an external uninterruptible power supply
- +G313: Power supply connection for a motor space heater output

For the voltages and fuse sizes, refer to the circuit diagrams delivered with the drive.

6

Electrical installation

Contents of this chapter

This chapter gives instructions on the wiring the drive.

Warning

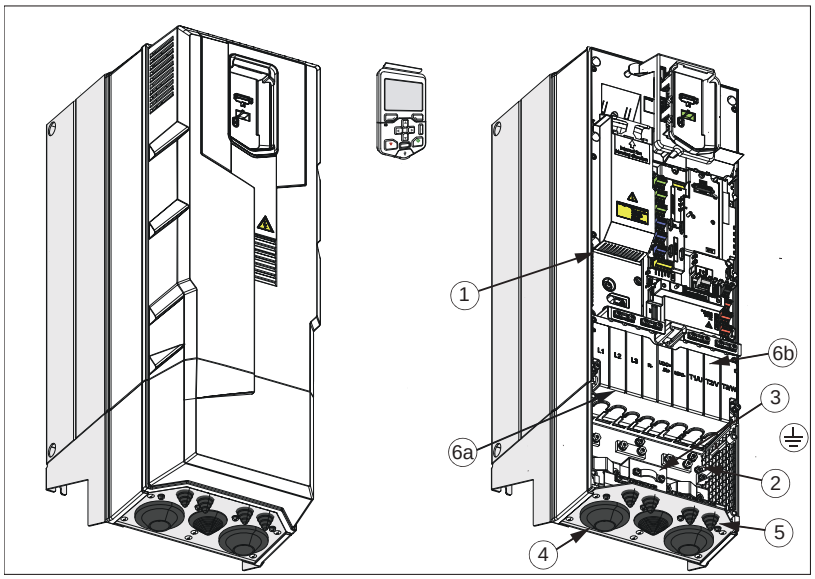
WARNING!
If you are not a qualified electrical professional, do not do installation or maintenance work. Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.

Attaching the device stickers on the cabinet door

A device sticker is delivered with the drive. Attach the stickers in the local language on the English texts, see section Door switches and lights (page 40).

Layout of the cable entries (frames R6...R9)

The layout of the input and motor cable connection terminals of frame R9 bottom entry without du/dt filter option (+E205) is shown below. The shrouds in front of the terminals are removed. The layout is similar for the other frame sizes.

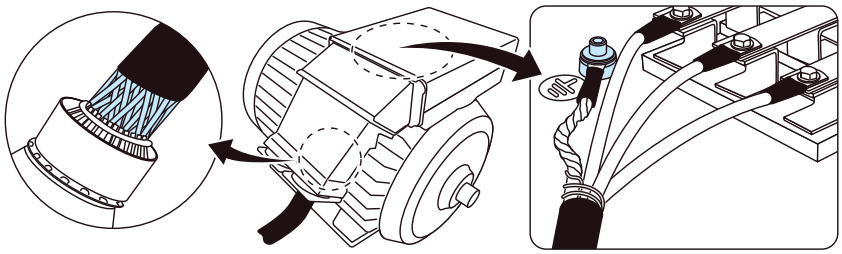


1	Strain relief
2	PE (ground) terminal
3	EMI-conductive cushion for grounding of the outer shields of the control cables
4	Power cable entry
5	Control cable entry
6a	L1, L2, L3: Input power cable terminals
6b	U2, V2, W2: Motor cable terminals

Connecting the motor cable at the motor end

Connect the power cables at the motor end.

For minimum radio-frequency interference, ground the cable shield 360° at the cable entry of the motor terminal box.



Measuring the insulation

Measuring the insulation resistance of the drive

WARNING!
Do not do voltage withstand or insulation resistance tests on the drive. The tests can cause damage to the drive. Every drive is tested for insulation between the main circuit and the chassis at the factory. Also, there are voltage-limiting circuits inside the drive which cut down the testing voltage automatically.

Measuring the insulation resistance of the input power cable

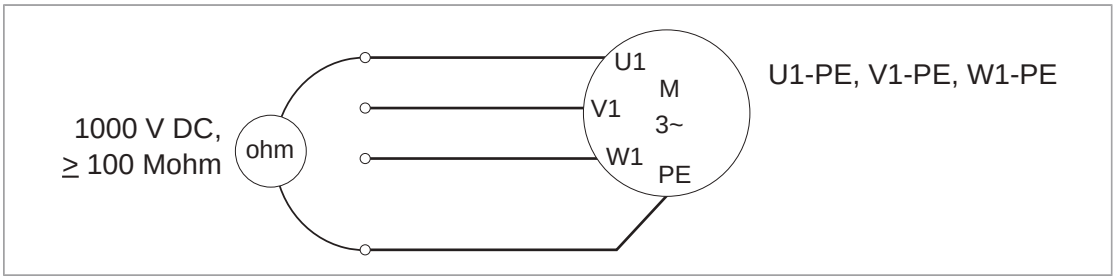
Before you connect the input power cable to the drive, measure its insulation resistance according to local regulations.

Measuring the insulation resistance of the motor and motor cable

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

1. Do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Make sure that the motor cable is disconnected from the drive output terminals.
3. Measure the insulation resistance between each phase conductor and the protective earth conductor. Use a measuring voltage of 1000 V DC. The insulation resistance of an ABB motor must be more than 100 Mohm (reference value at 25 °C [77 °F]). For the insulation resistance of other motors, refer to the manufacturer's instructions.

   Note: Moisture inside the motor reduces the insulation resistance. If you think that there is moisture in the motor, dry the motor and do the measurement again.



Grounding system compatibility check

The standard drive can be installed to a symmetrically grounded TN-S system. If you install the drive to another system, you may need to disconnect the EMC filter and ground-to-phase varistor. See sections When to disconnect the ground-to-phase varistor: TN-S, IT, corner-grounded delta and midpoint-grounded delta systems (page 223) and Disconnecting the EMC filter and ground-to-phase varistor (frames R6…R9) (page 226).

WARNING!
Do not install the drive with the EMC filter connected to a system that the filter is not suitable for. This can cause danger or damage the drive.

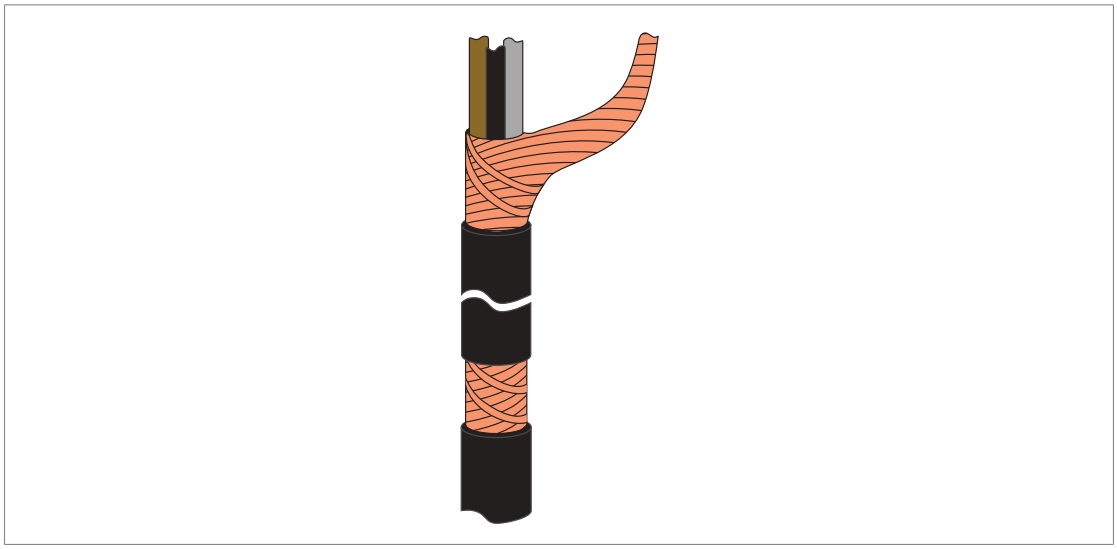
WARNING!
Do not install the drive with the ground-to-phase varistor connected to a system that the varistor is not suitable for. If you do, the varistor circuit can be damaged.

Connecting the power cables

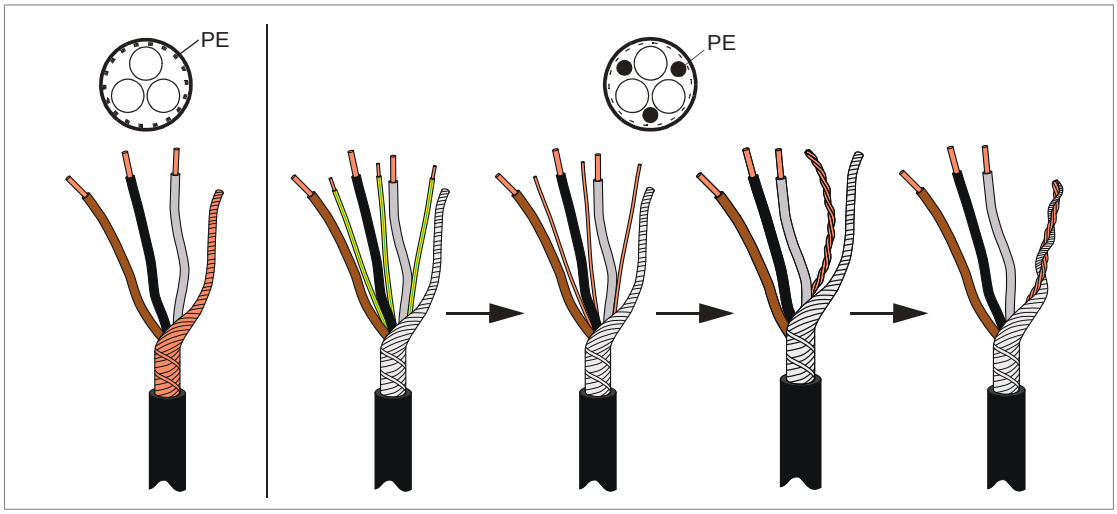
Preparing the cable ends and making 360° grounding at the cable entry

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.

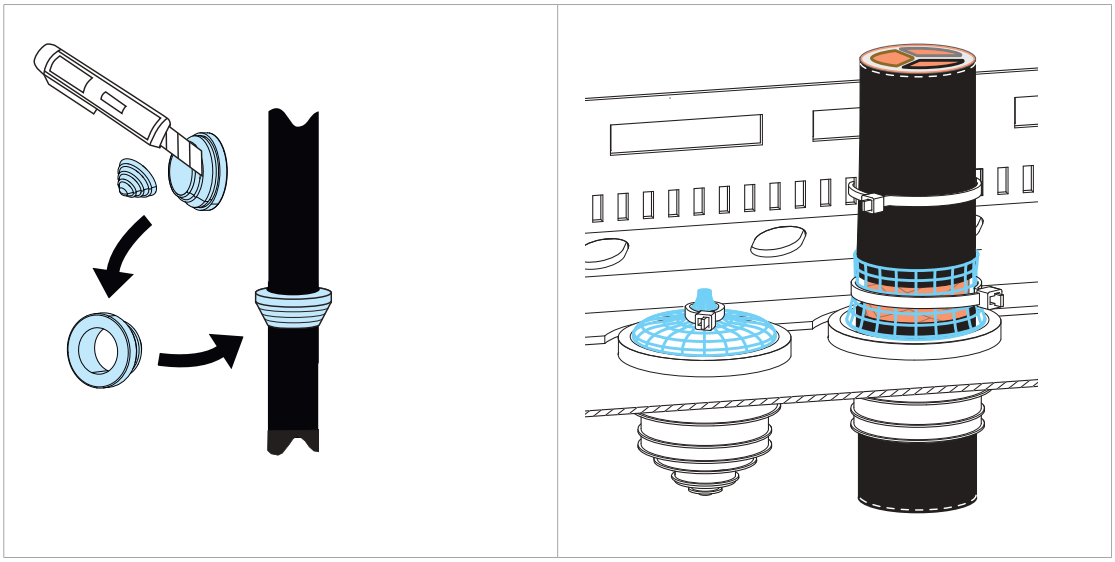
1. Do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Peel off 3…5 cm (1 1/4 … 2 in) of the outer insulation of the cables at the cable entries with the conductive sleeves for the 360° high-frequency grounding.



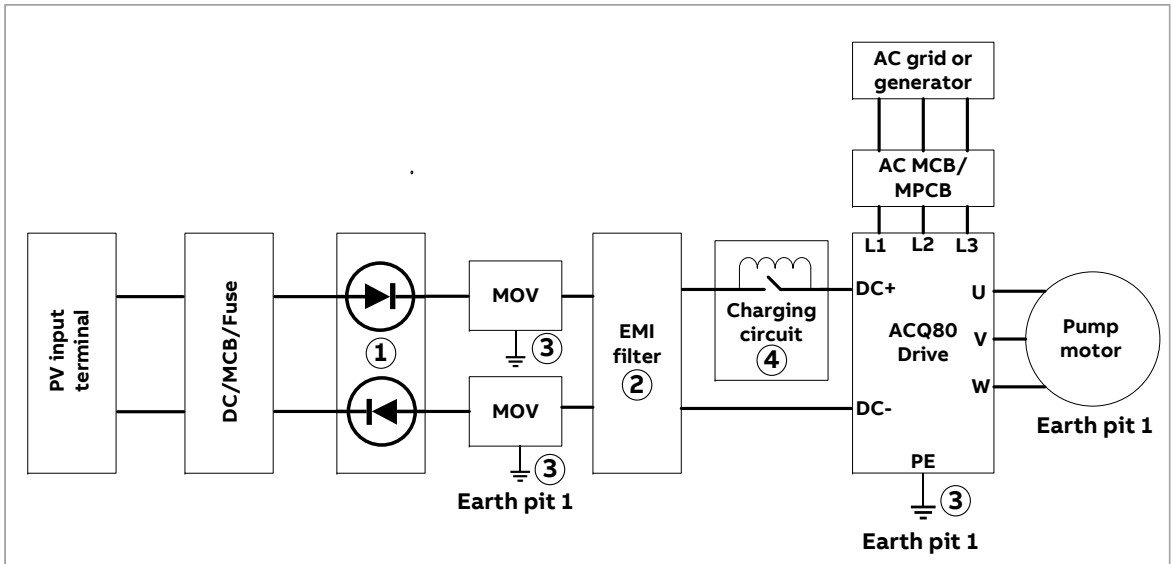
3. Prepare the ends of the cables.



4. Put the cables through the entry plate. If the entry holes have rubber grommets, use one grommet for each cable. Cut adequate hole into the grommet and put the cable through the grommet inside the cabinet.
5. Attach the conductive sleeves to the cable shields with cable ties. Tie up the unused conductive sleeves with cable ties. An example of bottom entry is shown below. For top entry, put the grommet upwards.



Connection diagram



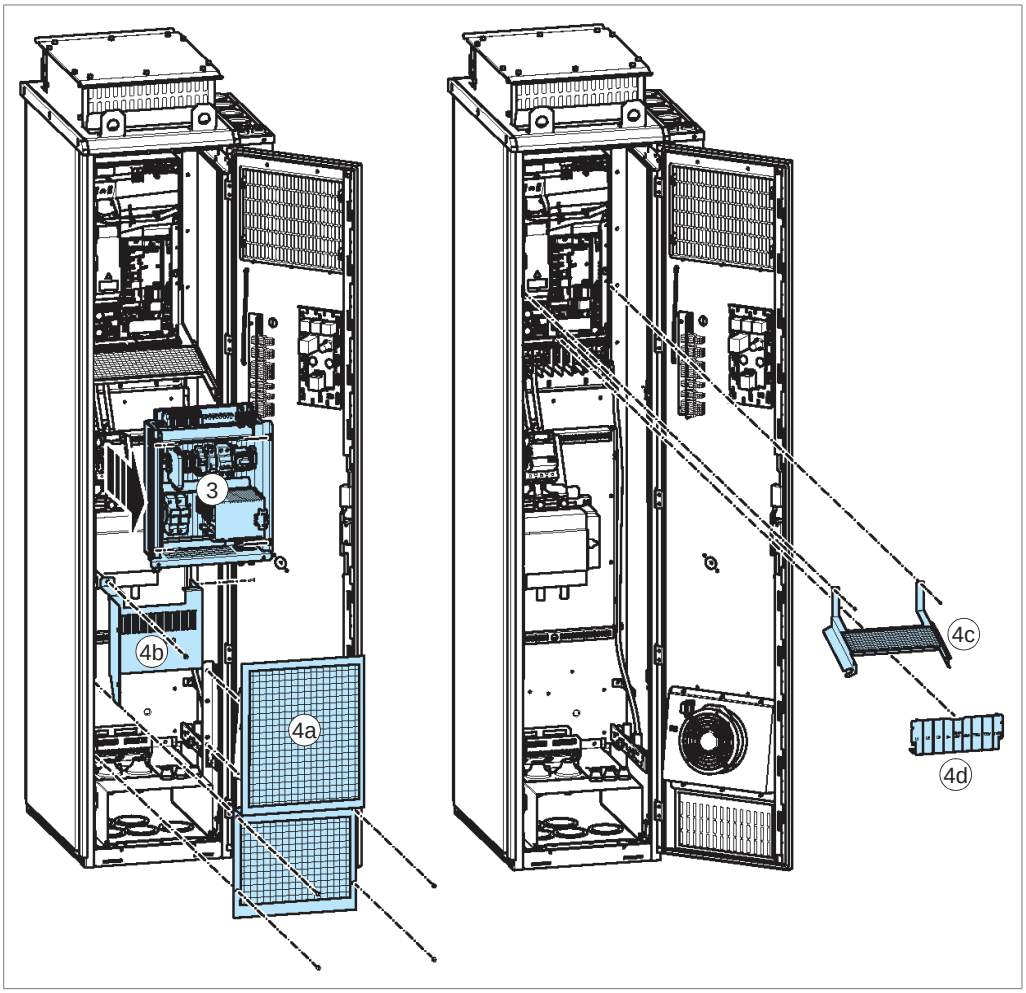
1	Reverse polarity diodes.
2	EMI filter is optional but is mandatory for EN62920 standard compliance which is required in Europe.
3	Ground connection should be common for MOV, drive, and pump.
4	Initially the charging happens through the resistance and once predefine voltage charging is completed then the contactor will be closed.

Note: ACQ80 is intended to be used for speed control of 3-phase AC pump motors and is powered from either AC Grid or DC photo-voltaic array. ABB recommends not to use it as an island grid forming inverter or to supply generic single phase or 3-phase loads, other than 3-phase AC pump motors.

Connection procedure (frames R6...R9)

This section applies to drives with bottom entry and exit of power cables.

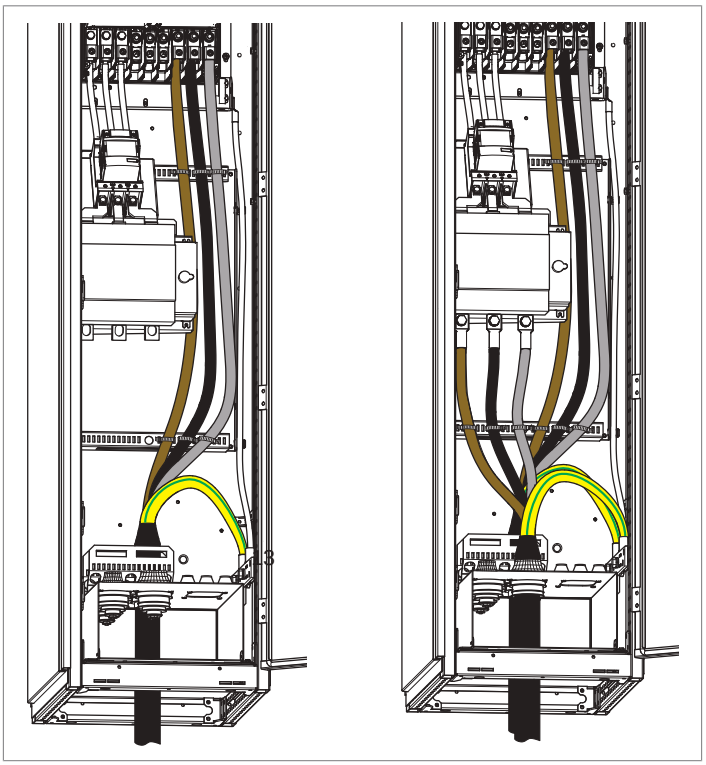
1. Do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. For drives without option +E205: To remove the mounting plate, undo the mounting screws and unplug the connectors on top of it:
   - auxiliary voltage supply connectors X23, X22 and X21
   - contactor control connectors: X3, X6
   - contactor feedback connector X250 with option +F250
   - cabinet door fan supply connector X8 and control X505
   - cabinet heater connector X300 with option +G300.
4. For drives without option +E205: Remove the shrouds (4a, 4b, 4c and 4d). To remove the shroud on the power cable terminals, release the clips with a screwdriver and pull the shroud out (4d). For drives with option +E205: Remove the shrouds 4a, 4b.



5. For drives without option +E205: Knock out holes in the shroud for the motor cable conductors.
6. Connect the twisted shields of the motor cables to the ground bar and the phase conductors to the U2, V2 and W2 terminals of the drive module. For drives with

du/dt filter (option +E205), connect the phase conductors to the T1/U2, T2/V2 and T3/W2 terminals of the cabinet with cable lugs.

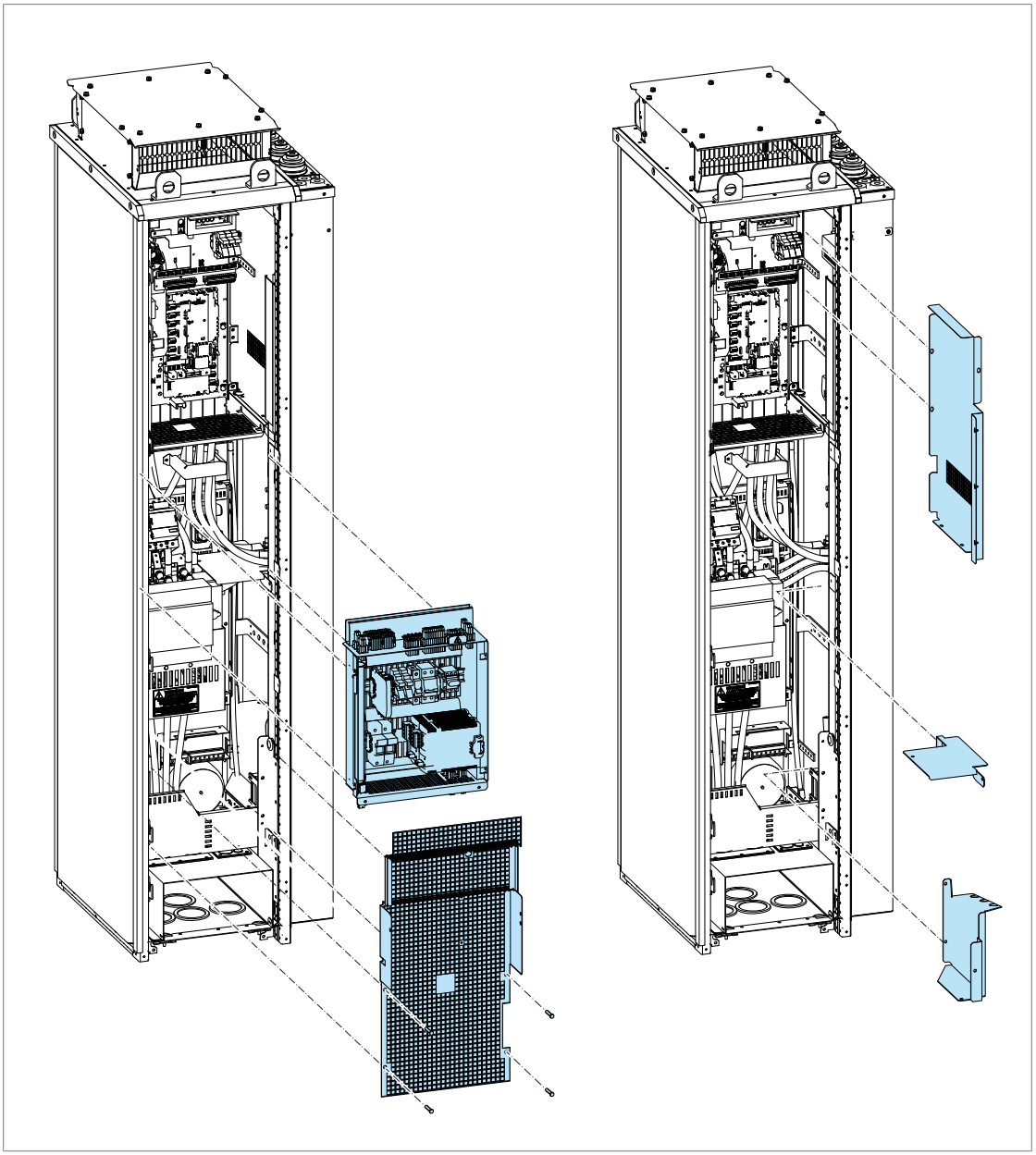
7. Connect the twisted shields of the input cables and separate ground cable (if present) to the PE terminal of the cabinet and the phase conductors to the L1, L2 and L3 terminals.



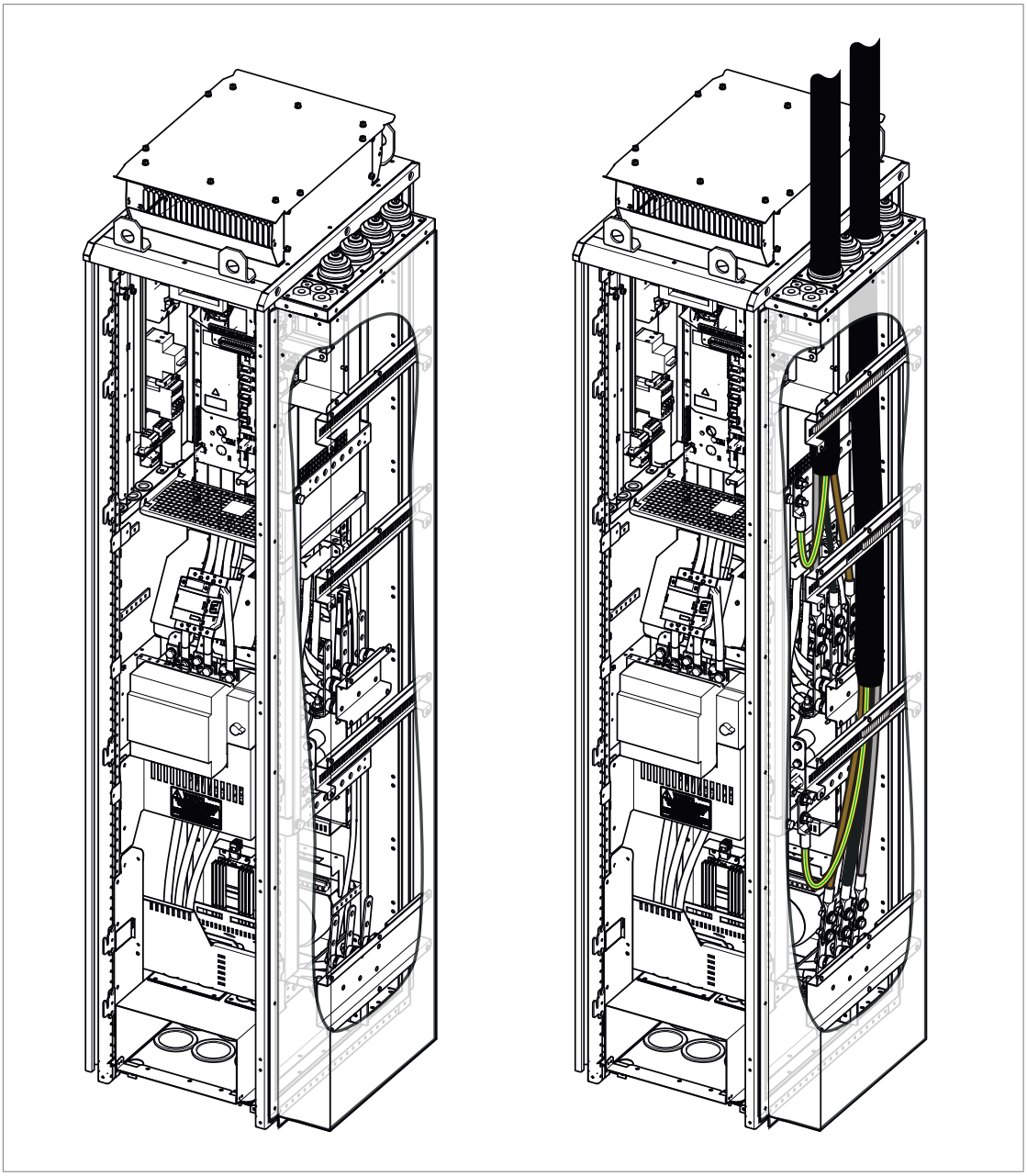
8. Tighten the power cable screws to the torque given in Terminal and entry data for the power cables (page 168).
9. Reinstall the shrouds and mounting plate.

Connection procedure (frames R6 and R7 with options +H351 and +H353)

1. Do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Remove the shrouds.



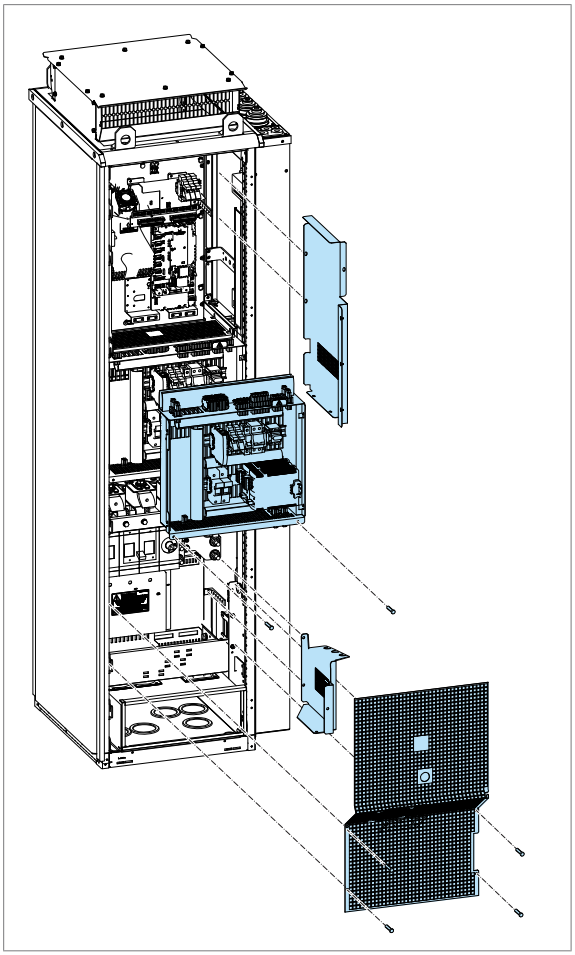
4. Connect the twisted shields of the motor cables to the ground bar and the phase conductors to the U2, V2 and W2 terminals of the drive module.
5. Connect the twisted shields of the input cables and separate ground cable (if present) to the PE terminal of the cabinet and the phase conductors to the L1, L2 and L3 terminals.



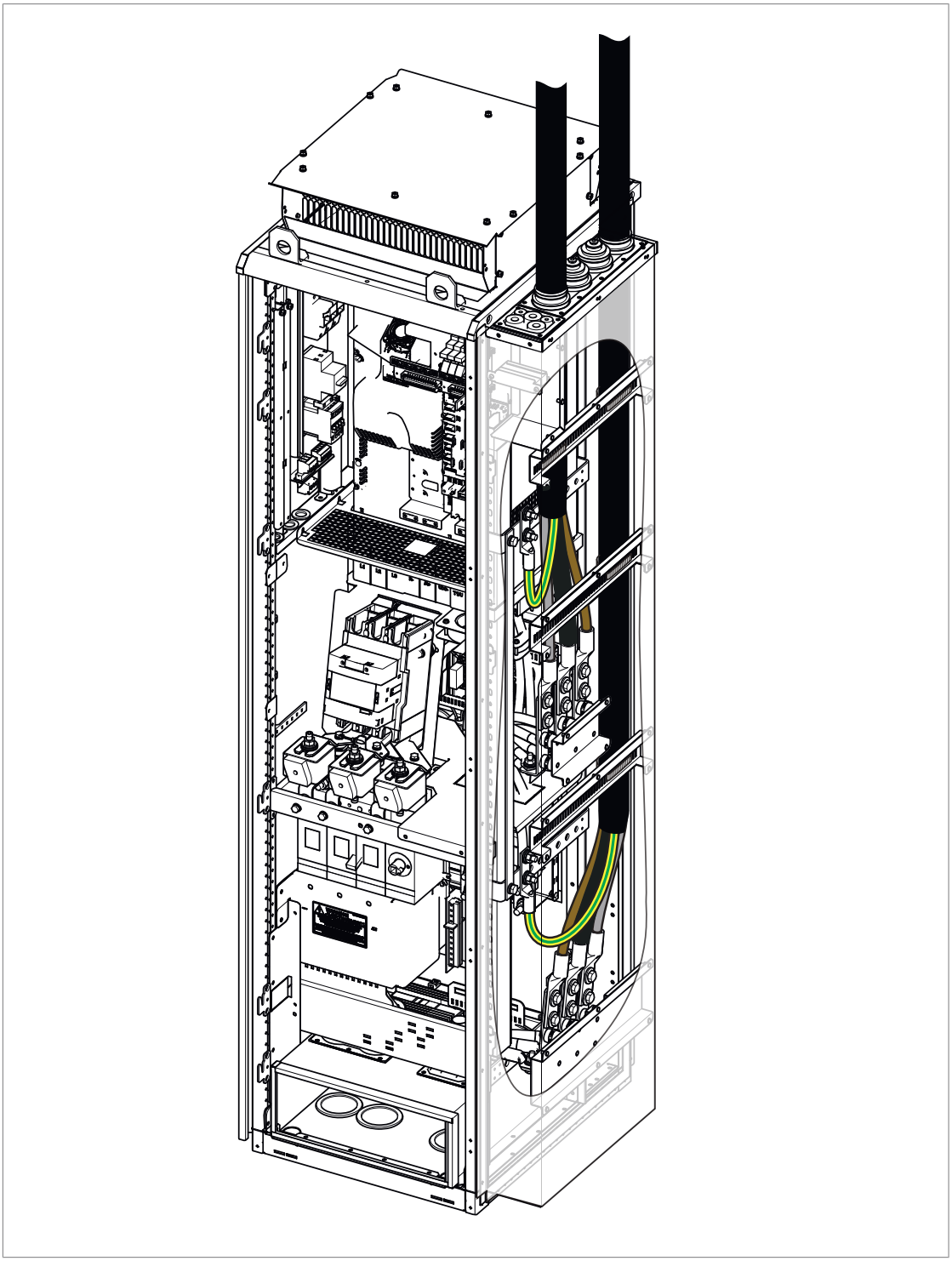
6. Tighten the power cable screws to the torque given in Terminal and entry data for the power cables (page 168).
7. Reinstall the shrouds and mounting plate.

Connection procedure (frames R8 and R9 with options +H351 and +H353)

1. Do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Remove the shrouds.



4. Connect the twisted shields of the motor cables to the ground bar and the phase conductors to the U2, V2 and W2 terminals of the drive module.
5. Connect the twisted shields of the input cables and separate ground cable (if present) to the PE terminal of the cabinet and the phase conductors to the L1, L2 and L3 terminals.



6. Tighten the power cable screws to the torque given in Terminal and entry data for the power cables (page 168).
7. Reinstall the shrouds and mounting plate.

Connecting the control cables

See chapter Control unit (page 115) for the default I/O connections of the drive control program. The default I/O connections can be different with some hardware options, see the circuit diagrams delivered with the drive for the actual wiring.

Connect the cables as described under Overview of control cable connection procedure (page 103).

Overview of control cable connection procedure

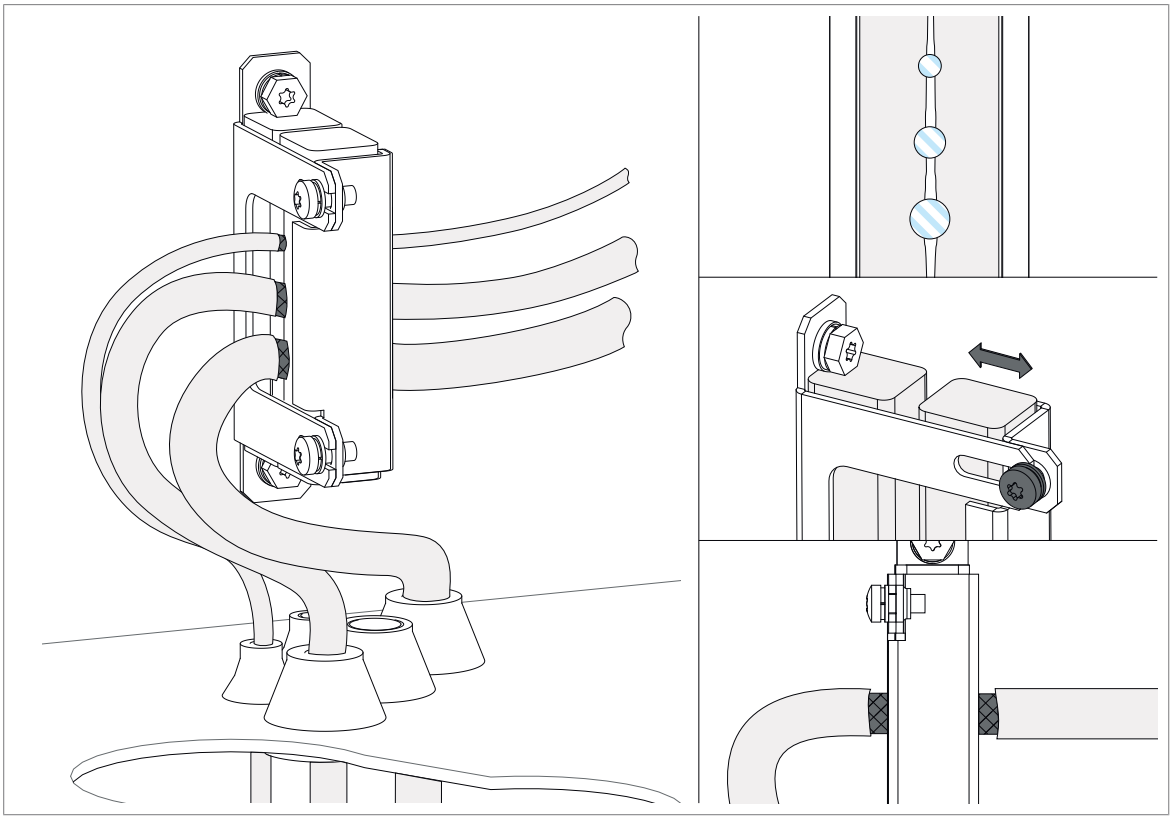
WARNING!
Obey the instructions in chapter Safety instructions. If you ignore them, injury or death, or damage to the equipment can occur.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Run the control cables to the inside the cabinet as described in section Grounding the outer shields of the control cables 360° at the cabinet entry (page 103).
3. Route the control cables as described in section Routing the control cables inside the cabinet (page 105).
4. Connect the control cables as described in sections
   - Connecting external wiring to the control unit or optional I/O terminal block (page 107)
   - Connecting the emergency stop push buttons (options +Q951 and +Q963) (page 108)
   - Connecting the Safe torque off circuit (page 109)
   - Connecting external power supply wires for the cabinet heater (option +G300) (page 109).

Grounding the outer shields of the control cables 360° at the cabinet entry

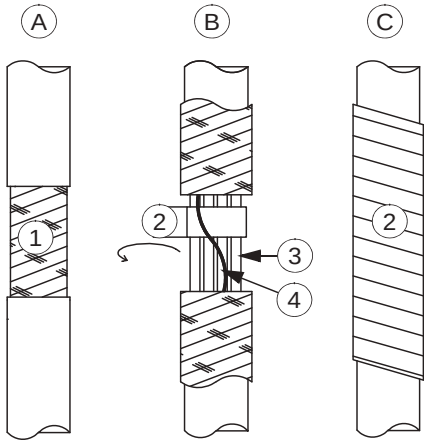
Ground the outer shields of all control cables 360° with the EMI conductive cushions at the cabinet entry. The grounding principle is the same for top and bottom entry cables. The illustrations show the bottom entry. The actual design details can vary.

1. If necessary, remove the shrouding in front of the cable entry.
2. Put the cables in sequence from the smallest to the largest. This will help to achieve a good contact with the cushions.
3. Loosen the tightening bolts of the EMI conductive cushions and pull them apart.
4. Cut holes in the grommets and put the cables through the grommets.
5. Peel the insulation from the part of the cable that will be in contact with the EMI conductive cushion.
6. Put the cables between the cushions.
7. Move the cushions back together.
8. Tighten the bolts to make sure that the EMI conductive cushions press tightly around the peeled part of the cables.



If the outer surface of the shield is non-conductive:

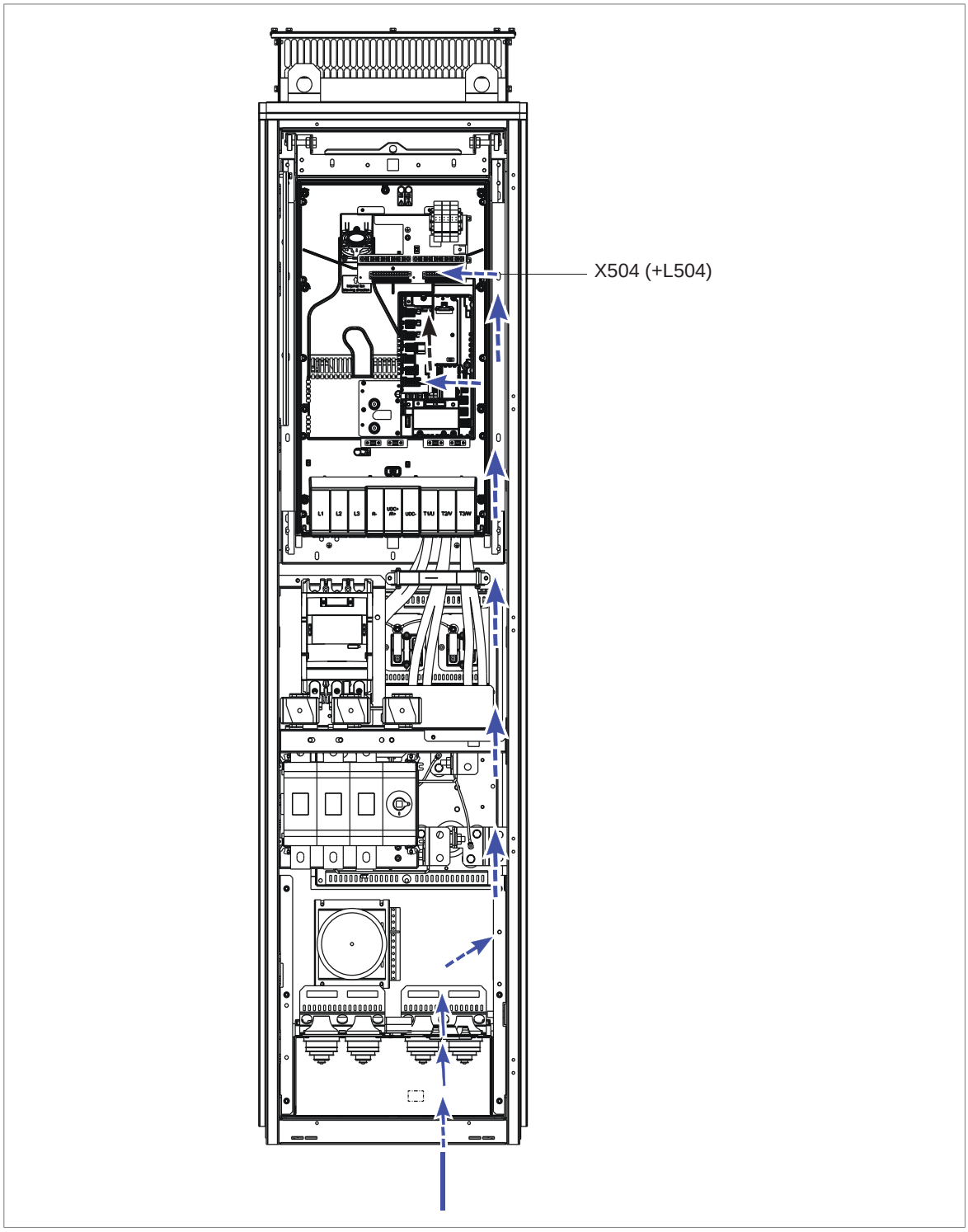
- Cut the shield at the midpoint of the peeled part. Be careful not to cut the conductors or the grounding wire.
- Turn the conductive side of the shield inside out over the insulation.
- Cover the exposed shield and the peeled cable with copper foil to keep the shielding continuous.

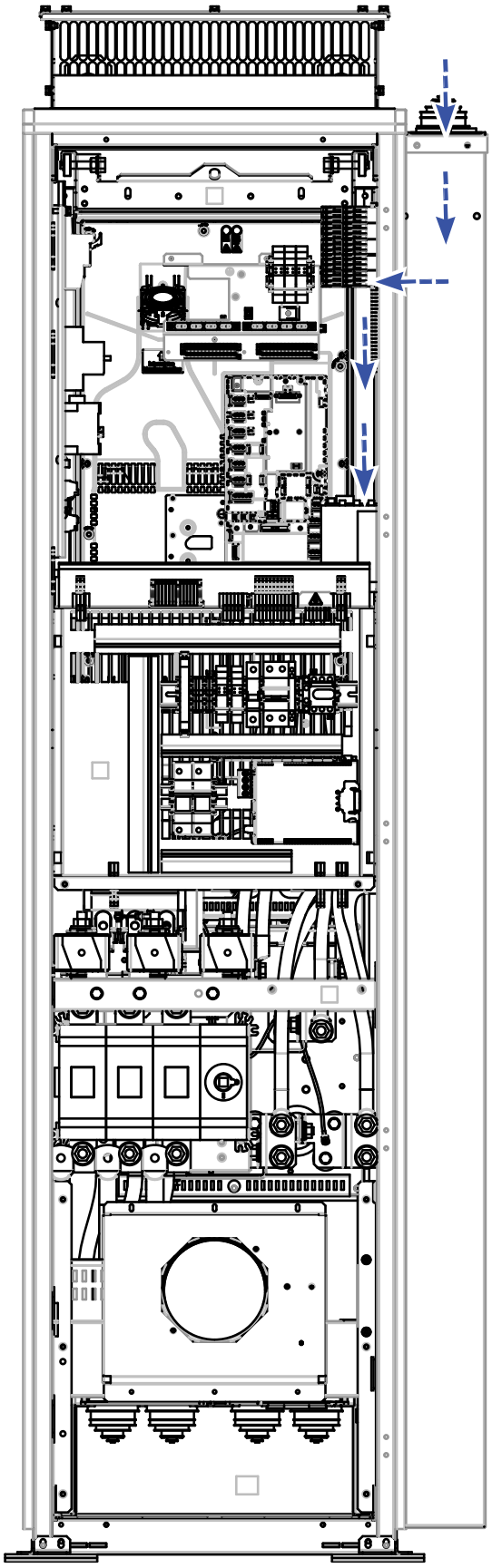


A	Stripped cable
B	Conductive surface of the shield exposed
C	Stripped part covered with copper foil
1	Cable shield
2	Copper foil
3	Shielded twisted pair
4	Grounding wire

Routing the control cables inside the cabinet

The route of the control cables is shown below in frame R9. The route is similar for frames R6, R7 and R8.



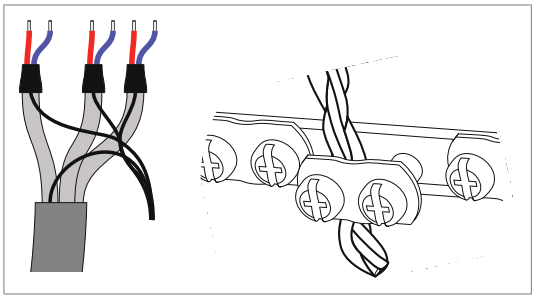


Connecting external wiring to the control unit or optional I/O terminal block

Note: Keep any signal wire pairs twisted as close to the terminals as possible. Twisting the wire with its return wire reduces disturbances caused by inductive coupling.

Note: Leave slack to the control wires to make it possible to lift the control unit mounting plate a little when the drive module is replaced.

Ground the pair-cable shields and all grounding wires to the grounding clamp.



Leave the other ends of the control cable shields unconnected or ground them indirectly via a high-frequency capacitor with a few nanofarads, eg, 3.3 nF / 630 V. The shield can also be grounded directly at both ends if they are in the same ground line with no significant voltage drop between the end points.

Connect the conductors to the appropriate terminals (see Default I/O connection diagram (page 117)) of the control unit or with option +L504 to the detachable terminal block X504.

Connecting for wired remote monitoring (option +K496)

This option provides a gateway to connect the drive to ABB Ability™ via a local Ethernet network. Includes NETA-21 remote monitoring tool and FMBT-21 Modbus/TCP adapter module.

The NETA and FMBT-21 are installed at the factory and wired internally. An Ethernet cable for customer connection is routed from the NETA to the external control connections mounting plate (number 6 in the layout drawing for frames R6...R9). Use an RJ45 coupler (not included) to connect your Ethernet cable to the additional Ethernet cable.

See the appropriate manual for more information.

Manual	Code (English)
NETA-21 remote monitoring tool user's manual	3AUA0000096939
NETA-21 remote monitoring tool installation and start-up guide	3AUA0000096881
FMBT-21 Modbus/TCP adapter module user's manual	3AXD50000158607
FMBT-21 Modbus/TCP adapter module quick installation and start-up guide	3AXD50000158560

Connecting for wireless remote monitoring (option +K497)

This option provides a gateway to connect the drive to ABB Ability™ via a wireless 4G network. Includes NETA-21 remote monitoring tool, FMBT-21 Modbus/TCP adapter module and modem.

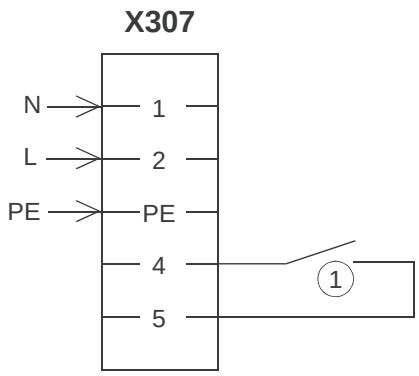
The NETA and FMBT-21 are installed at the factory and wired internally. An Ethernet cable for customer connection is routed from the NETA to the external control connections mounting plate (number 6 in the layout drawing for frames R6...R9, number 12 for frames R10 and R11). Use an RJ45 coupler (not included) to connect your Ethernet cable to the additional Ethernet cable.

See the appropriate manual for more information.

Manual	Code (English)
NETA-21 remote monitoring tool user's manual	3AUA0000096939
NETA-21 remote monitoring tool installation and start-up guide	3AUA0000096881
FMBT-21 Modbus/TCP adapter module user's manual	3AXD50000158607
FMBT-21 Modbus/TCP adapter module quick installation and start-up guide	3AXD50000158560

Connecting a 230/115 V AC auxiliary voltage supply (UPS, option +G307)

Wire the external control voltage to terminal block X307 as shown below.

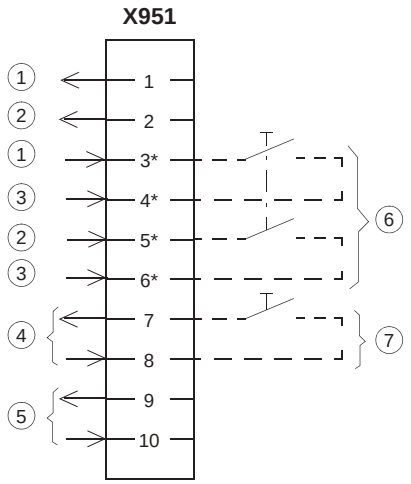


1 Internal wiring of UPS supervision: circuit breaker or fuse off/fault = contact open.

Connecting the emergency stop push buttons (options +Q951 and +Q963)

See the circuit diagrams delivered with the drive for connecting the emergency stop circuit and the user manuals of the options.

Frames R6...R9



Internal connections	
1	Emergency stop push button on the cabinet door
2	Emergency stop push button on the cabinet door
3	Emergency stop circuit
4	Emergency stop reset button on the cabinet door
5	Emergency stop indication on the cabinet door
Customer connections	
6	Customer external emergency stop button
7	Customer external emergency stop reset
*	Remove bridges 3–4 and 5–6 if there is an external emergency stop button. The bridge connections are installed only if the cabinet door push button is in use.

Wiring the starter for auxiliary motor fan (options +M601...M605)

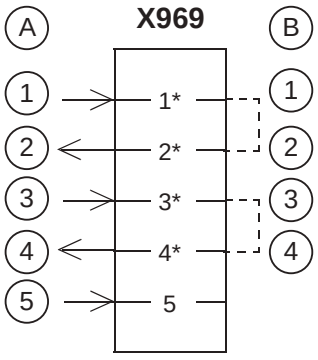
Connect the power supply wires for the auxiliary motor fan to terminal block X601 according to the circuit diagrams delivered with the drive.

Connecting the Safe torque off circuit

Connect the customer Safe torque off circuit as described in chapter The Safe torque off function.

For drives with options +Q951, +Q963 and +Q971, connect the Safe torque off circuit to terminal block X969 – not to the control unit STO terminals.:

A	Internal connections
1	STO OUT1
2	STO IN1
3	STO IN2
4	STO OUT2
5	STO INTERNAL



B	Customer connections
1	STO OUT1
2	STO IN1
3	STO IN2
4	STO OUT2

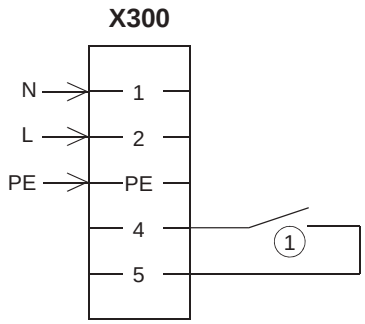
* Remove bridges 1-2 and 3-4 if there is an external Safe torque off function.

Connecting external power supply wires for the cabinet heater (option +G300)

See the circuit diagrams delivered with drive.

Connect the external power supply wires for the cabinet heater to terminal block X300 at the back of the mounting plate.

Frames R6...R9

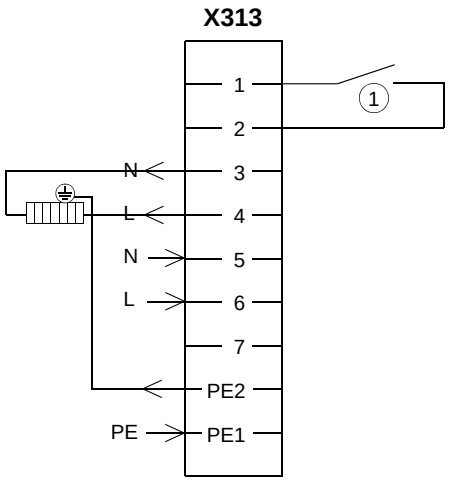


1 Internal wiring of the cabinet heater: heater off/fault = contact open.

Connecting external power supply wires for the motor space heater (option +G313)

See the circuit diagrams delivered with drive.

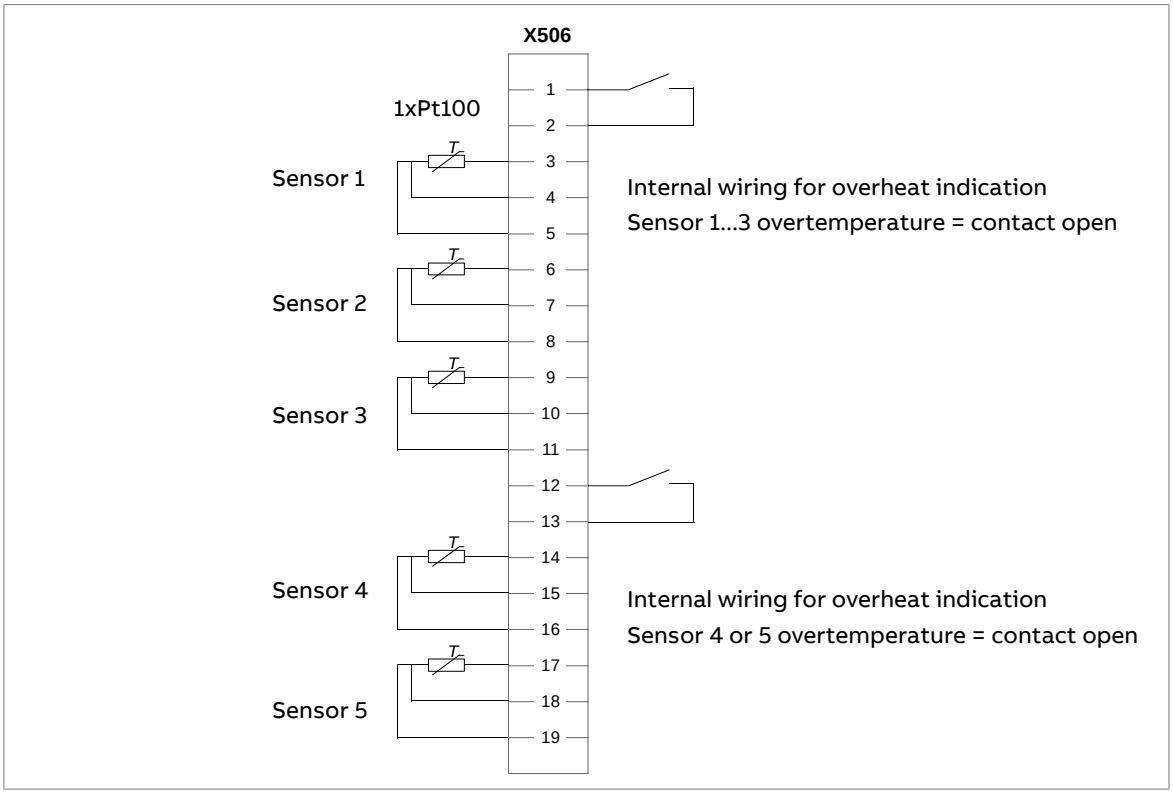
Connect the motor heater wiring to terminal block X313 as shown below. Maximum external power supply 16 A.



1 Internal wiring of the motor space heater supervision: heater off/fault = contact open.

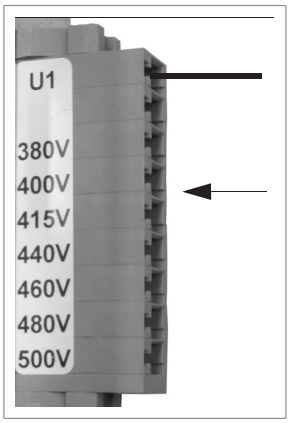
Wiring the Pt100 relays (option +nL506)

External wiring of sensor modules is shown below. Contact load capacity 250 V AC 10 A. For the actual wiring, see the circuit diagram delivered with the drive.



Setting the voltage range of the auxiliary control voltage transformer (T21)

Connect the power supply wires of the auxiliary control voltage transformer according to the power network voltage.

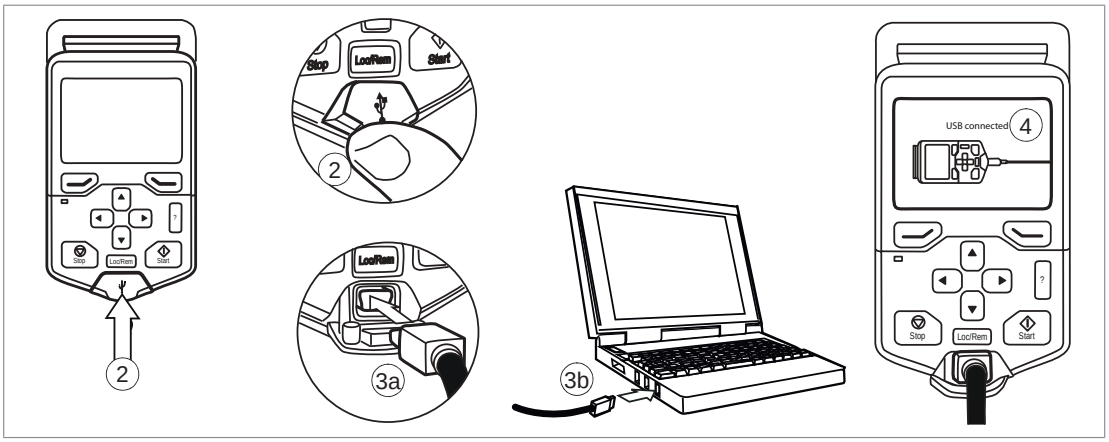


Connecting a PC

WARNING!
Do not connect the PC directly to the control panel connector of the control unit. It can cause damage.

A PC (with, for example, the Drive Composer PC tool) can be connected as follows:

1. To connect a control panel to the unit, either
   - insert the control panel into the panel holder or platform, or
   - use an Ethernet (eg, Cat 5e) networking cable.
2. Remove the USB connector cover on the front of the control panel.
3. Connect an USB cable (Type A to Type Mini-B) between the USB connector on the control panel (3a) and a free USB port on the PC (3b).
4. The panel will display an indication whenever the connection is active.
5. See the documentation of the PC tool for setup instructions.



Installing option modules

Option slot 1 (fieldbus adapter modules)

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

WARNING!
Use ESD wristband when you handle printed circuit boards. Do not touch the boards unnecessarily. The boards are sensitive to electrostatic discharge.

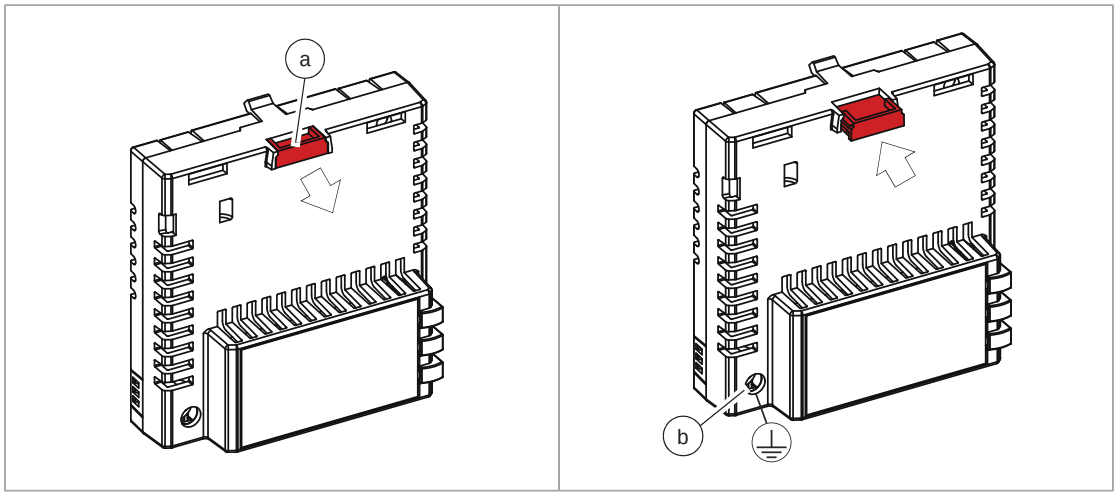
Pay attention to the free space required by the cabling or terminals coming to the option modules.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Pull out the lock (a) with a screw driver.

   Note: The location of the lock depends on the module type.
3. Install the module to a free option module slot on the control unit.
4. Push in the lock (a).
5. Tighten the grounding screw (b) to a torque of 0.8 N·m (7 lbf·in).

   Note: The screw tightens the connections and grounds the module. It is essential for fulfilling the EMC requirements and for proper operation of the module.

   WARNING!
   Do not use excessive force, or leave the screw too loose. Over-tightening can cause damage to the screw or module. A loose screw can cause an operation failure.



6. Connect the wiring to the module. Obey the instructions given in the documentation of the module.

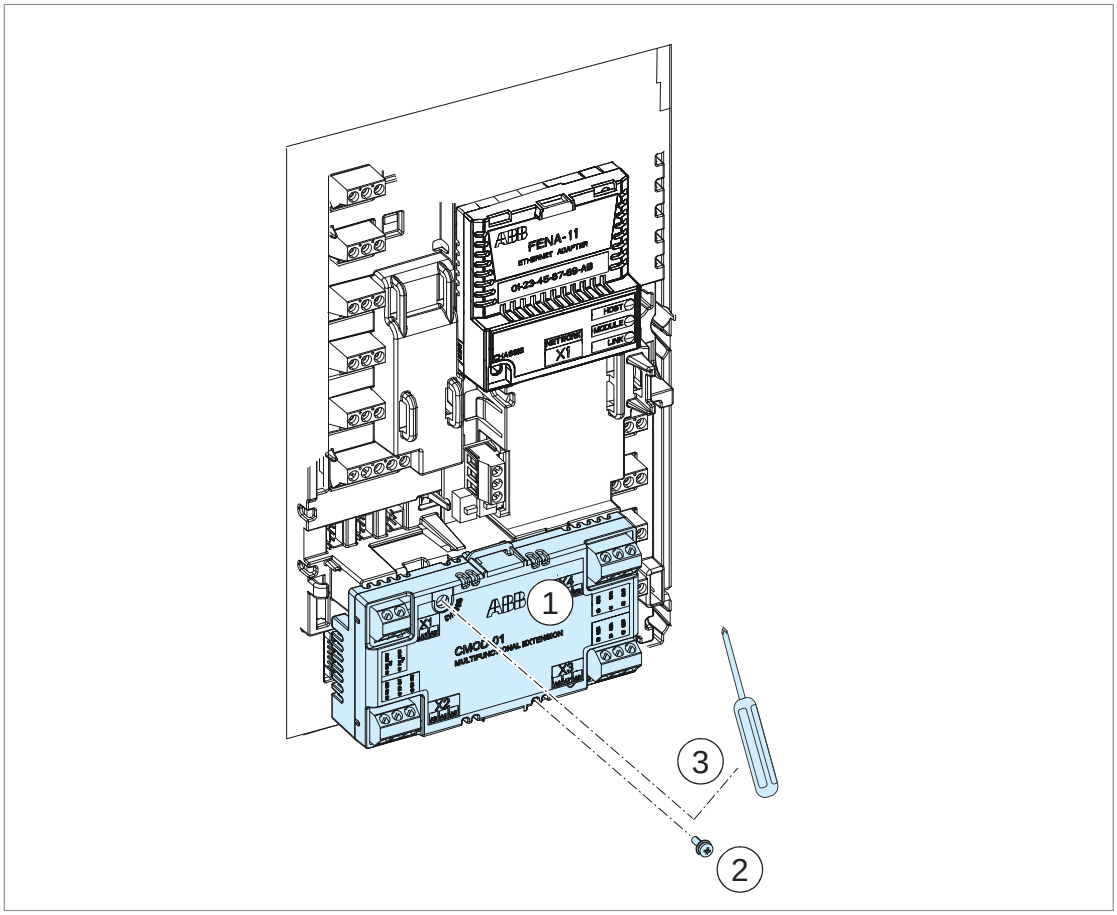
If you must remove the option module after it is installed into the drive, use a suitable tool (for example, small pliers) to carefully pull out the lock.

Option slot 2 (I/O extension modules)

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

WARNING!
Use ESD wristband when you handle printed circuit boards. Do not touch the boards unnecessarily. The boards are sensitive to electrostatic discharge.

1. Put the module carefully into its position on the control unit.
2. Tighten the mounting screw.
3. Tighten the grounding screw (CHASSIS) to 0.8 N·m (7 lbf·in). The screw grounds the module. This is necessary for fulfilling the EMC requirements and for correct operation of the module.



Wiring the optional modules

See the appropriate option module manual or for I/O options the appropriate chapter in this manual.

7

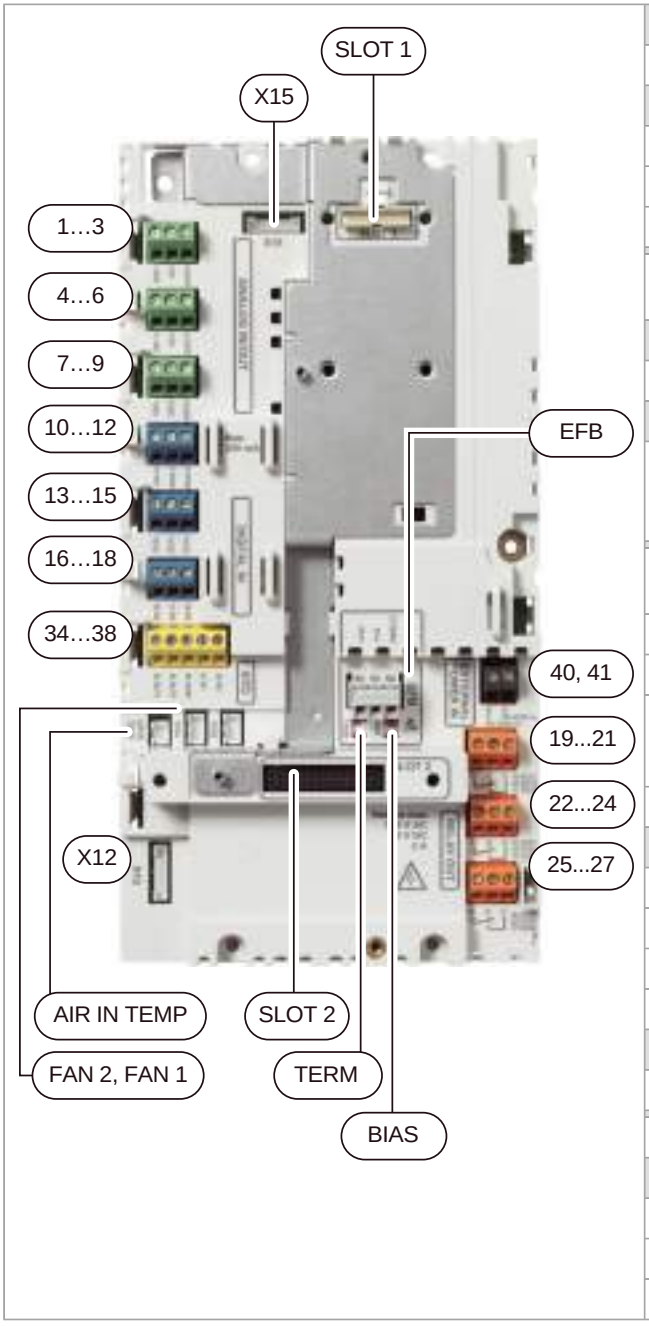
Control unit

Contents of this chapter

This chapter contains the default I/O connection diagram, descriptions of the terminals and technical data for the drive control unit (CCU-24).

Layout

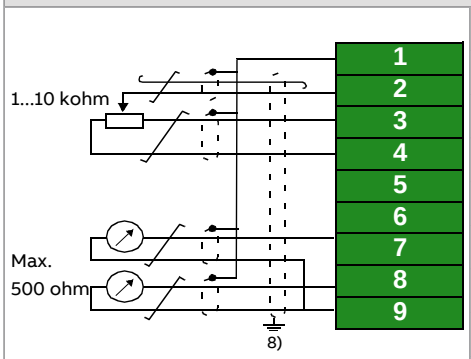
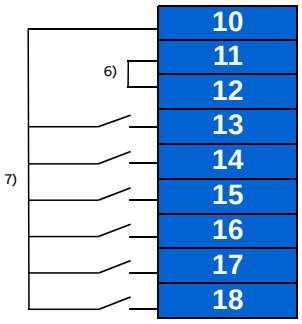
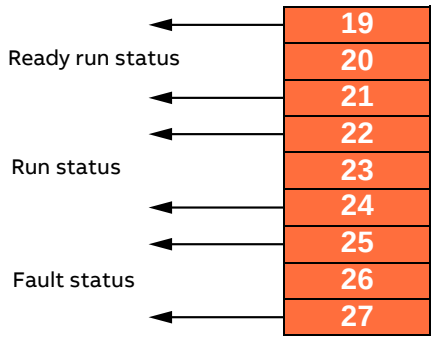
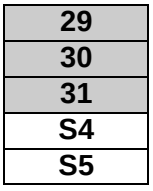
The layout of the external control connection terminals on the drive module control unit is shown below.

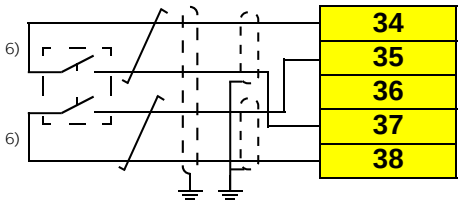


SLOT 1	
Option slot 1 (fieldbus adapter modules)	
ANALOG IN/OUT	
1…3	Analog input 1
4…6	Analog input 2
7…9	Analog outputs
10…12	Auxiliary voltage output, digital input common
DIGITAL IN	
13…18	Digital inputs
STO	
34…38	Safe torque off connection. Reserved for internal use with options +Q951, +Q963 and +Q971.
AIR IN TEMP	Internal air temperature NTC sensor connection
FAN2	Internal fan 2 connection
FAN1	Internal fan 1 connection
X12	Panel port (control panel connection, wired at the factory to the control panel)
X15	Reserved to internal use.
EFB	
EIA/RS-485 fieldbus connector	
BIAS	Bias resistor switch
TERM	End termination switch
29…31	Connection terminals
SLOT 2	
Option slot 2 (I/O extension modules)	
40, 41	24 V AC/DC external power input
RO1 … RO3	
19…21	Relay output 1 (RO1)
22…24	Relay output 2 (RO2)
25…27	Relay output 3 (RO3)

Default I/O connection diagram

The default I/O connections of the ABB Standard macro are shown below.

Connection	Term	Description
X1 Reference voltage and analog inputs and outputs		
		
1	SCR	Signal cable shield (screen)
2	AI1	**Output frequency reference:** 0…10 V [1) 3)]
3	AGND	Analog input circuit common
4	+10V	Reference voltage 10 V DC
5	AI2	Not configured
6	AGND	Analog input circuit common
7	AO1	**Output frequency:** 0…20 mA
8	AO2	**Motor current:** 0…20 mA
9	AGND	Analog output circuit common
X2 & X3 Aux. voltage output and programmable digital inputs		
		
10	+24V	Aux. voltage output +24 V DC, max. 250 mA [2)]
11	DGND	Aux. voltage output common
12	DCOM	Digital input common for all
13	DI1	**Stop (0) / Start (1)**
14	DI2	**Forward (0) / Reverse (1)**
15	DI3	**Constant frequency selection** [4)]
16	DI4	**Constant frequency selection** [4)]
17	DI5	**Ramp set 1 (0) / Ramp set 2 (1)** [5)]
18	DI6	Not configured
X6, X7, X8 Relay outputs		
		
19	RO1C	**Ready run** 250 V AC / 30 V DC 2 A
20	RO1A	
21	RO1B	
22	RO2C	**Running** 250 V AC / 30 V DC 2 A
23	RO2A	
24	RO2B	
25	RO3C	**Fault (-1)** 250 V AC / 30 V DC 2 A
26	RO3A	
27	RO3B	
X5 EIA-485 Modbus RTU		
		
29	B+	Embedded Modbus RTU (EIA-485)
30	A-	
31	DGND	
S4	TERM	Serial data link termination switch
S5	BIAS	Serial data link bias resistors switch
X4 Safe Torque Off		

Connection		Term	Description
	34	OUT1	Safe torque off. Factory connection. Both circuits must be closed for the drive to start.Refer to The Safe torque off function (page 205).
	35	OUT2	
	36	SGND	
	37	IN1	
	38	IN2	
X10 24 V AC/DC			
	40	24 V AC/DC+ in	External 24 V AC/DC input to power up the control unit when the main supply is disconnected. 9)
	41	24 V AC/DC- in	

Total load capacity of the Auxiliary voltage output +24V (X2:10) is 6.0 W (250 mA / 24 V DC).

Digital inputs DI1…DI5 also support 10…24 V AC.

Terminal sizes (all terminals): 0.14 … 2.5 mm^2 (26…14 AWG)

Tightening torques: 0.5 … 0.6 N·m (4.4 … 5.3 lbf·in)

Wire strip length 7…8 mm (0.3 in)

Notes:

1) Current [0(4)…20 mA, R_{in} = 100 ohm] or voltage [0(2)…10 V, R_{in} >200 kohm]. Change of setting requires changing the corresponding parameter.

2) Total load capacity of the Auxiliary voltage output +24V (X2:10) is 6.0 W (250 mA / 24 V) minus the power taken by the option modules installed on the board.

3) AI1 is used as a speed reference if vector control is selected.

4) In scalar control (default): See **Menu > Primary settings > Start, stop, reference > Constant frequencies** or parameter group 28 Frequency reference chain.
In vector control: See **Menu > Primary settings > Start, stop, reference > Constant speeds** or parameter group 22 Speed reference selection

DI3	DI4	Operation/Parameter	
		Scalar control (default)	**Vector control**
0	0	Set frequency through AI1	Set speed through AI1
1	0	28.26 Constant frequency 1	22.26 Constant speed 1
0	1	28.27 Constant frequency 2	22.27 Constant speed 2
1	1	28.28 Constant frequency 3	22.28 Constant speed 3

5) In scalar control (default): See **Menu - Primary settings - Ramps** or parameter group 28 Frequency reference chain.
In vector control: See **Menu - Primary settings - Ramps** or parameter group 23 Speed reference ramp.

DI5	Ramp set	Parameters	
		Scalar control (default)	**Vector control**
0	1	28.72 Freq acceleration time 1 28.73 Freq deceleration time 1	23.12 Acceleration time 1 23.13 Deceleration time 1
1	2	28.74 Freq acceleration time 2 28.75 Freq deceleration time 2	23.14 Acceleration time 2 23.15 Deceleration time 2

6) Connected with jumpers at the factory.

7) Use shielded twisted-pair cables for digital signals.

8) Ground the outer shield of the cables 360° at the cabinet entry.

9) **WARNING!** Connect an external AC power supply (24 V AC) only to control unit connectors 40 and 41. If you connect it to connector AGND, DGND or SGND, damage to the power supply or control unit can occur.

Additional information on the control connections

Embedded EIA-485 fieldbus connection

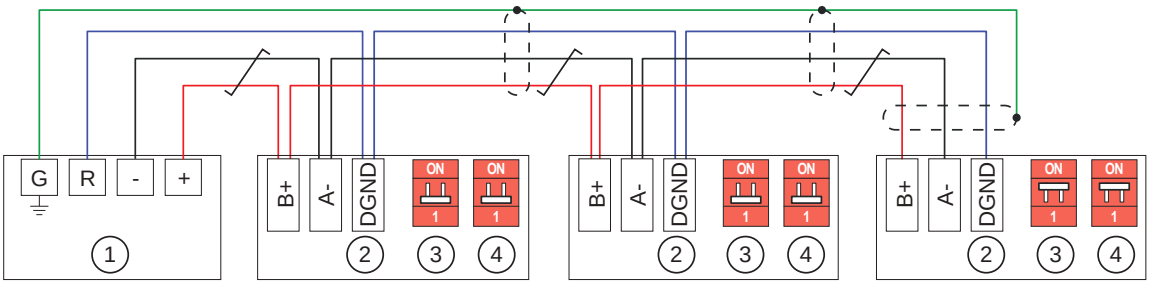
The EIA-485 network uses shielded, twisted-pair cable with a characteristic impedance of 100 … 130 ohm for data signaling. The distributed capacitance between conductors is less than 100 pF per meter (30 pF per foot). Distributed capacitance between conductors and shield is less than 200 pF per meter (60 pF per foot). Foil or braided shields are acceptable.

Connect the cable to the EIA-485 terminal on the I/O module. Obey these wiring instructions:

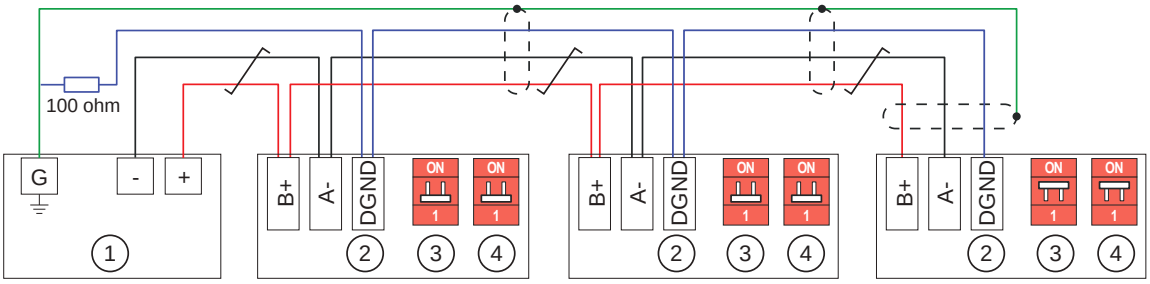
- Attach the cable shields together at each drive, but do not connect them to the drive.
- Connect the cable shields only to the grounding terminal in the automation controller.
- Connect the signal ground (DGND) conductor to the signal ground reference terminal in the automation controller. If the automation controller does not have a signal ground reference terminal, connect the signal ground conductor to the cable shield through a 100 ohm resistor, preferably near the automation controller.

Connection examples are shown below.

With signal ground reference terminal



Without signal ground reference terminal

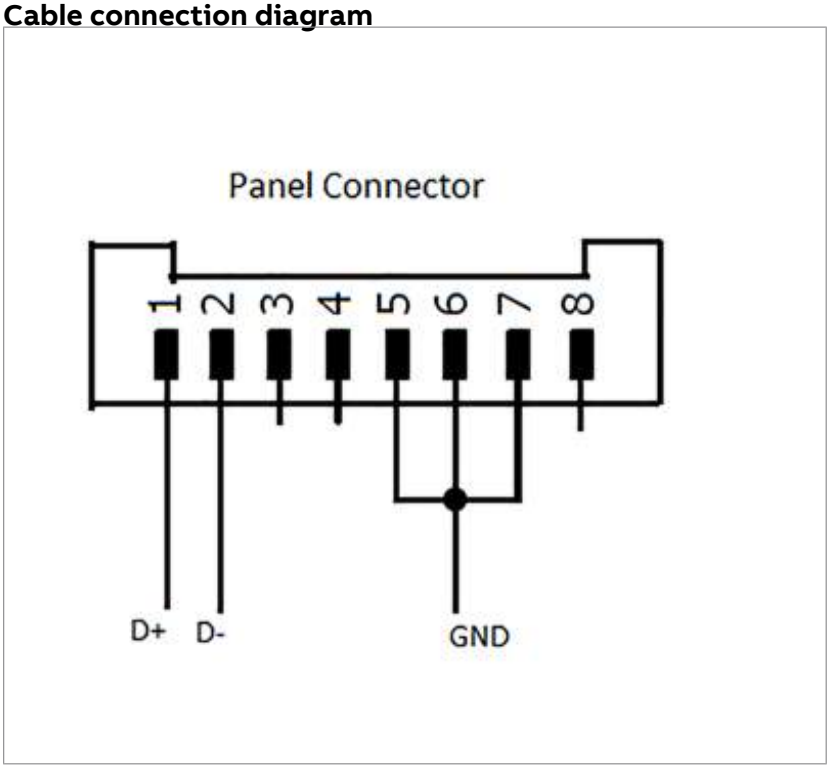


1	Automation controller
2	Drive
3	Termination switch. The devices at the ends of the fieldbus must have termination on. All other devices must have termination off.
4	Biasing switch. One (and only one) device, preferably at the end on the bus must have the bias on.

Change panel port to EFB port

You can use panel port as EFB port. To change panel port to EFB port, set parameter *58.01 Protocol enable* to Modbus RTU and restart the drive. If the changeover of the panel part to EFB port is success, the drive does not detect control panel within 20 seconds. If the drive detects the control panel, remove the control panel and reboot the drive again.

Cable connection diagram



Note:

- When an external IO module (RIIO, BIO-01 etc) is connected to drive, this changeover does not happen and only external IO is used for communication.
- This feature is applicable only for R0-R2 frames.

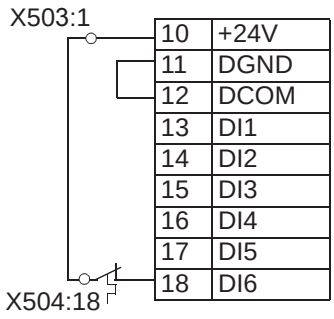
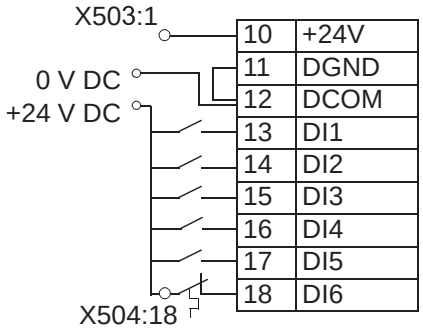
Connecting motor temperature sensors to the drive

IEC/EN 60664 requires double or reinforced insulation between the control unit and the live parts of the motor. To achieve this, use an CMOD-02 I/O extension module or CPTC-02 ATEX-certified thermistor protection module. Refer to section Implementing a motor temperature sensor connection and chapter CMOD-02 multifunction extension module (external 24 V AC/DC and isolated PTC interface) (page 239).

PNP and NPN configurations for digital inputs

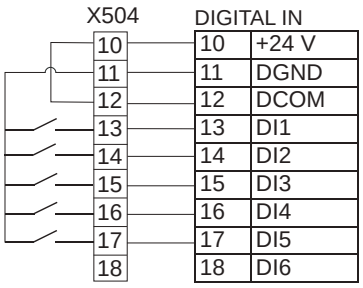
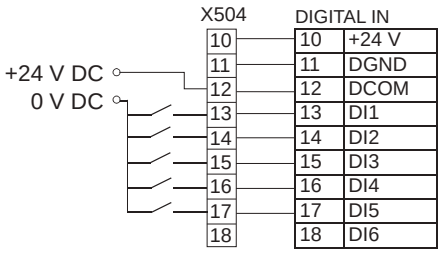
PNP configurations with option +L504

Internal and external +24 V power supply connections with option +L504 for PNP configuration are shown below.

Internal +24 V power supply PNP connection (source)	External +24 V power supply PNP connection (source)
	

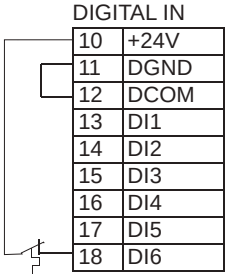
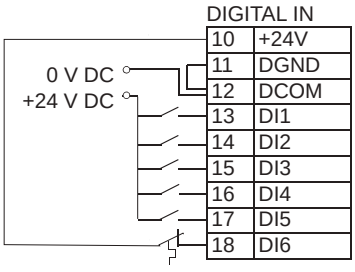
NPN configurations with option +L504

Internal and external +24 V power supply connections for NPN configuration are shown below.

Internal +24 V power supply NPN connection (sink)	External +24 V power supply NPN connection (sink)
	
Note: DI6 is not supported in the NPN configuration.	

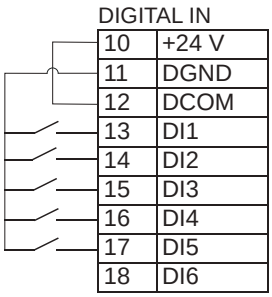
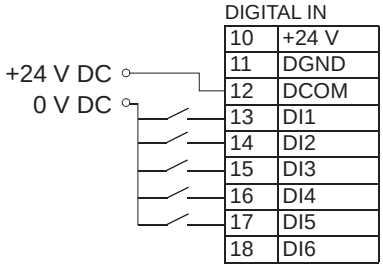
PNP configurations without option +L504

Internal and external +24 V power supply connections without option +L504 for PNP configuration are shown below.

Internal +24 V power supply PNP connection (source)	External +24 V power supply PNP connection (source)
	

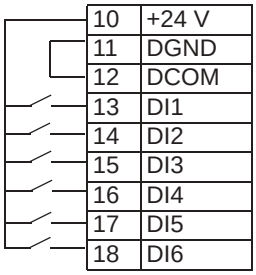
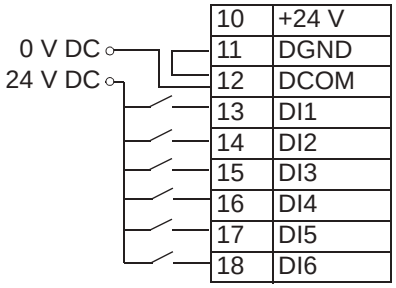
NPN configurations without option +L504

Internal and external +24 V power supply connections without option +L504 for NPN configuration are shown below.

Internal +24 V power supply NPN connection (sink)	External +24 V power supply NPN connection (sink)
	
Note: DI6 is not supported in the NPN configuration.	

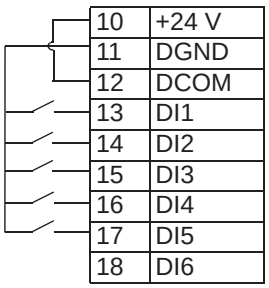
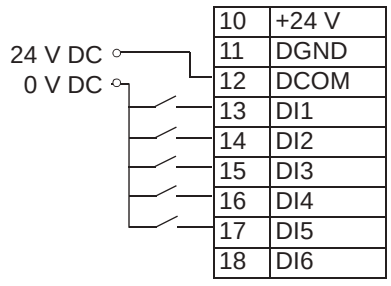
PNP configuration for digital inputs (X2 & X3)

Internal and external +24 V power supply connections for PNP configuration are shown in the figure below.

Internal +24 V power supply PNP connection (source)	External +24 V power supply PNP connection (source)
	

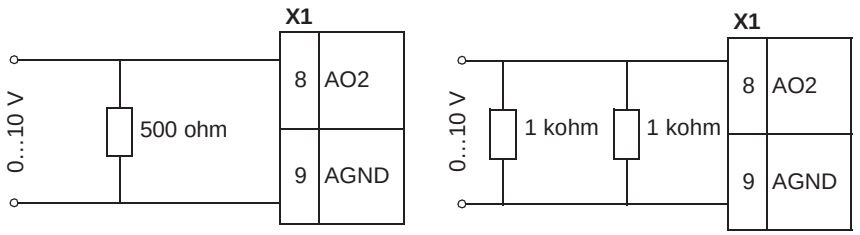
NPN configuration for digital inputs (X2 & X3)

Internal and external +24 V power supply connections for NPN configuration are shown in the figure below.

Internal +24 V power supply NPN connection (sink)	External +24 V power supply NPN connection (sink)
	
Note: DI6 is not supported in the NPN configuration.	

Connection for obtaining 0…10 V from analog output 2 (AO2)

To obtain 0…10 V from analog output AO2, connect a 500 ohm resistor (or two 1 kohm resistors in parallel) between analog output AO2 and analog common ground AGND.

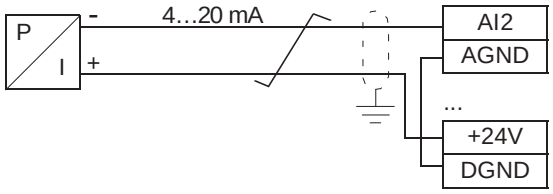


Connection examples of two-wire and three-wire sensors to analog input (AI2)

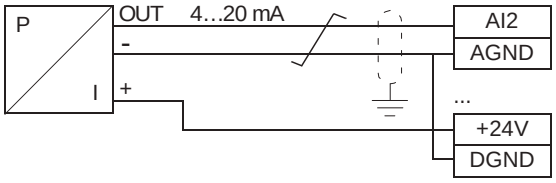
Hand/Auto, Hand/PID, and PID macros use analog input AI2.

Note: The maximum capability of the auxiliary voltage output (24 V DC [250 mA]) must not be exceeded.

An example of a two-wire sensor/transmitter supplied by the drive auxiliary voltage output is shown below. Set the input signal to 4…20 mA, not 0…20 mA.



An example of a three-wire sensor/transmitter supplied by the drive auxiliary voltage output is shown below.The sensor is supplied through its current output and the drive feeds the supply voltage (+24 V DC). Thus the output signal must be 4…20 mA, not 0…20 mA.



DI5 as frequency input

For setting the parameters for the digital frequency input, see the firmware manual.

Safe torque off (X4)

For the drive to start, both connections (+24 V DC to IN1 and +24 V DC to IN2) must be closed. By default, the terminal block has jumpers to close the circuit.

Remove the jumpers before connecting an external Safe torque off circuitry to the drive. See also chapter The Safe torque off function (page 205).

Note: Only 24 V DC can be used for STO. Only PNP input configuration can be used.

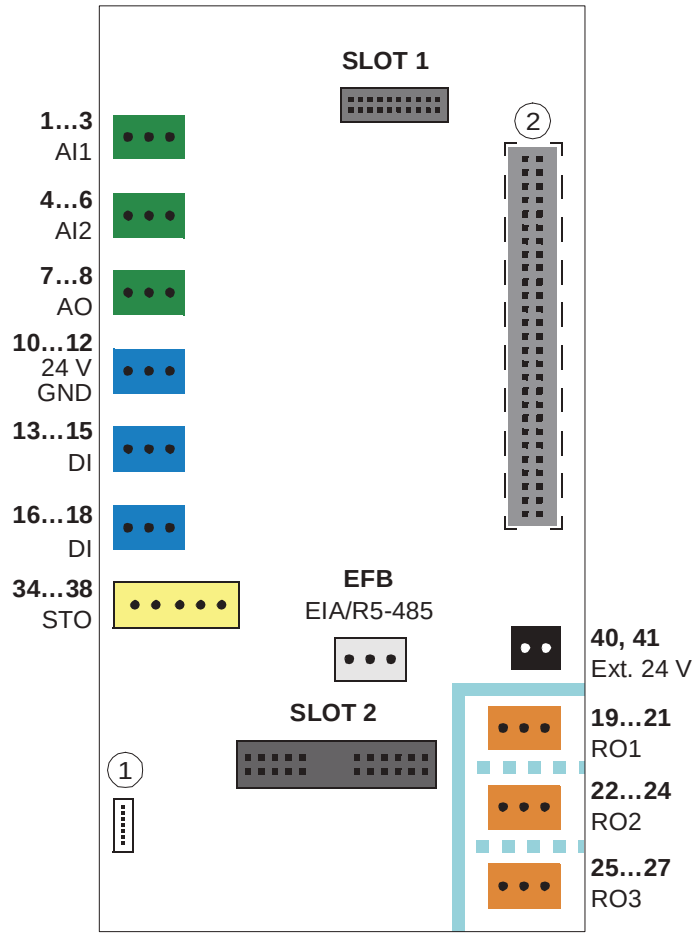
Technical data

R6…R9

External power supply Term. 40, 41	Maximum power: 36 W, 1.50 A at 24 V AC/DC ±10% as standard Terminal size: 0.14 … 2.5 mm² (26 … 14 AWG)
+24 V DC oaroutput (Term. 10)	Total load capacity of this outputs is 6.0 W (250 mA / 24 V) minus the power taken by the option modules installed on board. Terminal size: 0.14 … 2.5 mm² (26 … 14 AWG)
Digital inputs DI1…DI6 (Term. 13…18)	Input type: NPN/PNP Terminal size: 0.14 … 2.5 mm² (26 … 14 AWG) DI1…DI4 (Term. 13…16) 12/24 V DC logic levels: "0" < 4 V, "1" > 8 V R_{in}: 3 kohm Hardware filtering: 0.04 ms, digital filtering: 2 ms sampling DI5 (Term.17) Can be used as a digital or frequency input. 12/24 V DC logic levels: "0" < 4 V, "1" > 8 V R_{in}: 3 kohm Max. frequency: 16 kHz Symmetrical signal (duty cycle D = 0.50) DI6 (Term.18) Can be used as a digital or PTC input. 12/24 V DC logic levels: "0" < 3 V, "1" > 8 V R_{in}: 3 kohm Max. frequency: 16 kHz Symmetrical signal (duty cycle D = 0.50) Hardware filtering: 0.04 ms, digital filtering: 2 ms sampling **Note:** DI6 is not supported in the NPN configuration. PTC mode – PTC thermistor can be connected between DI6 and +24 V DC: < 1.5 kohm = '1' (low temperature), > 4 kohm = '0' (high temperature), open circuit = '0' (high temperature). DI6 is not a reinforced/double insulated input. Connecting the motor PTC sensor to this input requires usage of a reinforced/double insulated PTC sensor inside the motor
Relay outputs RO1…RO3 (Term. 19…27)	250 V AC / 30 V DC, 2 A. Terminal size: 0.14 … 2.5 mm² (26 … 14 AWG) See section Isolation areas (page 128).
Analog inputs AI1 and AI2 (Term. 2 and 5)	Current/voltage input mode selected with a parameter, see Connecting motor temperature sensors to the drive (page 122). Current input: 0(4)…20 mA, R_{in}: 100 ohm Voltage input: 0(2)…10 V, R_{in}: > 200 kohm Terminal size: 0.14 … 2.5 mm² (26 … 14 AWG) Inaccuracy: typical ±1%, max. ±1.5% of full scale Inaccuracy for Pt100 sensors: 10 °C (50 °F)
Analog outputs AO1 and AO2 (Term. 7 and 8)	Current/voltage output mode for AO1 selected with a parameter, see Connection for obtaining 0…10 V from analog output 2 (AO2) (page 124). Current output: 0…20 mA, R_{load}: < 500 ohm Voltage input: 0…10 V, R_{load}: > 100 kohm (AO1 only) Terminal size: 0.14 … 2.5 mm² (26 … 14 AWG) Inaccuracy: ±1% of full scale (in voltage and current modes)
Reference voltage output for analog inputs +10V DC (Term. 4)	Max. 20 mA output Inaccuracy: ±1%

Safe torque off (STO) inputs IN1 and IN2 (Term. 37 and 38)	24 V DC logic levels: "0" < 5 V, "1" > 13 V R_{in}: 2.47 kohm Terminal size: 0.14 … 2.5 mm^2 (26 … 14 AWG)
Embedded fieldbus (X5)	Connector pitch 5 mm, maximum wire size 2.5 mm^2 (14 AWG) Physical layer: EIA-485 Cable type: Shielded twisted pair cable with twisted pair for data and a wire or pair for signal ground, nominal impedance 100…165 ohms, for example Belden 9842 Transmission rate: 9.6 … 115.2 kbit/s Termination by switch
Control panel - drive connection	EIA-485, male RJ-45 connector, max. cable length 100 m (328 ft)
Control panel - PC connection	USB Type Mini-B, max. cable length 2 m (6.5 ft)

Isolation areas



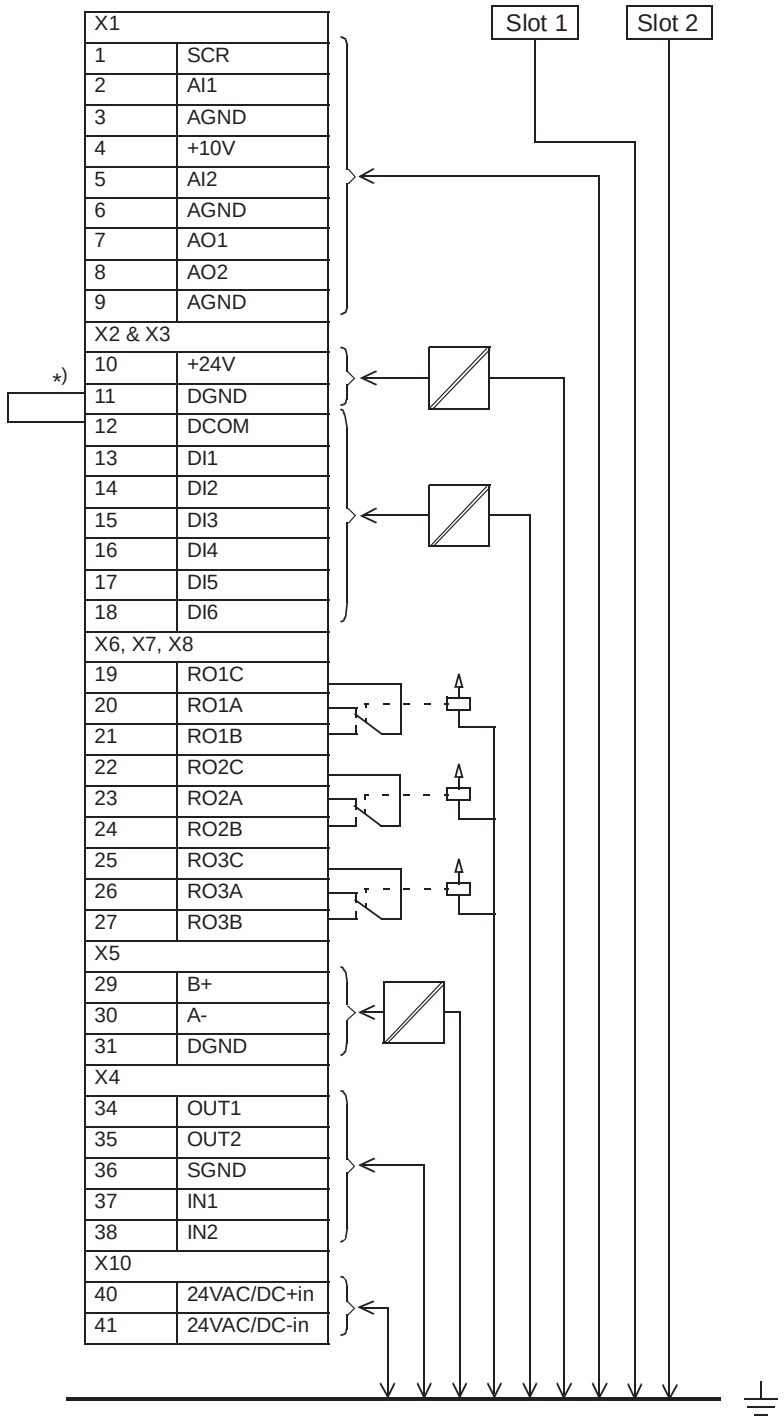
1	Panel port
2	Power unit connection at the bottom of the control unit
	Reinforced insulation (IEC/EN 61800-5-1:2007, UL 61800-5-1 First edition)
	Functional insulation (IEC/EN 61800-5-1:2007, UL 61800-5-1 First edition)

The terminals on the control unit fulfill the Protective Extra Low Voltage (PELV) requirements (EN 50178): There is reinforced insulation between the user terminals which only accept ELV voltages and terminals that accept higher voltages (relay outputs).

Note: There is functional insulation also between the individual relay outputs.

Note: There is reinforced insulation on the power unit.

Ground isolation diagram



*) Jumper installed at factory

8

Installation checklist

Contents of this chapter

This chapter contains a checklist for the mechanical and electrical installation of the drive.

Checklist

Examine the mechanical and electrical installation of the drive before start-up. Go through the checklist together with another person.

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

WARNING!
Do the steps in section Electrical safety precautions (page 19) before you start the work.

Make sure that ...	☑
The ambient operating conditions meet the drive ambient conditions specification and enclosure rating (IP code).	☐
The supply voltage matches the nominal input voltage of the drive. See the type designation label.	☐
The insulation resistance of the input power cable, motor cable and motor is measured according to local regulations and the manuals of the drive.	☐
The drive is installed in a shaded location with proper protection from rain and external elements.	☐
The drive cabinet is having a rating IP54 or higher.	☐

Make sure that ...	☑
The drive cabinet is attached to the floor, and if necessary due to vibration etc, also by its top to the wall or roof.	☐
The cooling air can flow freely in and out of the drive.	☐
If the drive is connected to a network other than a symmetrically grounded TN-S system: You have done all the required modifications (for example, you may need to disconnect the EMC filter or ground-to-phase varistor) the electrical installation instructions.	☐
There is an adequately sized protective earth (ground) conductor(s) between the drive and the switchboard, the conductor is connected to correct terminal, and the terminal is tightened to the correct torque. Grounding has also been measured according to the regulations.	☐
Solar array direction, earth connection, DC cable connection and usage of string combiner box aligns with the solar array manufacturer's guidelines.	☐
Solar array size is sufficient with respect to the required AC voltage and temperature conditions of the location.	☐
The input power cable is connected to the correct terminals, the phase order is correct, and the terminals are tightened to the correct torque.	☐
There is an adequately sized protective earth (ground) conductor between the motor and the drive. The conductor is connected to the correct terminal, and the terminal is tightened to the correct torque. Grounding has also been measured according to the regulations.	☐
The motor cable is connected to the correct terminals, the phase order is correct, and the terminals are tightened to the correct torque.	☐
The motor cable is routed away from other cables.	☐
No power factor compensation capacitors are connected to the motor cable.	☐
The control cables are connected to the correct terminals, and the terminals are tightened to the correct torque.	☐
The voltage setting of the auxiliary voltage transformers (if any) is correct. See the electrical installation instructions.	☐
If a drive bypass connection will be used: The direct-on-line contactor of the motor and the drive output contactor are either mechanically and/or electrically interlocked, that is, they cannot be closed at the same time. A thermal overload device must be used for protection when bypassing the drive. Refer to local codes and regulations.	☐
There are no tools, foreign objects or dust from drilling inside the drive.	☐
The area in front of the drive is clean: the drive cooling fan cannot draw any dust or dirt inside.	☐
The terminal box cover of the motor is in place. Cabinet shrouds are in place and doors are closed.	☐
The motor and the driven equipment are ready for power-up.	☐
The MC4 DC terminals between Drive and solar modules/string combiner box are disconnected	☐
Until the solar array is fully configured and sting combiner box connection is completed (if used), solar array MC4 terminals to drive is not connected.	☐
A string combiner box is used to combine multiple strings when you use multiple strings to meet require current rating of motor.	☐
Output of string combiner box is only two cables, DC+ and DC-. Do not try to use drive terminals for combining multiple strings.	☐

9

Start-up

Contents of this chapter

This chapter contains the start-up procedure of the drive. The default device designations (if any) are given in brackets after the name, for example "main switch-disconnector (Q1)". The same device designations are also used in the circuit diagrams, typically.

Start-up procedure

Action	☑
Safety	
WARNING! Obey the safety instructions during the start-up procedure. See chapter Safety instructions.	☐
Basic checks with no voltage connected	
Check the mechanical and electrical installation of the drive. See Installation checklist (page 131).	☐
For drives with Pt100 relays (option +(n)L506): • Check the connections against the circuit diagrams of the delivery. • Set the alarm and trip levels of the Pt100 relays. Set the alarm and trip levels of the Pt100 relay as low as possible based on the operating temperature and test results of the machine. The trip level can be set, for example, 10 °C higher than what the temperature of the machine is at maximal load in the maximum environmental temperature. ABB recommends to set the operating temperatures of the relay, typically for example, as follows: • 120…140 °C when only tripping is in use • alarm 120…140 °C and trip 130…150 °C when both alarm and tripping are used.	☐
Connecting voltage to the input terminals and auxiliary circuit	

Action	☑
Note: Before you close the door, make sure that the main protective circuit breaker (F21) for the auxiliary voltage supply is closed.	☐
Make sure that it is safe to connect voltage. Make sure that: • cabinet doors are closed • nobody is working on the drive or circuits that have been wired from outside into the drive cabinet • cover of the motor terminal box is on.	☐
Close the main switch-disconnector (Q1).	☐
Setting up the drive parameters, and performing the first start	
Setup the drive control program. See *ACQ80-07 drive quick start-up guide* (3AXD50000946433 [English])	☐
Powering up	
Drive with the emergency stop cat. 0 (option +Q951): Reset the emergency stop relay (A61) with the emergency stop reset button (S62) on the cabinet door. Otherwise you cannot close the main contactor.	☐
Drive with the emergency stop cat. 0 (option +Q963): Reset the emergency stop relay (A61) with the emergency stop reset button (S62) on the cabinet door. Otherwise you cannot start the drive because the STO signal circuit is open.	
Drives with main contactor (Q2, option +F250): Close the main contactor by turning the operating switch on the cabinet door from OFF into ON position.	☐
Perform the first start of the drive and motor.	☐
Stop the motor and drive.	☐
Drives with a fieldbus adapter module (optional): Set the fieldbus parameters. Activate the appropriate assistant in the control program, or see the user's manual of the fieldbus adapter module, and the drive firmware manual. Not all control programs include assistants. Check that the communication works between the drive and the PLC.	☐
On-load checks	
Check that the cooling fans rotate freely in the right direction, and the air flows upwards. A paper sheet set on the intake (door) gratings stays. The fans run noiselessly.	☐
Check that the motor starts. stops and follows the speed reference in right direction when controlled with the control panel.	☐
Check that the motor starts. stops and follows the speed reference in right direction when controlled through the customer-specific I/O or fieldbus.	☐
Drives in which the Safe torque off control circuit is connected: Test and validate the operation of the Safe torque off function. See chapter The Safe torque off function (page 205).	☐
Drives with an emergency stop circuit (options +Q951 and +Q963): Test and validate the operation of the emergency-stop circuit. See section Implementing the emergency stop function (page 86).	☐

10

Fault tracing

Contents of this chapter

This chapter describes the fault tracing possibilities of the drive.

Warning and fault messages

See the firmware manual for the descriptions, causes and remedies of the drive control program warning and fault messages.

11

Maintenance

Contents of this chapter

This chapter contains preventive maintenance instructions.

Maintenance intervals

The tables show the maintenance tasks that can be done by the end user. For the ABB Service offering, contact your local ABB Service representative (new.abb.com/contact-centers).

Description of symbols

Action	Description
I	Inspection (visual inspection and maintenance action if needed)
P	Performance of on/off-site work (commissioning, tests, measurements or other work)
R	Replacement

Recommended maintenance intervals after start-up

Recommended annual maintenance actions by the user	
Action	**Description**
I	IP42 air inlet and outlet meshes on the cabinet doors
I	IP54 air filters on the cabinet doors
P	Quality of supply voltage
I	Spare parts
P	Capacitor reforming for spare modules and spare capacitors, see Capacitors (page 154)

Recommended annual maintenance actions by the user	
Action	**Description**
I	Tightness of terminals
I	Dustiness, corrosion or temperature
P	Heatsink cleaning

Component	**Years from start-up**					
	3	**6**	**9**	**12**	**15**	**18**
Cooling						
Main cooling fans						
Main cooling fans (frames R6 to R9)			R			R
Auxiliary cooling fans						
Auxiliary cooling fan for circuit boards (frames R6 to R9)			R			R
Second auxiliary cooling fan (frames R8 and R9)			R			R
Cabinet cooling fans						
Cabinet cooling fan, door (frames R6 to R9)			R			R
Aging						
Control panel battery (real-time clock)			R			R
Functional safety						
Safety function test	I See the maintenance information of the safety function.					
Safety component expiry (Mission time, T_M)	20 years					

Note:

- The maintenance and component replacement intervals are based on the assumption that the equipment operates within the specified ratings and ambient conditions. ABB recommends annual drive inspections to ensure the highest reliability and optimum performance.
- Long-term operation near the specified maximum ratings or ambient conditions may require shorter maintenance intervals for certain components. Contact your local ABB Service representative for additional maintenance recommendations.

Cleaning the interior of the cabinet

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

WARNING!
Use a vacuum cleaner with antistatic hose and nozzle, and wear a grounding wristband. Using a normal vacuum cleaner creates static discharges which can damage circuit boards.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Clean the interior of the cabinet. Use a vacuum cleaner and a soft brush.
4. Clean the air inlets of the fans and air outlets of the modules (top).
5. Clean the air inlet gratings (if any) on the door.
6. Close the door.

Cleaning the exterior of the drive

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

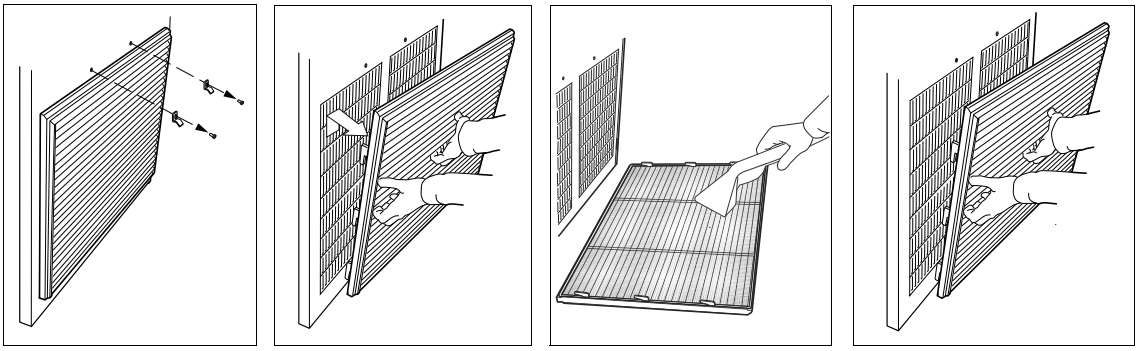
1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Clean the exterior of the drive. Use:
   - vacuum cleaner with an antistatic hose and nozzle
   - soft brush
   - dry or damp (not wet) cleaning cloth. Moisten with clean water, or mild detergent (pH 5…9 for metal, pH 5…7 for plastic).

WARNING!
Prevent water from entering the drive. Never use excessive amount of water, a hose, steam, etc.

Cleaning the air inlet (door) meshes (IP42 / UL Type 1 Filtered)

Check the dustiness of the air inlet meshes. If the dust cannot be removed by vacuum cleaning from outside through the grating holes with a small nozzle, proceed as follows:

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Remove the fasteners at the top of the grating.
3. Lift the grating and pull it away from the door.
4. Vacuum clean or wash the grating on both sides.
5. Reinstall the grating in reverse order.

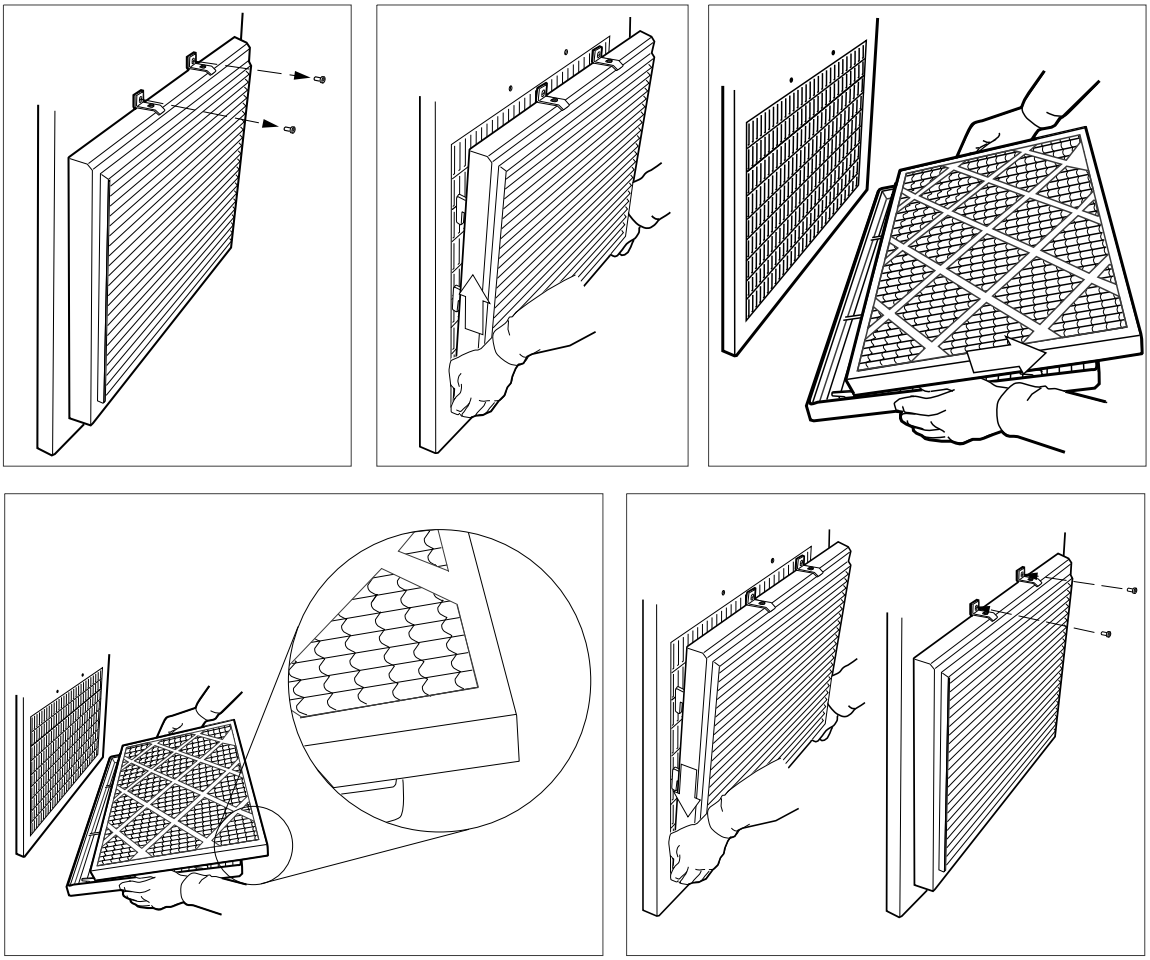


Replacing the air filters (IP54 / UL Type 12)

Check the air filters and replace if necessary.

Inlet (door) filters (IP54 / UL Type 12)

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Remove the fasteners at the top of the grating.
3. Lift the grating and pull it away from the door.
4. Remove the air filter mat.
5. Place the new filter mat in the grating the metal wire side facing the door.
6. Reinstall the grating in reverse order.



Outlet (roof) filters (IP54 / UL Type 12)

1. Remove the front and back gratings of the fan cubicle by lifting them upwards.
2. Remove the air filter mat.
3. Place the new filter mat in the grating.
4. Reinstall the gratings in reverse order.

Fans

The lifespan of the cooling fans of the drive depends on running time, ambient temperature and dust concentration. See the firmware manual for the actual signal which indicates the running time of the cooling fan. Reset the running time signal after fan replacement.

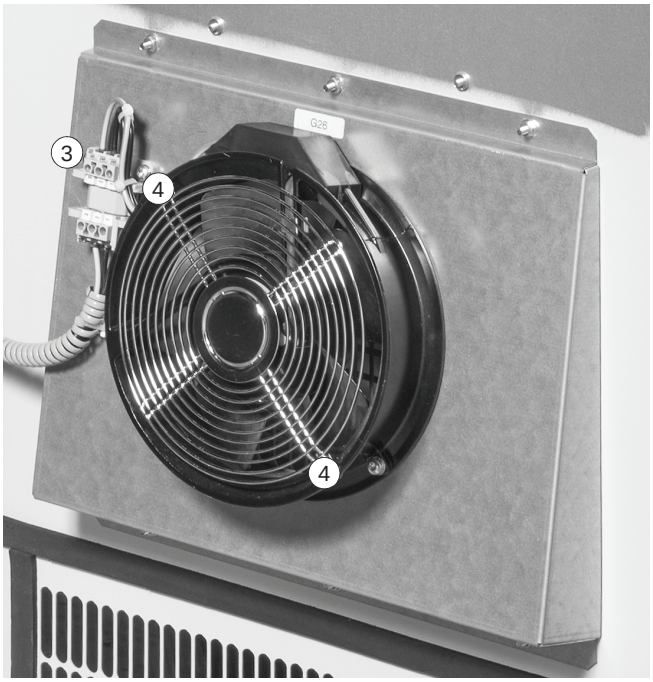
Replacement fans are available from ABB. Do not use other than ABB-specified spare parts.

Replacing the door fan (frames R6...R9)

Note: The fan is not present in all cabinet configurations.

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Unplug the power supply wires.
4. Undo the two mounting screws of the fan.
5. Install the new fan in reverse order.

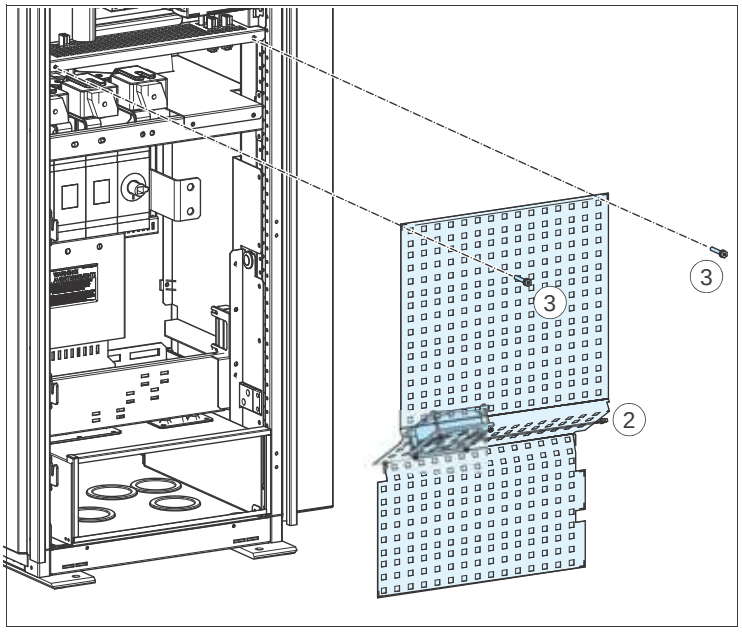


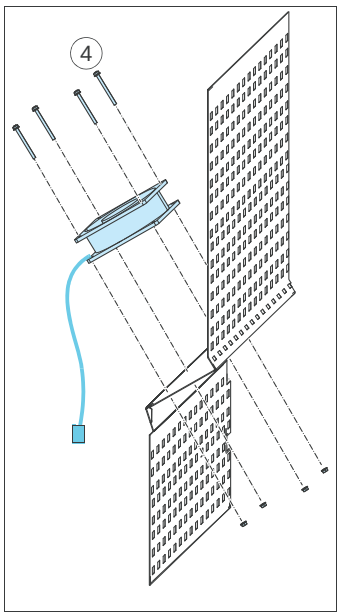
Replacing the cabinet fan (frames R6...R9)

Note: The fan is not present in all cabinet configurations.

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Unplug the power supply wires.
4. Remove the shroud.
5. Undo the mounting screws and nuts of the fan.
6. Install the new fan in reverse order.

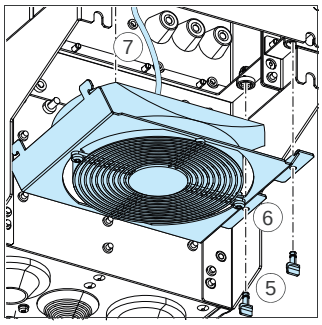


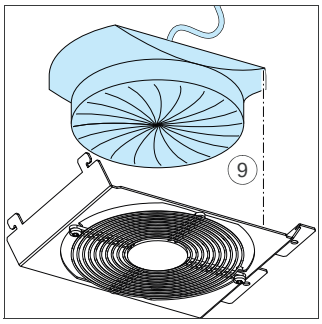


Replacing the drive module main fans (frames R6…R8)

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Remove the drive module from the cabinet as described in section Replacing the drive module (frames R6…R9) (page 148).
4. Remove the two mounting screws of the fan mounting plate at the bottom of the drive module.
5. Unplug the fan power supply wires from the drive.
6. Pull the fan mounting plate down from the side edge.
7. Unplug the fan power supply wires from the drive.
8. Lift the fan mounting plate off.
9. Remove the fan from the mounting plate.
10. Install the new fan in reverse order.
11. Reset the fan on-time counter in parameter group 5 of the drive control program.

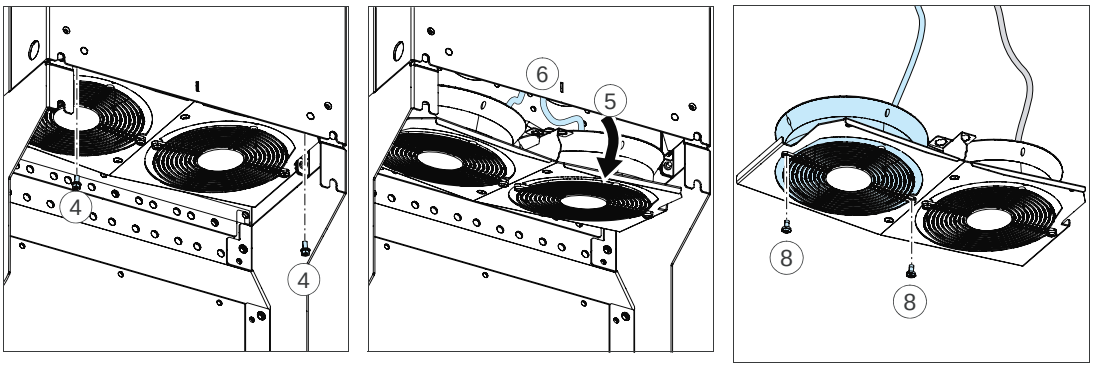




Replacing the drive module main fans (frame R9)

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Remove the drive module from the cabinet as described in section Replacing the drive module (frames R6…R9) (page 148).
4. Undo the two mounting screws of the fan mounting plate at the bottom of the drive module.
5. Turn the mounting plate downwards.
6. Unplug the fan power supply wires from the drive.
7. Remove the fan mounting plate.
8. Remove the fans by removing the two mounting screws.
9. Install the new fans in reverse order.
10. Reset the fan on-time counter in parameter group 5 of the drive control program.

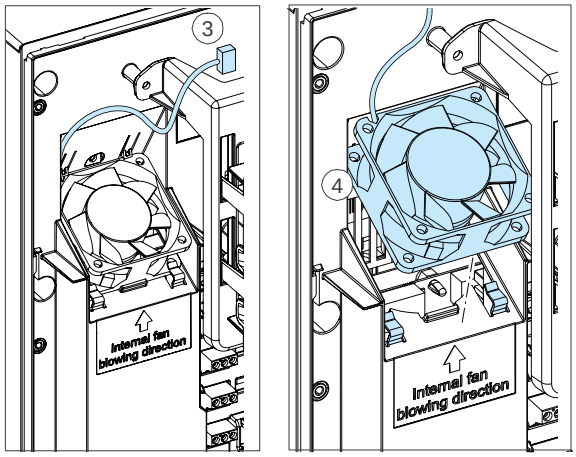


Replacing the auxiliary cooling fan of the drive module (frames R6...R9)

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Unplug fan power supply wires from the drive.
4. Release the retaining clips.
5. Lift the fan off.
6. Install the new fan in reverse order.

   Note: Make sure that the arrow on the fan points up.



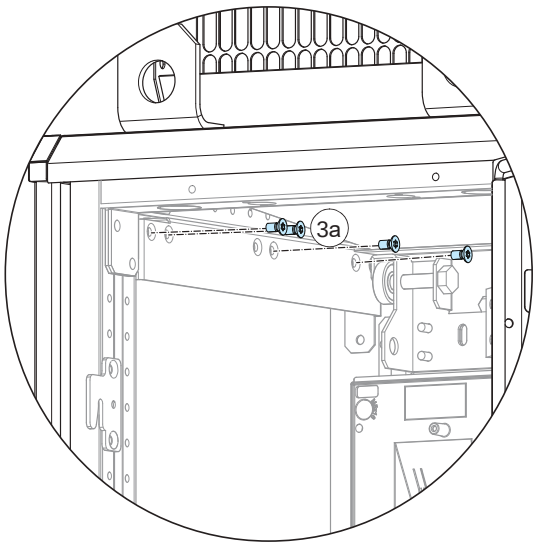
Replacing the drive module (frames R6...R9)

This replacing procedure requires: preferably two persons, a set of screw drivers with extension bar and a torque wrench, chains for securing the module during the installation. The drawings below show a cabinet of frame size R7. The procedure is the same for the other frame sizes.

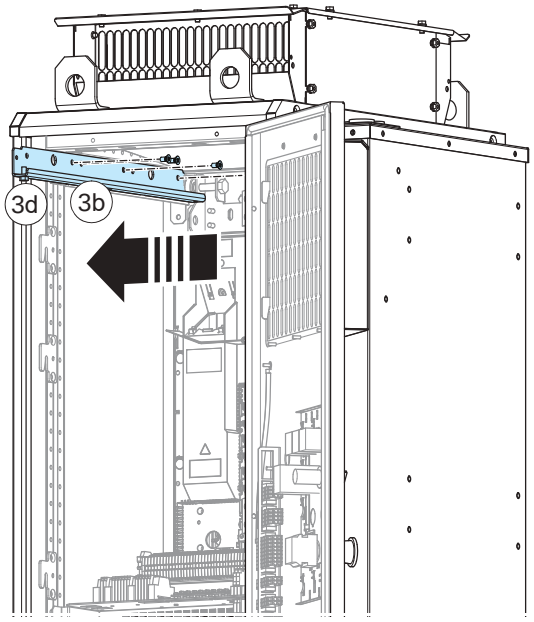
WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. To attach the sliding rails:
   3 a) Undo the four screws from the top horizontal studs.
   3 b) Attach the left-hand side sliding rail to the horizontal stud with the removed screws
   3 c) Attach the right-hand side sliding rail to the horizontal stud with the removed screws.

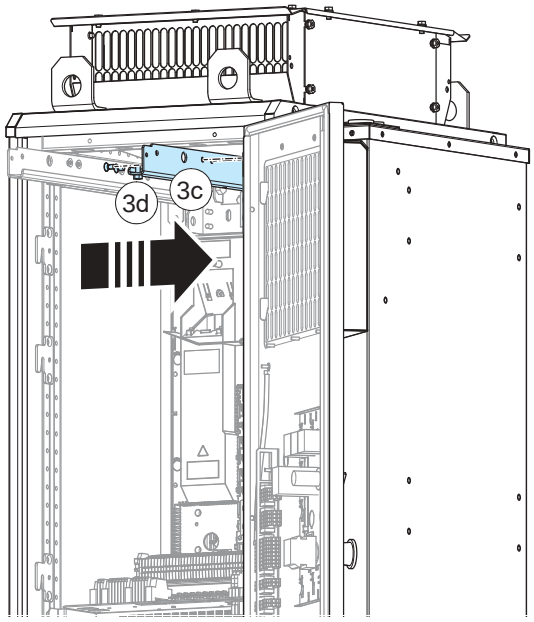
   WARNING!
   Check that the stopping screws (3d) at the ends of the studs are in place, so that the drive module cannot slide off the rail.



Torx M6x16

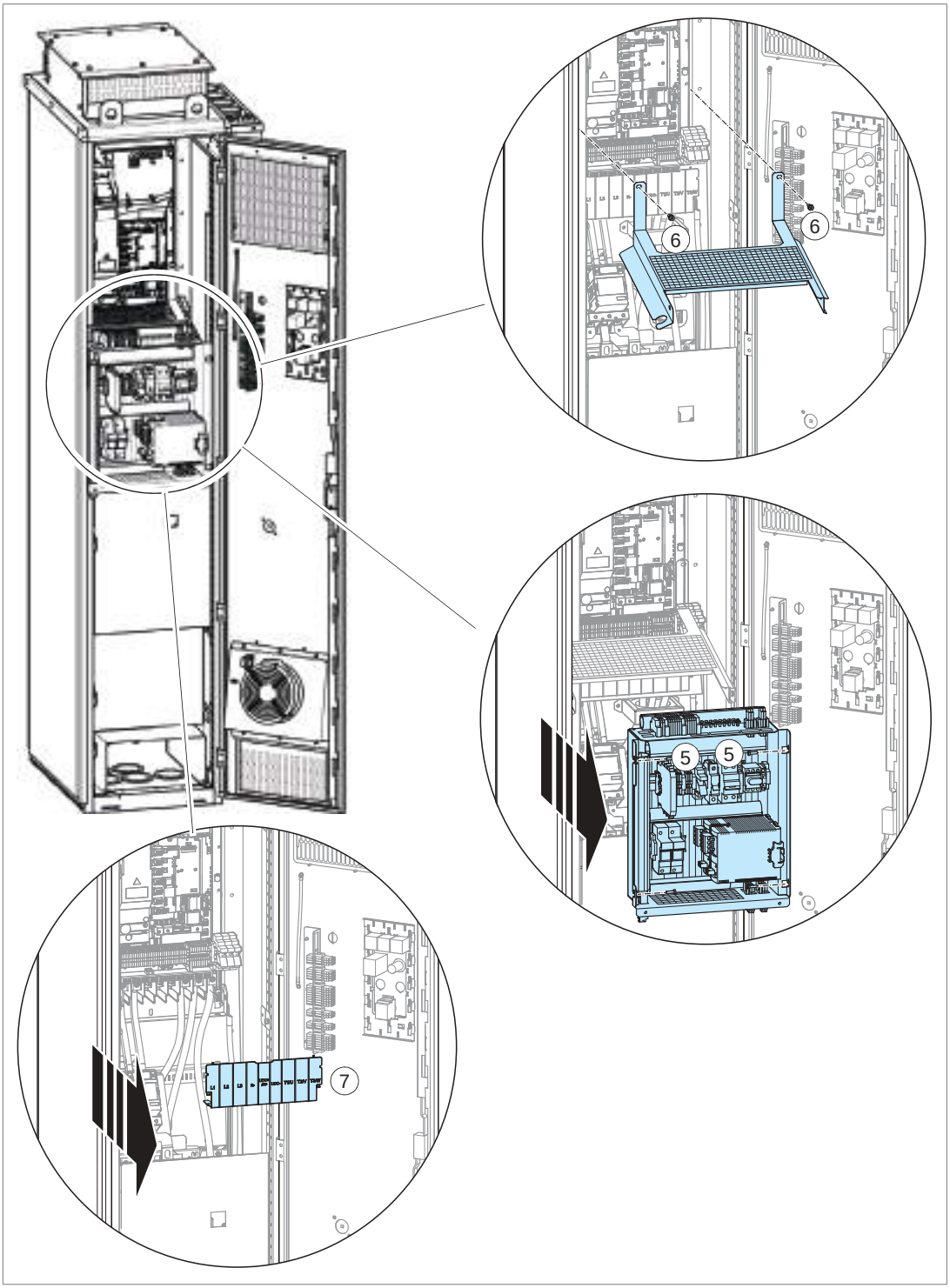


Torx M6x16



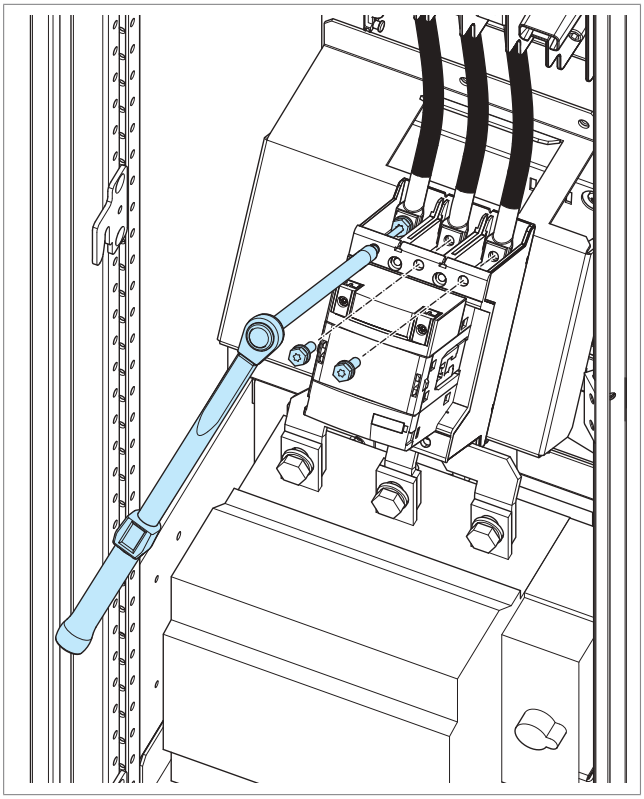
Torx M6x16

4. Unplug the wires connected to the mounting plate connectors (if present).
5. Remove the mounting plate (four screws).
6. Remove the shroud (two screws).
7. Remove the shroud on the power cable connection terminals.

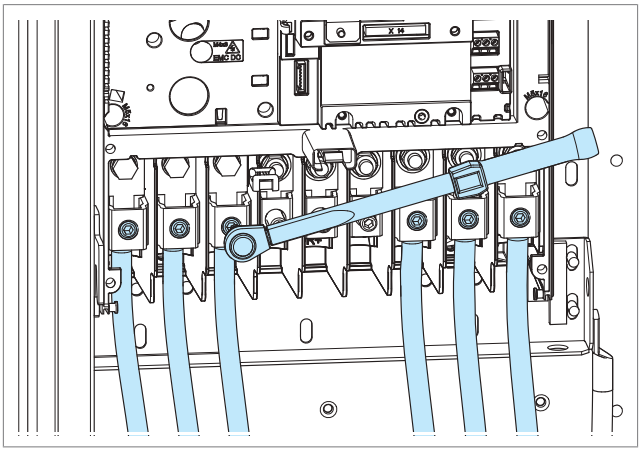


8. Disconnect the option modules from the control unit.
9. For drives with additional I/O terminal block (option +L504), disconnect the upper terminals and remove any fastening. Move the wires aside before you lift the module out. **Note:** Mark the wires for reconnection!

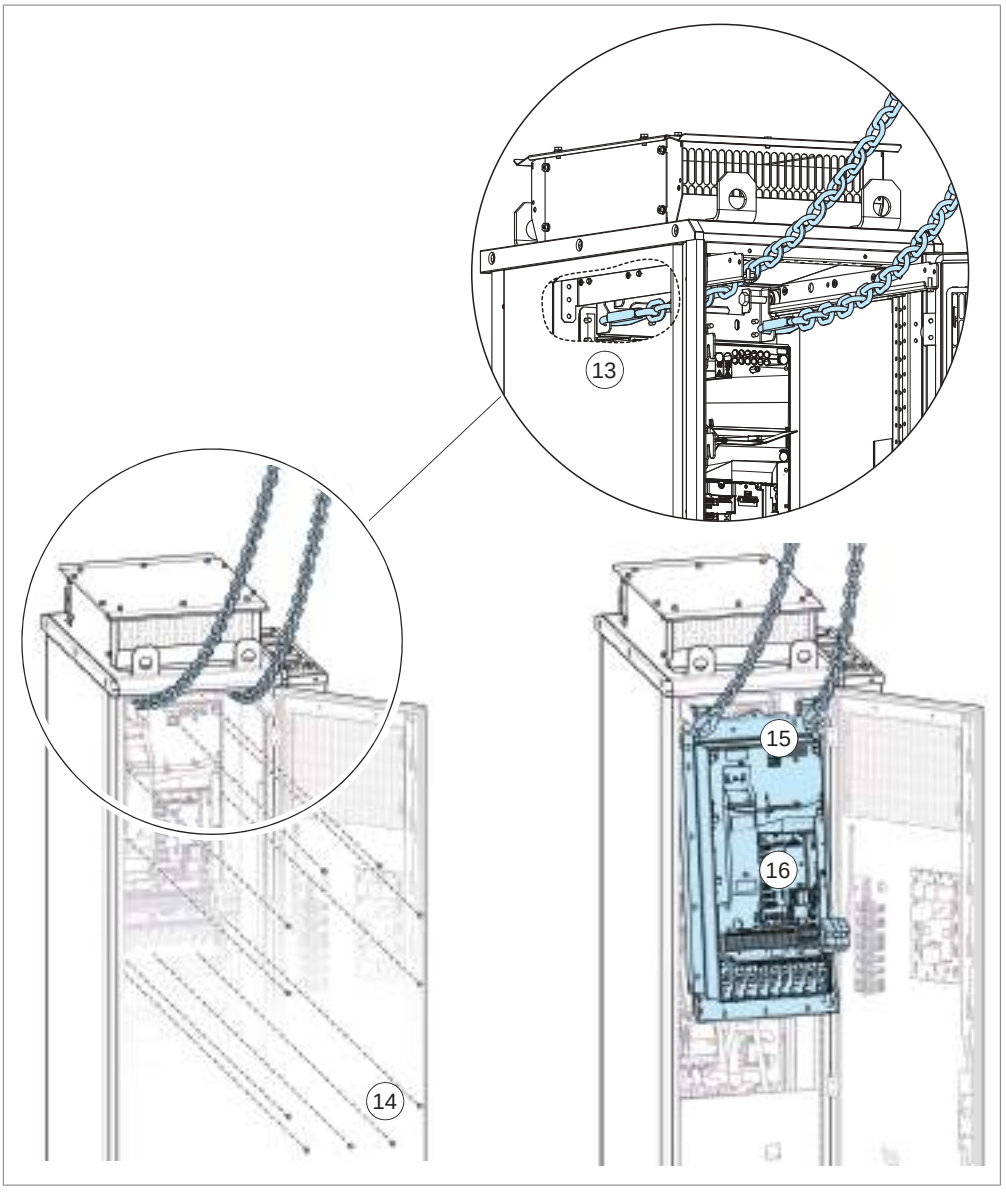
10. For drives without additional I/O terminal block (option +L504), disconnect the customer-installed wires from the control unit. **Note:** Mark the wires for reconnection!
11. For drives with line contactor (option +F250), disconnect the input power cables from the output of the contactor.



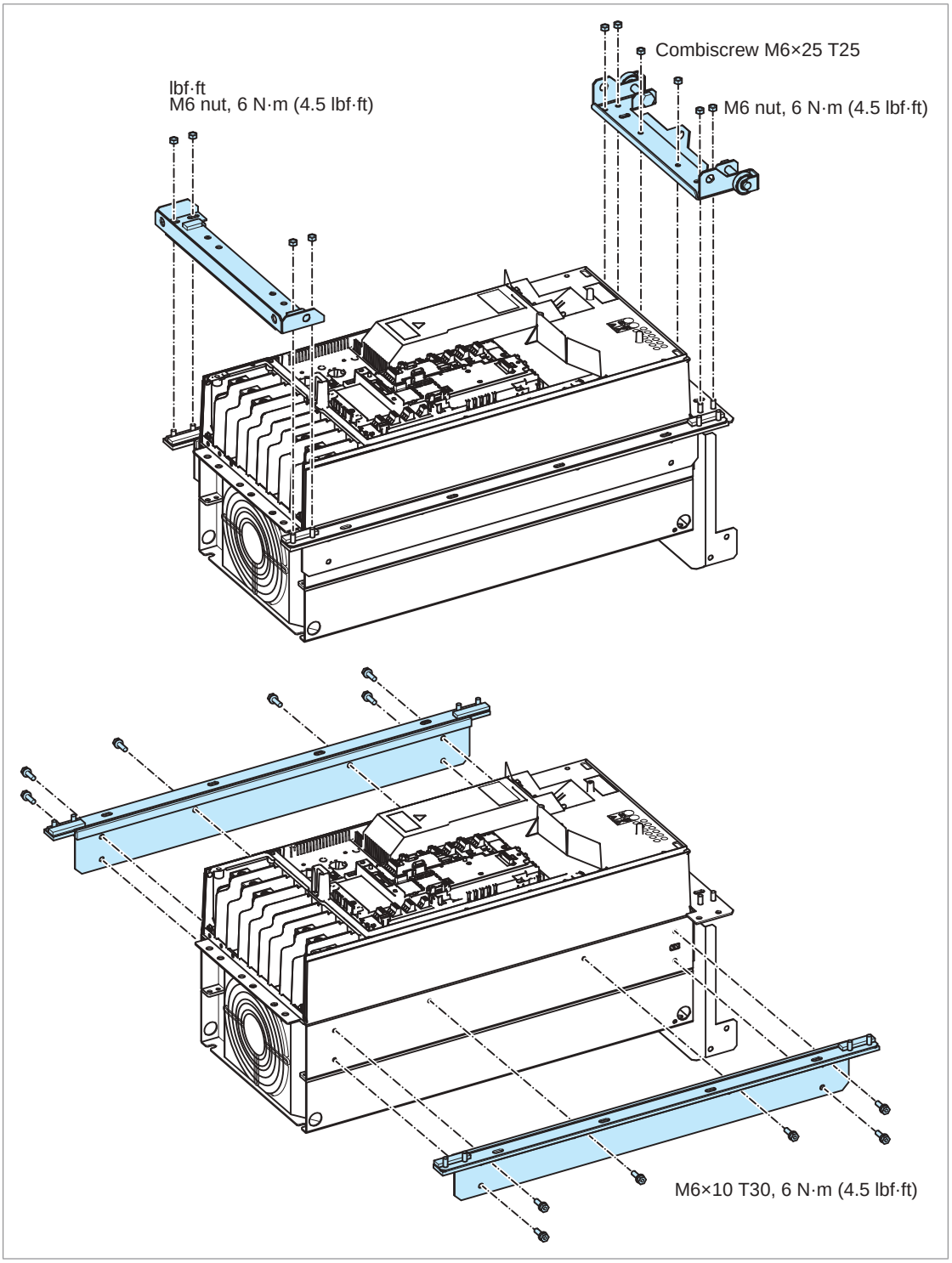
12. Disconnect the input power cable conductors and motor cable conductors from the drive module terminals.



13. Secure the drive module with chains from the lifting eyes.
14. Undo the mounting screws of the flange.
15. Slide the drive module forwards along the sliding bars.
16. Lift the module out of the cabinet with a lifting device.



17. Remove the flange.



18. Install the new module in reverse order.

Capacitors

The intermediate DC circuit of the drive contains several electrolytic capacitors. Operating time, load, and surrounding air temperature have an effect on the life of the capacitors. Capacitor life can be extended by decreasing the surrounding air temperature.

Capacitor failure is usually followed by damage to the unit and an input cable fuse failure, or a fault trip. If you think that any capacitors in the drive have failed, contact ABB.

Reforming the capacitors

The capacitors must be reformed if the drive has not been powered (either in storage or unused) for a year or more. The manufacturing date is on the type designation label. For information on reforming the capacitors, refer to Capacitor reforming instructions (3BFE64059629 [English]).

Fuses

Replacing AC fuses (frames R6 and R7)

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur. If you are not a qualified electrical professional, do not do installation, commissioning or maintenance work.

1. Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.
2. Open the cabinet door.
3. Remove the shrouding from in front of the switch fuse.
4. Replace the fuses with the fuse handle which is in the cabinet.
5. Reinstall the shrouding removed earlier and close the cabinet door.

Control panel

Refer to ACS-AP-I, -S, -W Assistant control panels user's manual (3AUA0000085685 [English]).

Refer to ACS-BP-S basic control panels user's manual (3AXD50000032527 [English]).

Functional safety components

The mission time of functional safety components is 20 years which equals the time during which failure rates of electronic components remain constant. This applies to the components of the standard Safe torque off circuit as well as any modules, relays and, typically, any other components that are part of functional safety circuits.

The expiry of mission time terminates the certification and SIL/PL classification of the safety function. The following options exist:

- Renewal of the whole drive and all optional functional safety module(s) and components.
- Renewal of the components in the safety function circuit. In practice, this is economical only with larger drives that have replaceable circuit boards and other components such as relays.

Note that some of the components may already have been renewed earlier, restarting their mission time. The remaining mission time of the whole circuit is however determined by its oldest component.

Contact your local ABB service representative for more information.

12

Technical data

Contents of this chapter

This chapter contains the technical specifications of the drive, for example, the ratings, sizes and technical requirements, provisions for fulfilling the requirements for CE and other markings.

Electrical ratings

IEC ratings

The nominal ratings for the drives with 50 Hz and 60 Hz supply are given below. The symbols are described in section Definitions (page 158).

IEC RATINGS										
ACQ80-07...	Frame size	Input rating	Output ratings							
			Nominal ratings				Light-duty use		Heavy-duty use	
		I_1	I_{max}	I_{DC}	I_2	P_n	I_{Ld}	P_{Ld}	I_{Hd}	P_{Hd}
		A	A	A	A	kW	A	kW	A	kW
U_n = 400 V										
075KW-4	R6	145	178	177.47	145	75	138	75	105	55
090KW-4	R7	169	247	206.85	169	90	161	90	145	75
110KW-4	R7	206	287	252.14	206	110	196	110	169	90
132KW-4	R8	246	350	301.1	246	132	234	132	206	110
160KW-4	R8	293	418	358.62	293	160	278	160	246 [1)]	132
200KW-4	R9	363	498	444.3	363	200	345	200	293	160

[1)] Continuous current, no overloadability

IEC RATINGS							
ACQ80-07...	Frame size	Input rating	Output ratings				
			Max. current	Light-duty use		Heavy-duty use	
		I_1	I_{max}	I_{Ld}	P_{Ld}	I_{Hd}	P_{Hd}
		A	A	A	hp	A	hp
U_n = 480 V							
075KW-4	R6	124	178	124	100	96	75
090KW-4	R7	156	247	156	125	124	100
110KW-4	R7	180	287	180	150	156	125
132KW-4	R8	240	350	240	200	180	150
160KW-4	R8	260	418	260	200	240 [1)]	150
200KW-4	R9	361	542	361	300	302	250

1) Continuous current, no overloadability

Definitions

U_n	Nominal voltage of the drive. For the input voltage range, see section Electrical power network specification (page 189).
I_1	Nominal rms input current
I_2	Nominal output current (available continuously with no over-loading)
I_{Dc}	Nominal DC input current
n	Apparent power (no overload)
P_n	Typical motor power in no-overload use
I_{Ld}	Continuous rms output current allowing 10% overload for 1 minute every 10 minutes.
P_{Ld}	Typical motor power in light-duty use (10% overload)
I_{max}	Maximum output current. Available for two seconds at start, then as long as allowed by drive temperature.
I_{Hd}	Continuous rms output current allowing 50% overload for 1 minute every 10 minutes.
P_{Hd}	Typical motor power in heavy-duty use

Note 1: The ratings apply at an ambient temperature of 40 °C (104 °F).

Note 2: To achieve the rated motor power given in the table, the rated current of the drive must be higher than or equal to the rated motor current.

The DriveSize dimensioning tool available from ABB is recommended for selecting the drive, motor and gear combination.

How to calculate required solar cell voltage and ISC

To calculate, required solar cell voltage and ISC for a motor at solar cell nominal conditions

Solar array V_{mp}/V_{mpp} = Motor nominal voltage * 1.35

Solar array I_{mp} = Drive nominal current /0.817

Note: When using a sine filter, there's no limitation of 600V for Vmp; it can be higher. Ensure that Vmp = 1.35*motor voltage recommendation, and make sure that VoC doesn't exceed 800V.

Definitions

V_{mp}	Voltage at maximum power
V_{mpp}	Maximum power point voltage
I_{mp}	Current at maximum power
DC	Nominal DC input current
ISC	Short circuit current
VOC	Open circuit voltage
VDC	Direct current voltage

Sizing

Drive sizing is based on the rated motor current, voltage and power. To achieve the rated motor power given in the table, the rated current of the drive must be higher than or equal to the rated motor current. Also the rated power of the drive must be higher than or equal to the rated motor power. The power ratings are the same regardless of the supply voltage within one voltage range.

Note: The ratings apply at ambient temperature of 40 °C (104 °F) for I_2. Above theses temperatures derating is required.

Deratings

The output load capacity (I_2, I_{Ld}, I_{Hd}; note that I_{max} is not derated) decreases in certain situations. In situations, where full motor power is required, oversize the drive so that the total derated output current provides sufficient capacity to supply the required nominal voltage to run the motor.

Note: The DriveSize dimensioning PC tool available from ABB (http://new.abb.com/drives/software-tools/drivesize) is also suitable for derating.

Note: If several situations are present at a time, the effects of derating are cumulative:

I_2 (derated) or I_{Ld} (derated) or I_{Hd} (derated) = (I_2 or I_{Ld} or I_{Hd}) x (switching frequency derating) x (altitude derating) x (ambient temperature derating), where no derating = 1.0.

Note: The motor may have a derating on it too.

Example:

How to calculate the derated current

The IP42 drive type is ACQ80-07-075KW-4, which has drive output current of 145 A. Calculate the derated drive output current (I_2) at 4kHz switching frequency, at 1500 m altitude and at 50 °C ambient temperature as follows:

1. Switching frequency derating by derating factor (page 161):

No derating needed for 4 kHz.

2. Altitude derating (page 160):
   The derating factor for 1500 m is 1 - ((1500m-1000m)/10000m) = 0.95.
   The derated drive output current becomes I_2 = 0.95 · 145 A = 137.8 A.

How to calculate the required drive

If your application requires a nominal motor current of 200.0 A at a switching frequency of 4 kHz, the supply voltage is 400 V, drive is situated at 1800 m altitude, and surrounding air temperature is 35 °C, calculate the appropriate drive size requirement as follows:

$$1 - \frac{1800m - 1000m}{10000m} = 0.92$$

The minimum size required becomes

$$\frac{200}{0.92} = 217.4A$$

Note: No derating needed for 35 °C ambient temperature.

To see if the derated output current of a drive is sufficient for the application, multiply the nominal output current (I_2) by the applicable derating factors. See Switching frequency derating by derating factor (page 161).

For example,

- if drive type has a nominal output current (I_2) of 246 A at 400 V. The switching frequency derating factor for this drive type is 0.82 at 4 kHz.
  The calculated derated drive output current is 246 A * 0.82 = 201.72 A at 4 kHz, which is not sufficient.
- if drive type has a nominal output current (I_2) of 293 A at 400 V. The switching frequency derating factor for this drive type is 0.82 at 4 kHz.
  The calculated derated drive output current is 293 A * 0.82 = 240.26 A at 4 kHz, which is the required drive size.
  Referring to I_2 in the ratings tables (starting from page 157), the drive type is ACQ80-07-160KW-4.

Altitude derating

In altitudes 1000…4000 m (3300…13120 ft) above sea level, the derating is 1% for every 100 m (330 ft).

Note: There are special considerations in corner-grounded installations above 2000 m. Contact your local ABB representative for further information.

The output current is calculated by multiplying the current given in the rating table by the derating factor k, which for x meters (1000 m <= x <= 4000 m) is:

$$K = 1 - 1/10000m * (X - 1000)m$$

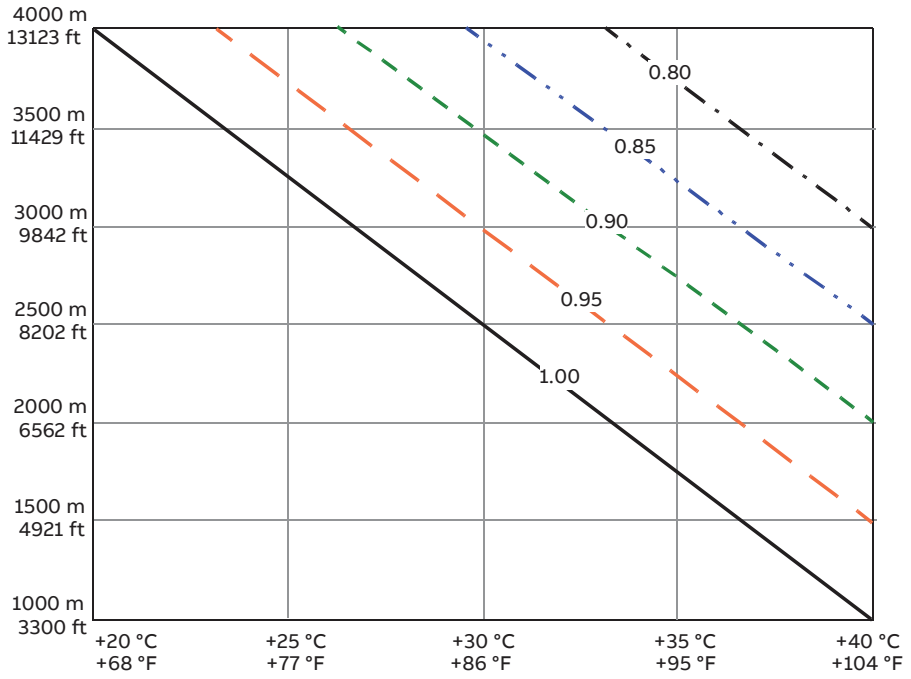
Altitude and surrounding air temperature

At altitudes from 1000…4000 m (3281…13123 ft) above sea level and temperature +40 °C (+104 °F), the derating is 1 percentage point for every additional 100 m (328 ft).

If surrounding air temperature is below +40 °C, the derating can be reduced by 1.5 percentage point for every 1 °C reduction in temperature.

A few combined altitude and temperature derating curves for 1000…4000 m are shown below. For example, if the temperature is 30 °C, the derating factor is 1 - 1.5% · 10 = 0.85.

For a more accurate derating, use the DriveSize PC tool.



	Derating factor 1.00
	Derating factor 0.95
	Derating factor 0.90
	Derating factor 0.85
	Derating factor 0.80

Note: Check the supply network compatibility restrictions above 2000 m (6562 ft), see Ambient conditions (page 191). Check also PELV limitation on relay output terminals above 2000 m (6562 ft), see section Isolation areas (page 128) for frames R6…R9.

Switching frequency derating by derating factor

The output current is calculated by multiplying the current given in the rating table by the derating factor given in the table below.

Note: If you change the minimum switching frequency with parameter 97.02, derate according to the table below. Changing parameter 97.01 does not require derating.

IEC

Frame size	ACQ80-07-...	Derating factor (k) for the minimum switching frequencies at 40 °C (+104 °F)				
		1 kHz	2 kHz	4 kHz	8 kHz	12 kHz
3-phase U_n = 400 V						
R6	075KW-4	1	0.97	0.84	0.66	0.52
R7	090KW-4…110KW-4	1	0.98	0.89	0.71	0.53

Frame size	ACQ80-07-...	Derating factor (k) for the minimum switching frequencies at 40 °C (+104 °F)				
		1 kHz	2 kHz	4 kHz	8 kHz	12 kHz
R8	132KW-4…160KW-4	1	0.96	0.82	0.61	0.45
R9	200KW-4	1	0.95	0.79	0.58	0.43

Switching frequency derating with actual output current values

These tables show the output current values with different switching frequencies. Note that other derating factors, for example ambient temperature and altitude, may also affect to the output current.

IEC

Frame size	ACQ80-07-...	Nominal output	Nominal output current (I_2) for the minimum switching frequencies at 40 °C (+104 °F)				
		I_2	1 kHz	2 kHz	4 kHz	8 kHz	12 kHz
		A	A	A	A	A	A
3-phase U_n = 400 V							
R6	075KW-4	145	145	141	122	96	75
R7	090KW-4	169	169	166	150	120	90
R7	110KW-4	206	206	202	183	146	109
R8	132KW-4	246	246	236	202	150	111
R8	160KW-4	293	293	281	240	179	132
R9	200KW-4	363	363	345	287	211	156

Fuses (IEC)

DC Fuses

ACQ80-07...	Input current (A)	IDC (A)	DC MCB 4 pole	Part number	AC input MCCB - TMD	Input contactor	Input AC fuse	Fuse base
U_n = 400 V, U_{DC} = 390...800 V								
075KW-4	145	118.76	T1D/PV 160 4p F FC Cu 1100V DC	1SDA069816R1	XT2 160 TMA In 160A	A145-30-11	170M3816	1
090KW-4	169	138.41	T4D/PV 250 4p F F 1100V DC	1SDA069823R1	XT4 250 TMA In 200A	A145-30-11	170M3817	1
110KW-4	206	186.71	T4D/PV 250 4p F F 1100V DC	1SDA069823R1	XT4 250 TMA In 250A	AF205-30-11	170M3818	1
132KW-4	246	201.47	T4D/PV 250 4p F F 1100V DC	1SDA069823R1	T5 400 TMA In 320A	AF265-30-11	170M5809	2
160KW-4	293	239.97	T5D/PV 500 4p F F 1100V DC	1SDA069824R1	T5 400 TMA In 320A	AF265-30-11	170M5810	2
200KW-4	363	297.30	T5D/PV 500 4p F F 1100V DC	1SDA069824R1	T5 400 TMA In 400A	AF400-30-11	170M5812	2

AC Fuses

uR and aR fuses

The standard drive is equipped with aR fuses listed below.

ACQ80-07...	Min. short circuit current [1]	Input current (A)	uR or aR (DIN 43620 blade style)				
			Nominal current (A)	A^2s	Voltage rating V	Type (Bussmann)	IEC 60269 size
U_n = 400 V							
075KW-4	1280	145	315	46500	690	170M3817	1
090KW-4	1800	169	450	105000	690	170M5809	2
110KW-4	2210	206	500	145000	690	170M5810	2
132KW-4	3010	246	630	275000	690	170M5812	2
160KW-4	4000	293	800	490000	690	170M6812D	3
200KW-4	5550	363	1000	985000	690	170M6814D	3

1) Minimum short-circuit current of the installation

ACQ80-07...	Min. short circuit current [1]	Input current (A)	uR or aR (DIN 43653 bolted tags)				
			Nominal current (A)	A^2s	Voltage rating V	Type (Bussmann)	IEC 60269 size
U_n = 400 V							
075KW-4	1000	145	250	28500	690	170M3016	1
090KW-4	1280	169	315	46500	690	170M3017	1
110KW-4	1520	206	350	68500	690	170M3018	1
132KW-4	3010	246	450	105000	690	170M5009	2
160KW-4	4000	293	500	145000	690	170M5010	2
200KW-4	5550	363	630	275000	690	170M5012	2

1) Minimum short-circuit current of the installation

gG fuses

ACQ80-07...	Min. short circuit current [1]	Input current (A)	gG (IEC 60269)				
			Nominal current (A)	A^2s	Voltage rating V	Type (ABB)	IEC 60269 size
U_n = 400 or 480 V							
075KW-4	1700	145	160	185000	500	OFAF00H160	00
090KW-4	3300	169	250	600000	500	OFAF0H250	0
110KW-4	5500	206	315	710000	500	OFAF1H315	1
132KW-4	6400	246	355	920000	500	OFAF1H355	1
160KW-4	7800	293	425	1300000	500	OFAF2H425	2
200KW-4	9400	363	500	2000000	500	OFAF2H500	2

[1] Minimum short-circuit current of the installation

Notes:

1 Fuses with a higher current rating than specified must not be used.

2 Fuses from other manufacturers can be used if they meet the ratings and the melting curve of the fuse does not exceed the melting curve of the fuse mentioned in the table.

Input circuit components

ACQ80-07...	Input current (A)	DC current	DC MCB	DC fuse	DC diode	AC MCCB	AC input contactor	AC fuse	Fuse base
075KW-4	145	177.5	T4D/PV 250 4p F F 1100V DC	170M4010	IRK 162	XT2 160 TMA In 160A	AF116	170M3816	1
090KW-4	169	206.9	T4D/PV 250 4p F F 1100V DC	170M5008	IRK 230	XT4 250 TMA In 200A	AF140	170M3817	1
110KW-4	206	252.1	T5D/PV 500 4p F F 1100V DC	170M5009	IRK 230	XT4 250 TMA In 250A	AF146	170M3818	1
132KW-4	246	301.1	T5D/PV 500 4p F F 1100V DC	170M5011	IRK 330	T5 400 TMA In 320A	AF190	170M5809	2
160KW-4	293	358.6	T5D/PV 500 4p F F 1100V DC	170M5012	IRK 330	T5 400 TMA In 320A	AF205	170M5810	2
200KW-4	363	444.3	T5D/PV 500 4p F F 1100V DC	170M6012	IRK 500	T5 400 TMA In 400A	AF265	170M5812	2

DC charging circuit

ACQ80-07...	Input current (A)	Charging fuse	Charging contactor	Resistance	Capacitance	Resistance description	Quantity
075KW-4	145	170M2673-20A	A30-30-10	36	2600	CAV 120 C 410 36R	1
090KW-4	169	170M2673-20A	A30-30-10	36	3800	CAV 120 C 410 36R	1
110KW-4	206	170M2673-20A	A30-30-10	36	3800	CAV 120 C 410 36R	1
132KW-4	246	170M2673-20A	A30-30-10	18	5600	CAV 120 C 410 36R	parallel 2
160KW-4	293	170M2673-20A	A30-30-10	18	5600	CAV 120 C 410 36R	parallel 2
200KW-4	363	170M2673-20A	A30-30-10	18	8800	CAV 120 C 410 36R	parallel 2

Reverse polarity diodes

ACQ80-07...	Diode type code (International rectifier make)	Quantity required with heatsink
075kW-4	IRKE 230	2
090kW-4	IRKE 230	2
110kW-4	IRKE 330	2
132kW-4	IRKE 330	2
160kW-4	IRKE 500	2
200kW-4	IRKE 500	2

Dimensions and weights

Frame size	Height	Width[1)]	Depth	Weight
	mm	mm	mm	kg
R6	2145	430	673	210
R7	2145	430	673	220
R8	2145	530	673	255
R9	2145	530	673	275

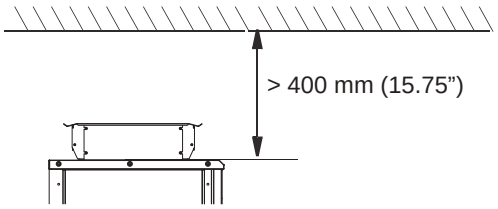
1) Additional width with options +H351 and +H353: 128 mm.

Free space requirements

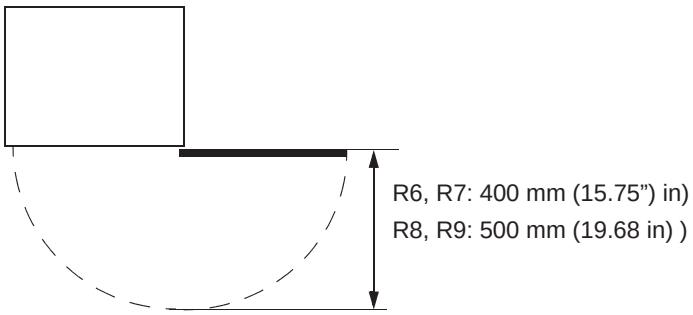
Free space requirements for cooling are given below.

Front		Side		Above *	
mm	in.	mm	in.	mm	in.
150	5.91	-	-	400	15.75

* measured from the base plate of the cabinet top.



Free space for door opening:



Maximum allowed plinth height for the extraction/installation ramp

The maximum plinth height for the extraction/installation ramp delivered with the drive is 50 mm (1.97 in).

Typical power cables

The table below gives typical copper and aluminum cable types with concentric copper shield for the drives with nominal current. For the cable sizes accepted by the drive cabinet cable entries and connection terminals, see Terminal and entry data for the power cables (page 168).

ACQ80-07...	Frame size	IEC [1]	
		Cu cable type	Al cable type
		mm²	mm²
U_n = 400 V			
075KW-4	R6	3×95	3×120
090KW-4	R7	3×120	3×150
110KW-4	R7	3×150	3×240
132KW-4	R8	2×(3×70)	2×(3×95)

ACQ80-07...	Frame size	IEC [1]	
		Cu cable type	Al cable type
		mm²	mm²
160KW-4	R8	2×(3×95)	2×(3×120)
200KW-4	R9	2×(3×120)	2×(3×185)

[1] The cable selection is based on max. 9 cables laid on a cable ladder side by side, three ladder type trays one on top of the other, ambient temperature 30 °C (86 °F) PVC insulation, surface temperature 70 °C (158 °F) (EN 60204-1 and IEC 60364-5-52). For other conditions, select the cables according to local safety regulations, appropriate input voltage and the load current of the drive.

Temperature: For IEC, select a cable rated for at least 70 °C maximum permissible temperature of conductor in continuous use.

Voltage: 600 V AC cable is accepted for up to 500 V AC.

Losses, cooling data and noise

ACQ80-07...	Air flow				Heat dissipation	Noise
	IP42 (UL Type 1)		IP54 (UL Type 12)			
	m³/h	cfm	m³/h	cfm	W	dB(A)
U_n = 400 V and 480 V						
075KW-4	685	403	585	344	2487	67
090KW-4	700	412	600	353	2497	67
110KW-4	700	412	600	353	3314	67
132KW-4	800	470	700	412	3806	65
160KW-4	800	470	700	412	4942	65
200KW-4	1400	824	1300	765	5868	68

These losses are not calculated according to the ecodesign standard IEC 61800-9-2.

Terminal and entry data for the power cables

There are two (in frame R6 to R9) 60 mm (2.36 in) diameter holes in the entry plate for the input power cables and two (in frames R6 to R9) 60 mm (2.36 in) diameter holes for the motor cables. Busbars for user power connections are tin-plated copper.

IEC – Standard configuration

Input and motor cable terminal bolt sizes, accepted wire sizes (per three phases) and tightening torques are given below.

Frame size	Input and motor cable connection terminals						PE (grounding) terminals	
	L1, L2, L3			T1/U2, T2/V2, T3/W2				
	Max. wire size mm²	Bolt size	Tightening torque N·m	Min. wire size [1] mm²	Max. wire size mm²	Tightening torque N·m	Bolt size mm²	Tightening torque N·m
R6	3×150	M10	20…40	3×25	3×150	30	M10	30…44
R7	2×(3×240)	M10	20…40	2×(3×95)	2×(3×240)	40	M10	30…44
R8	2×(3×150)	M10	20…40	2×(3×50)	2×(3×150)	40	M10	30…44
R9	2×(3×240)	M12	50…75	2×(3×95)	2×(3×240)	70	M10	30…44

[1] **Note:** Minimum wire size does not necessarily have enough current capability for full load. Make sure the installation complies with local laws and regulations.

IEC – With option +E205

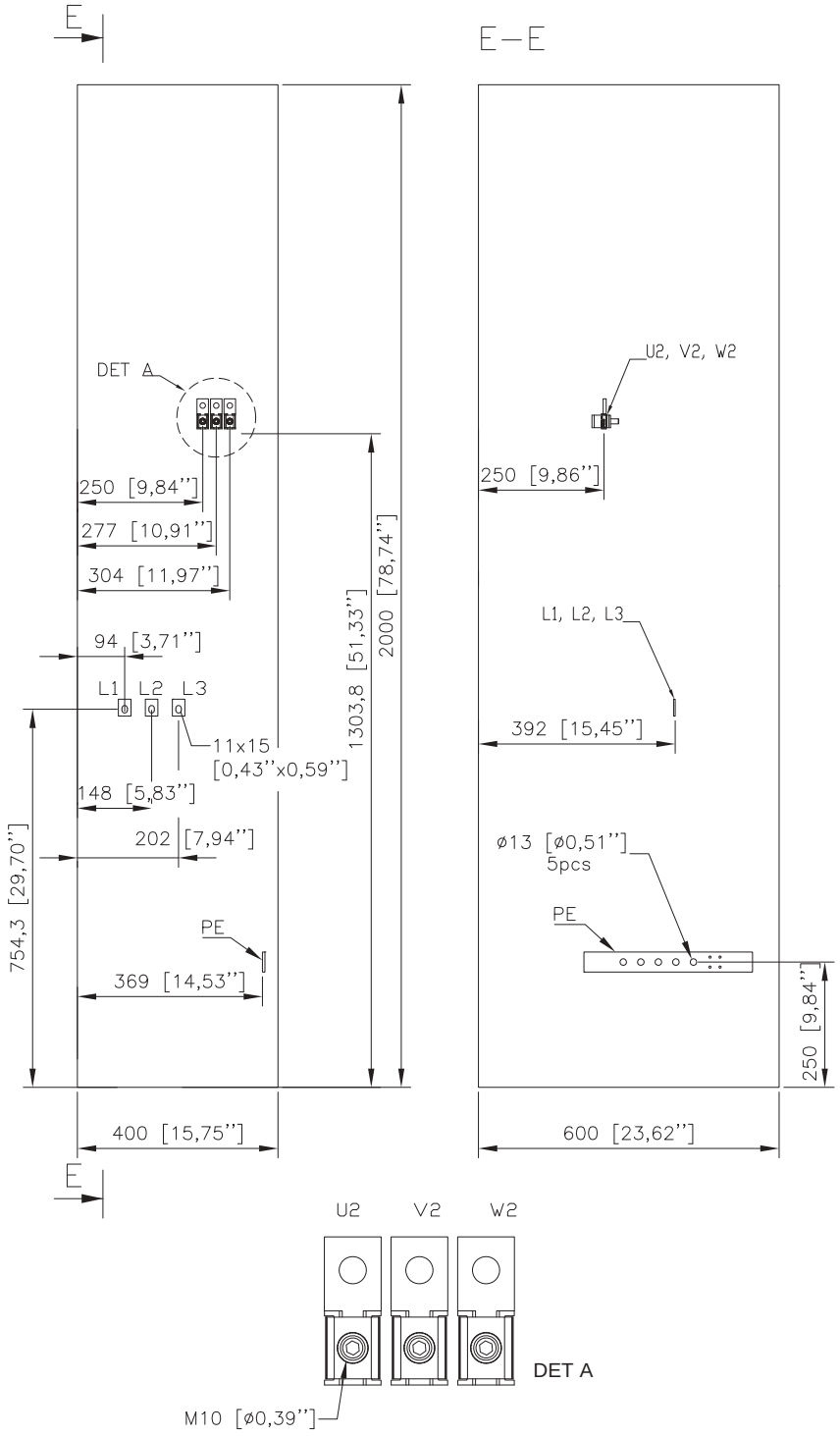
Input and motor cable terminal bolt sizes, maximum accepted wire sizes (per three phases) and tightening torques are given below.

Frame size	L1, L2, L3, U2, V2, W2			PE (grounding)	
	Max. wire size mm²	Bolt size	Tightening torque N·m	Bolt size mm²	Tightening torque N·m
R6	3×120	M10	20…40	M10	30…44
R7	3×240	M10	20…40	M10	30…44
R8	2×(3×120)	M10	20…40	M10	30…44
R9	2×(3×240)	M12	50…75	M10	30…44

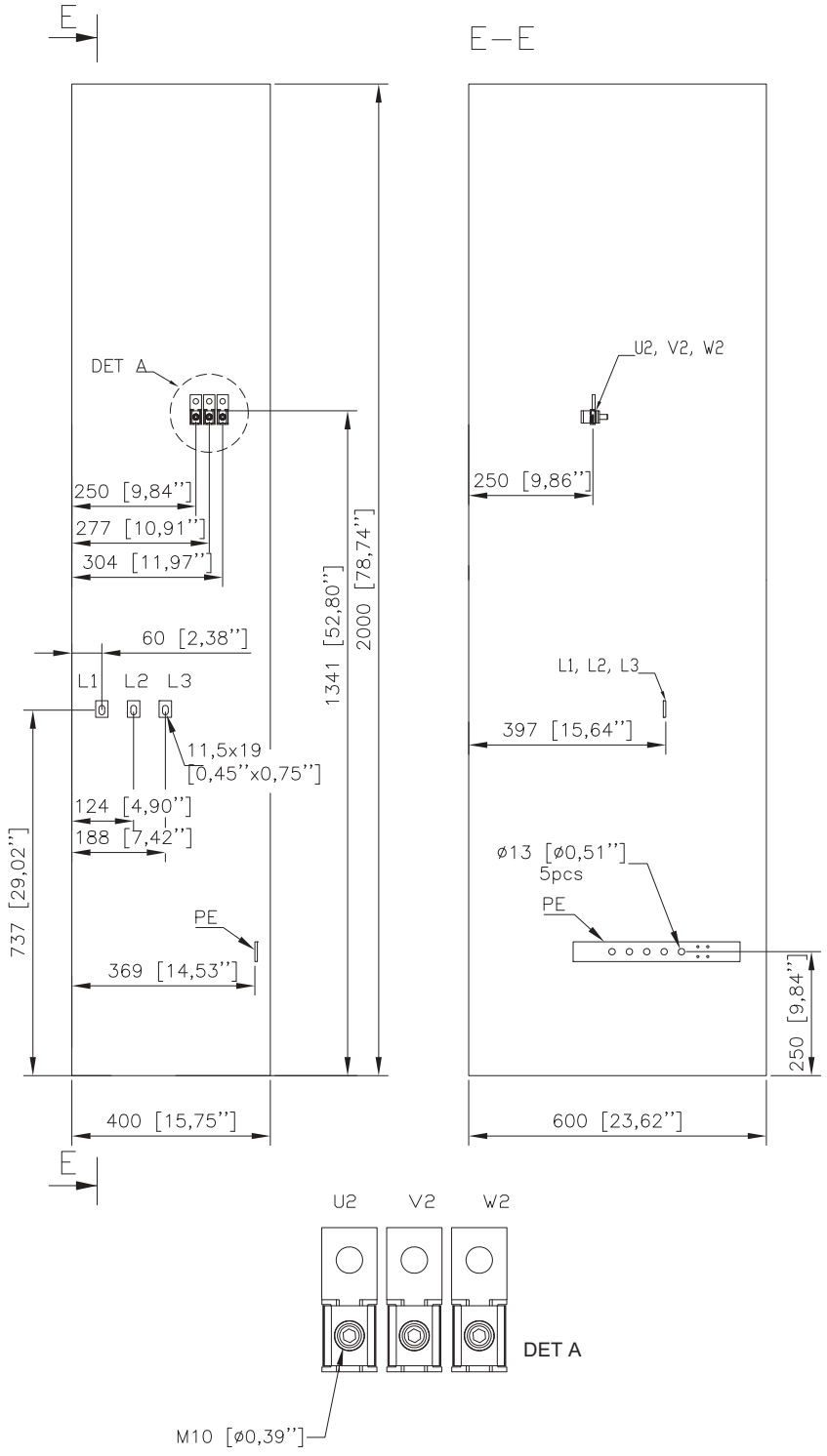
Dimension drawings

This table shows the dimensions of the power cable connection terminals. With a combination of bottom and top entry and exit options, look the connection points from the bottom entry and exit and top entry and exit drawings.

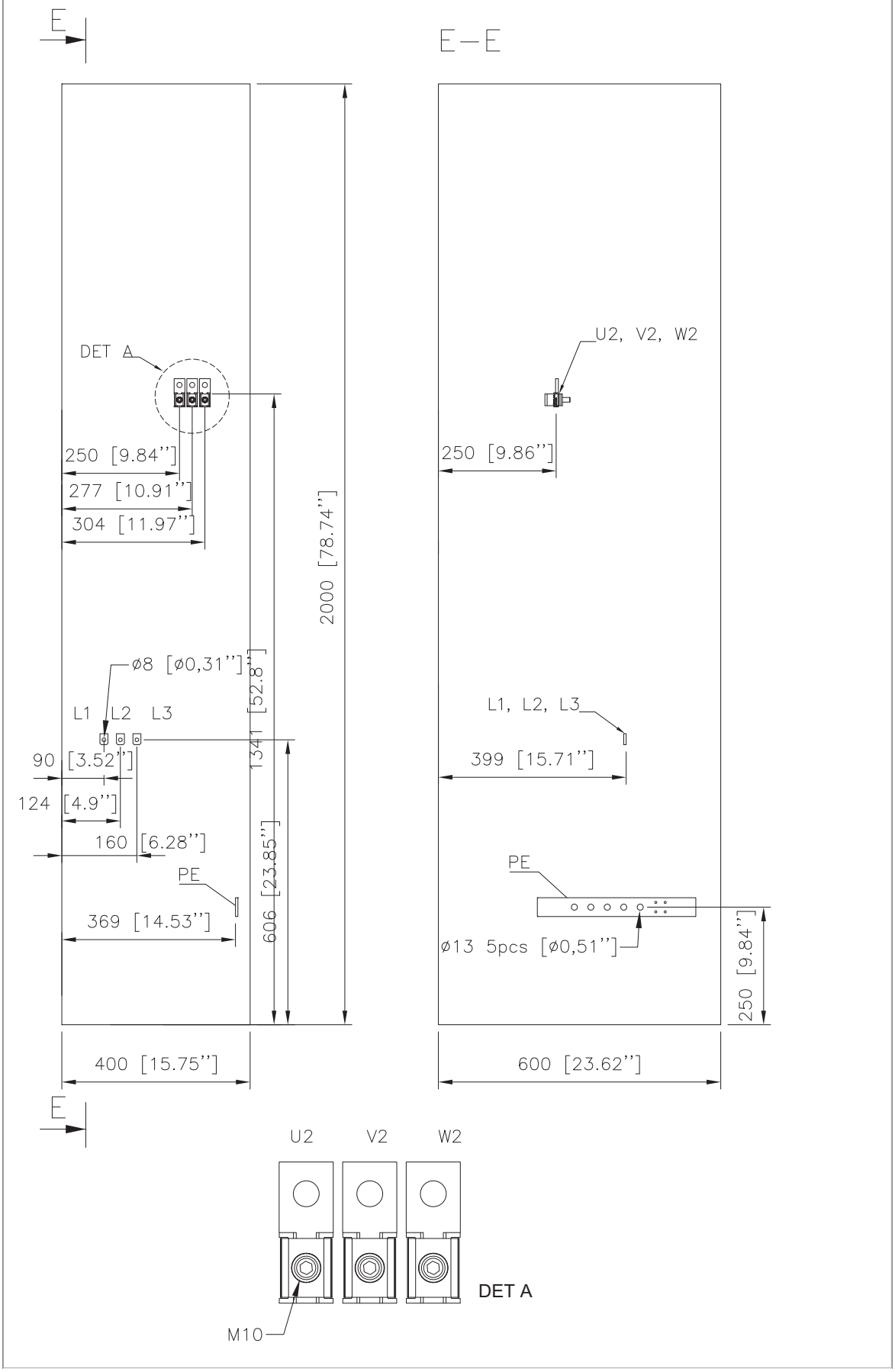
Frame R6: Input and motor cable terminal dimensions (bottom entry and exit, switch fuse OS250)



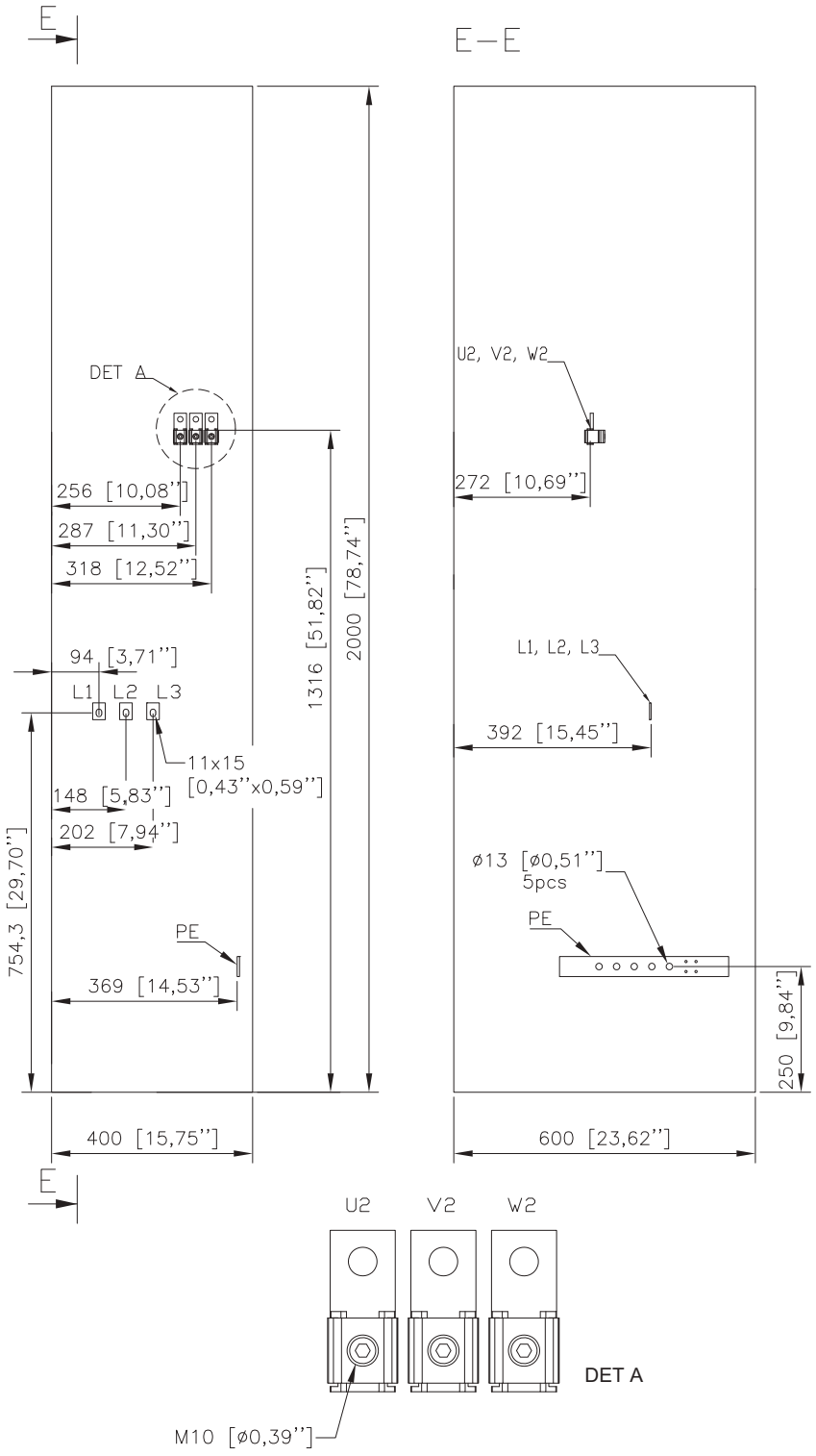
Frame R6: Input and motor cable terminal dimensions (bottom entry and exit, switch fuse OS400)



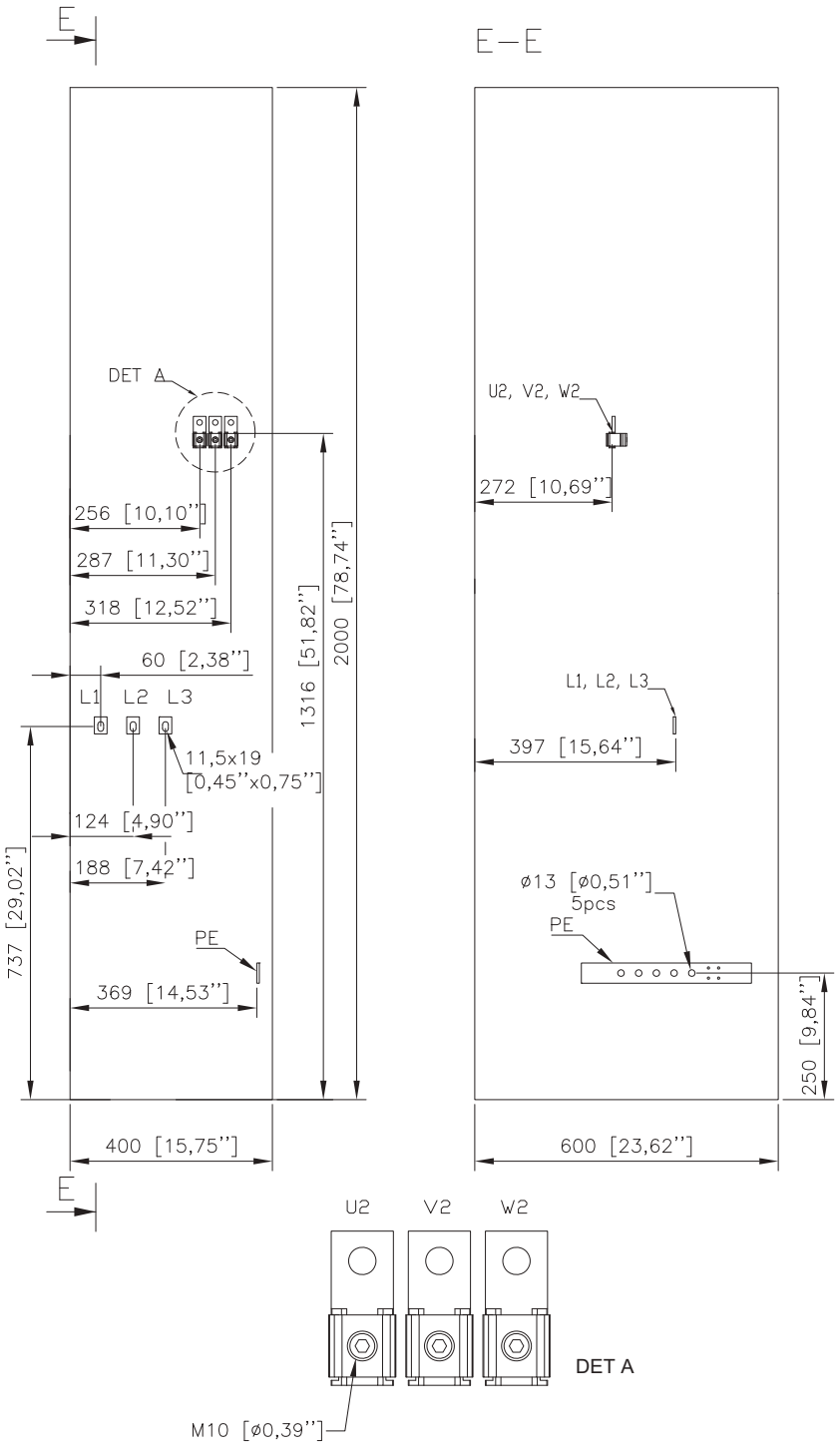
Frame R6: Input and motor cable terminal dimensions (option +F289)



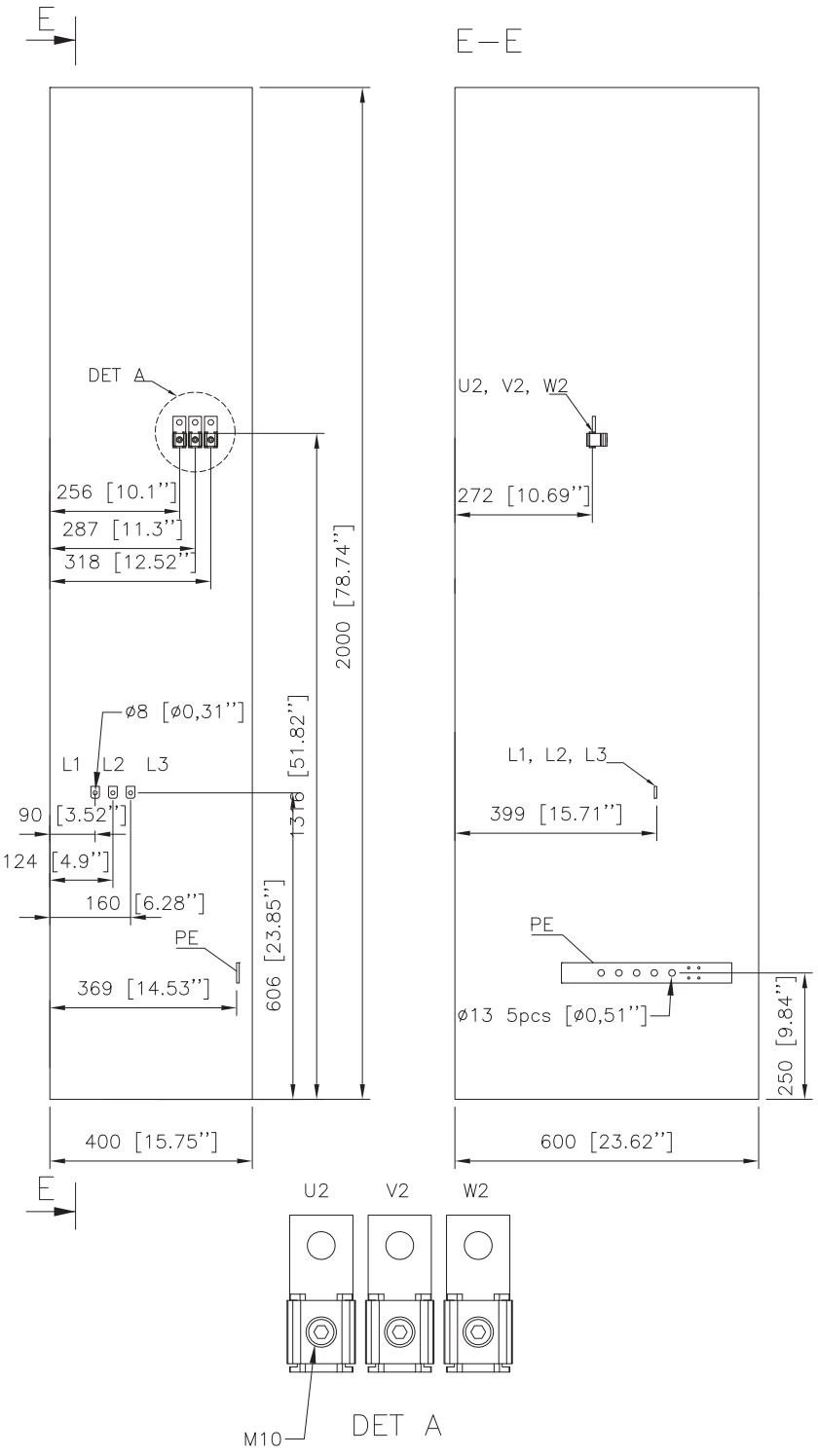
Frame R7: Input and motor cable terminal dimensions (bottom entry and exit, switch fuse OS250)



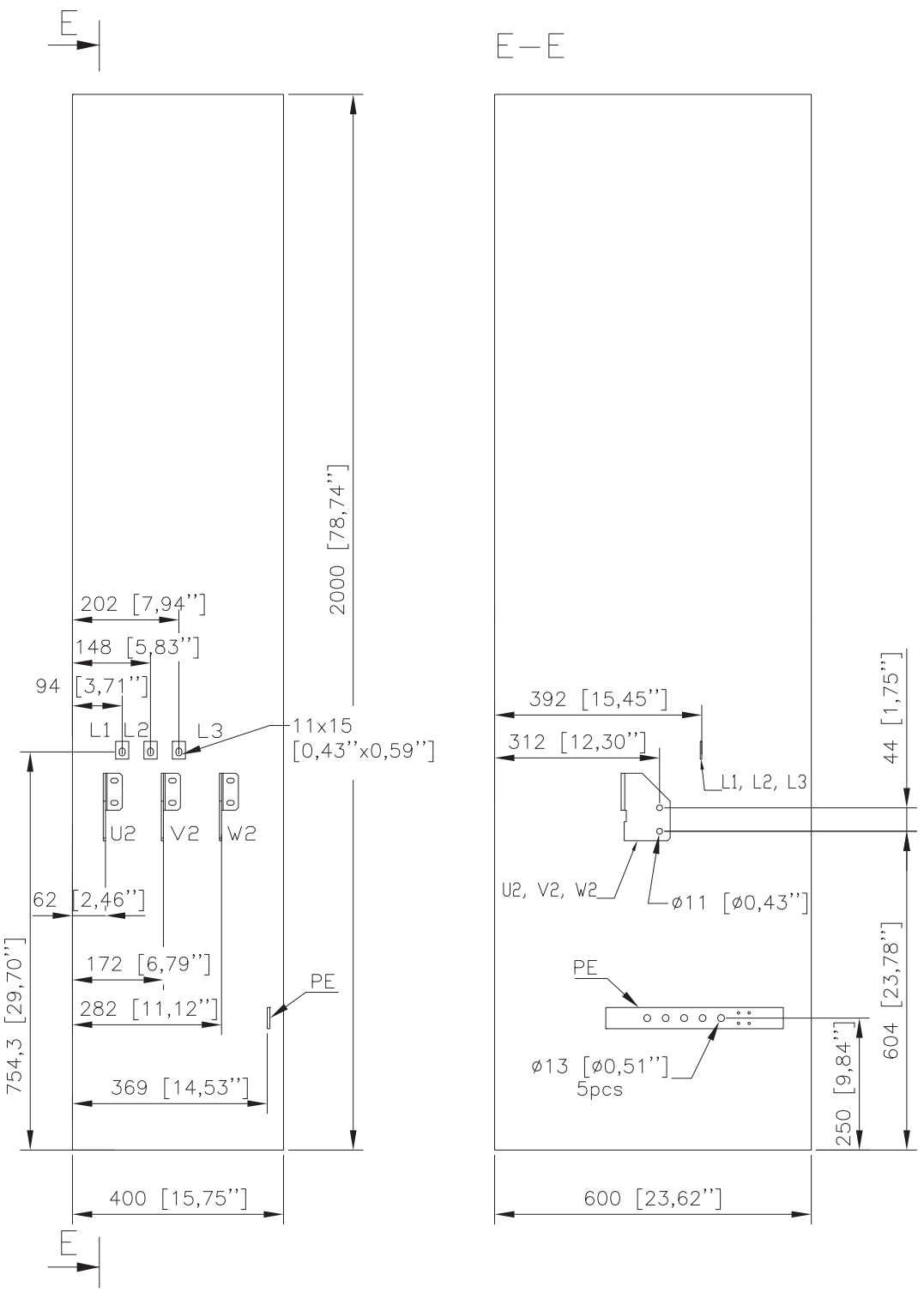
Frame R7: Input and motor cable terminal dimensions (bottom entry and exit, switch fuse OS400)



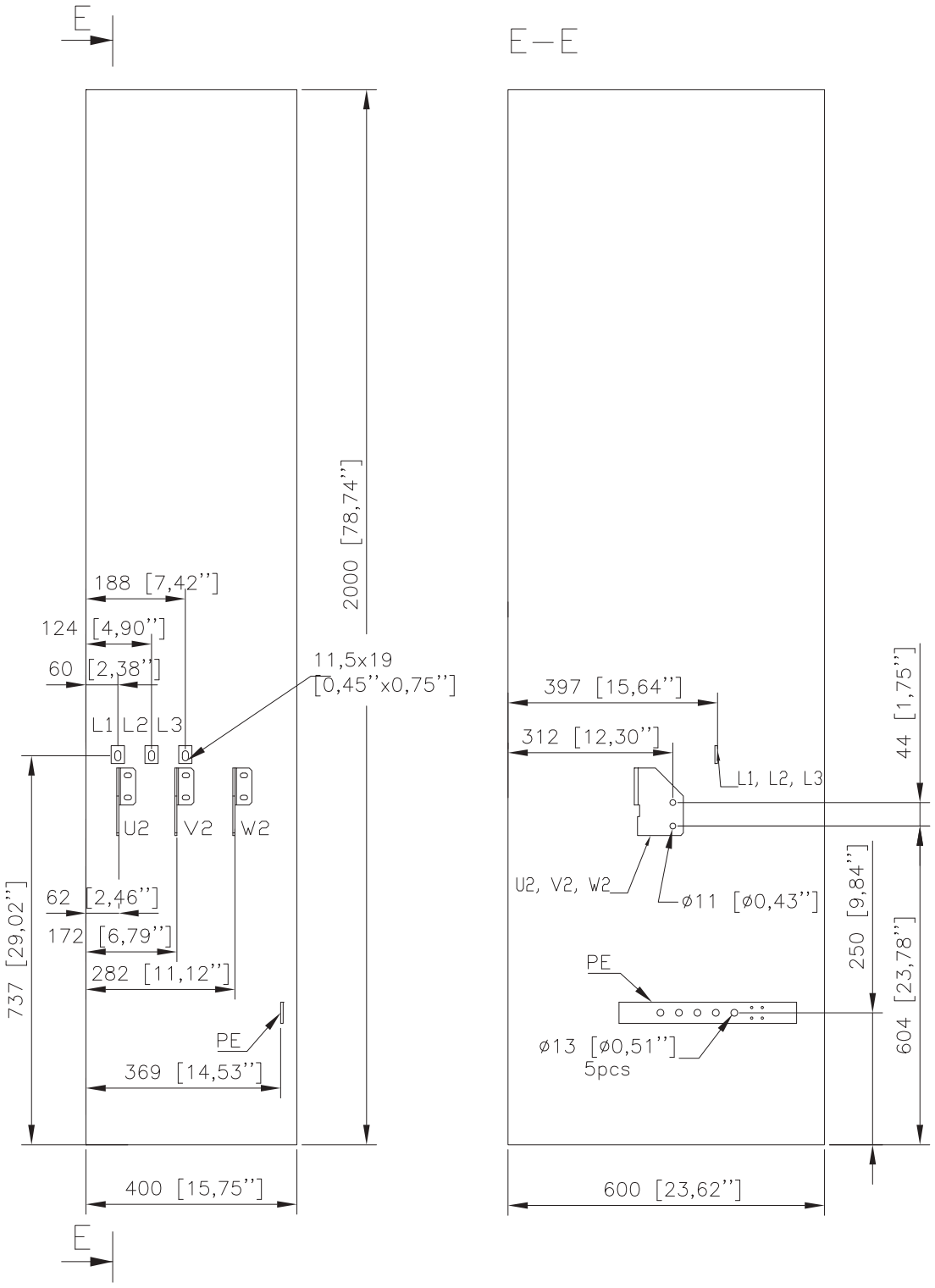
Frame R7: Input and motor cable terminal dimensions (bottom entry and exit, option +F289)



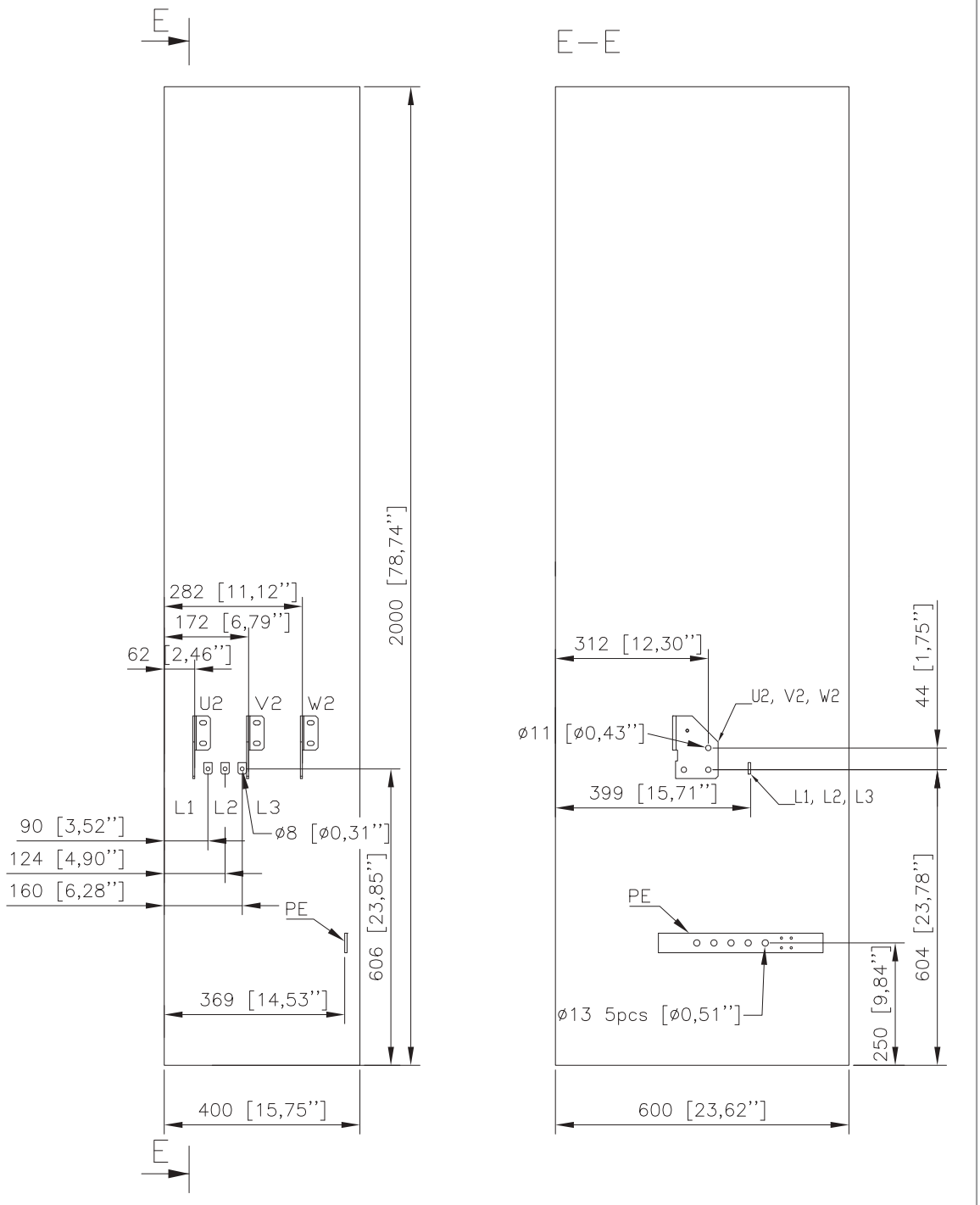
Frames R6 and R7: Input and motor cable terminal dimensions (bottom entry and exit, switch fuse OS250, du/dt filter [option +E205])



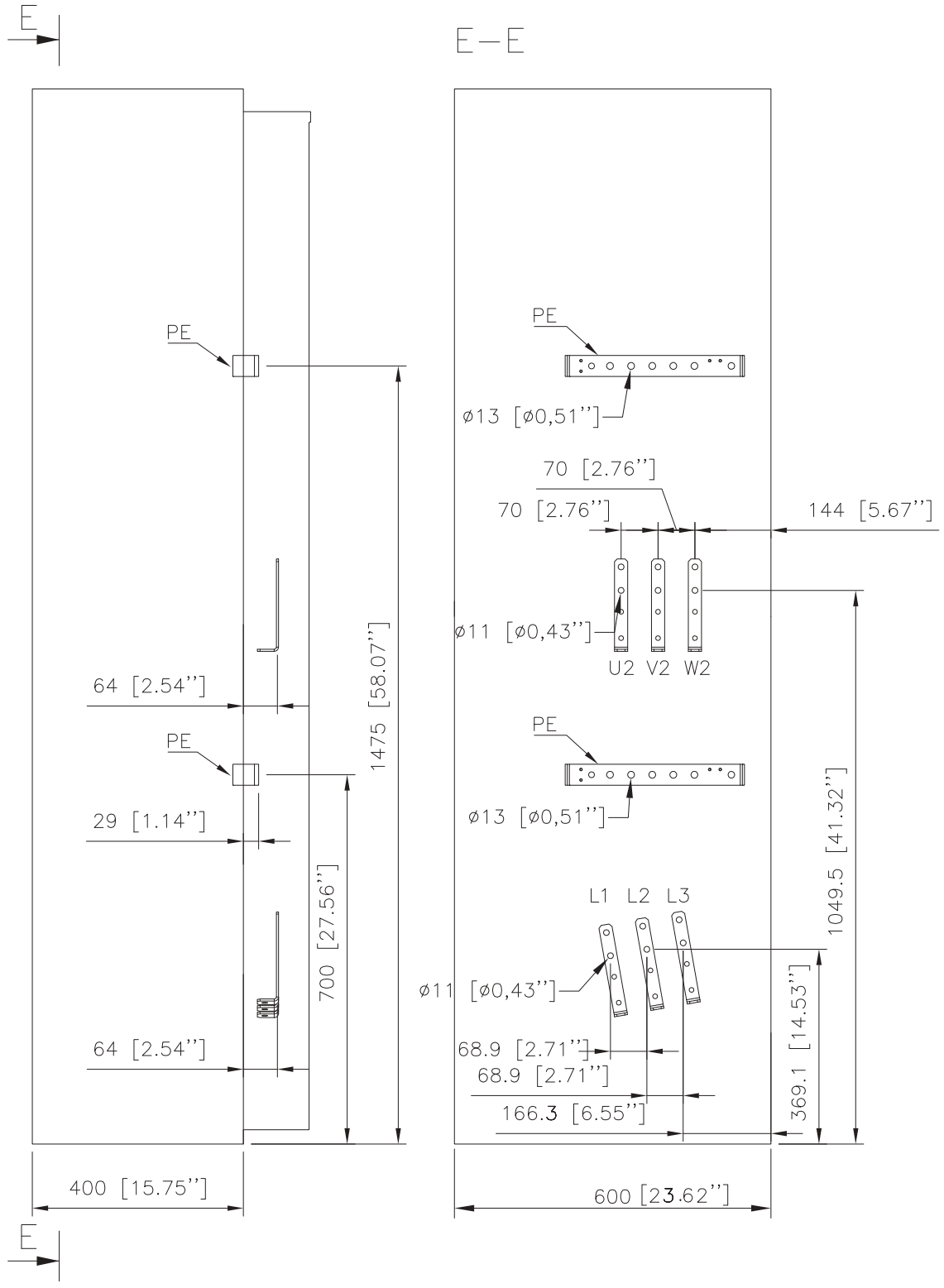
Frames R6 and R7: Input and motor cable terminal dimensions (bottom entry and exit, switch fuse OS400, du/dt filter [option +E205])



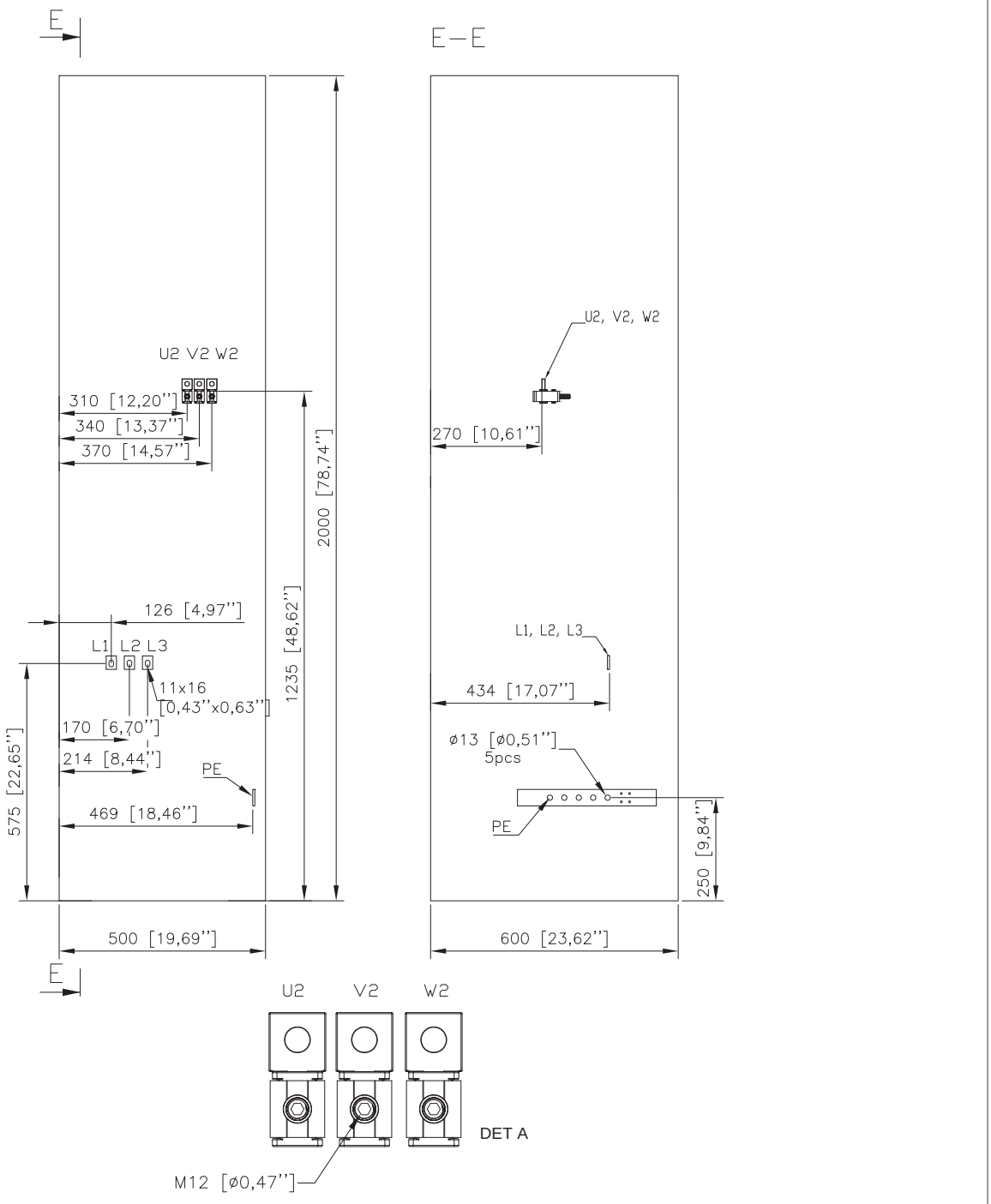
Frames R6 and R7: Input and motor cable terminal dimensions (bottom entry and exit, options +F289 and +E205)



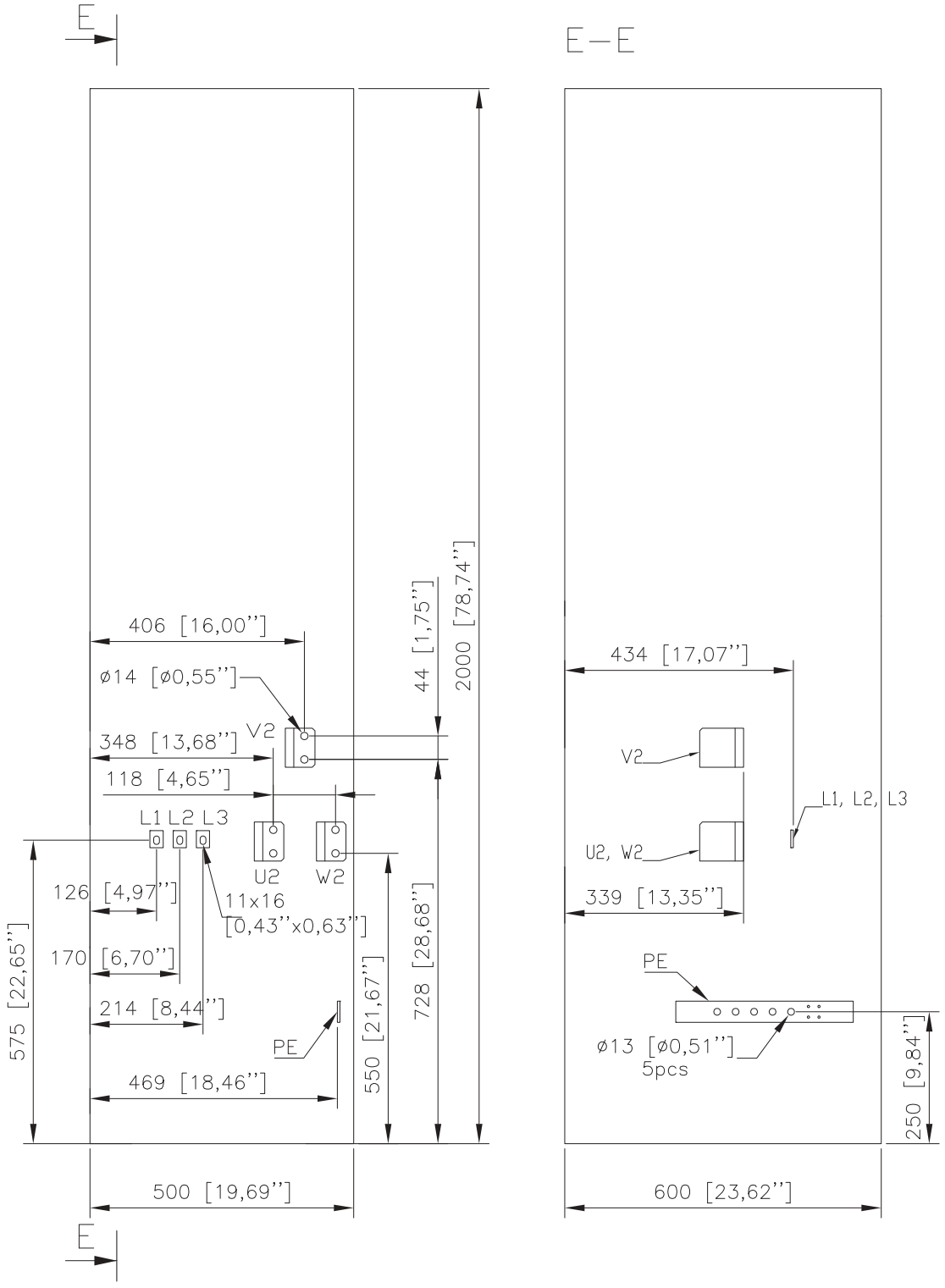
Frames R6 and R7: Input and motor cable terminal dimensions (top entry and exit, options +H351 and +H353)



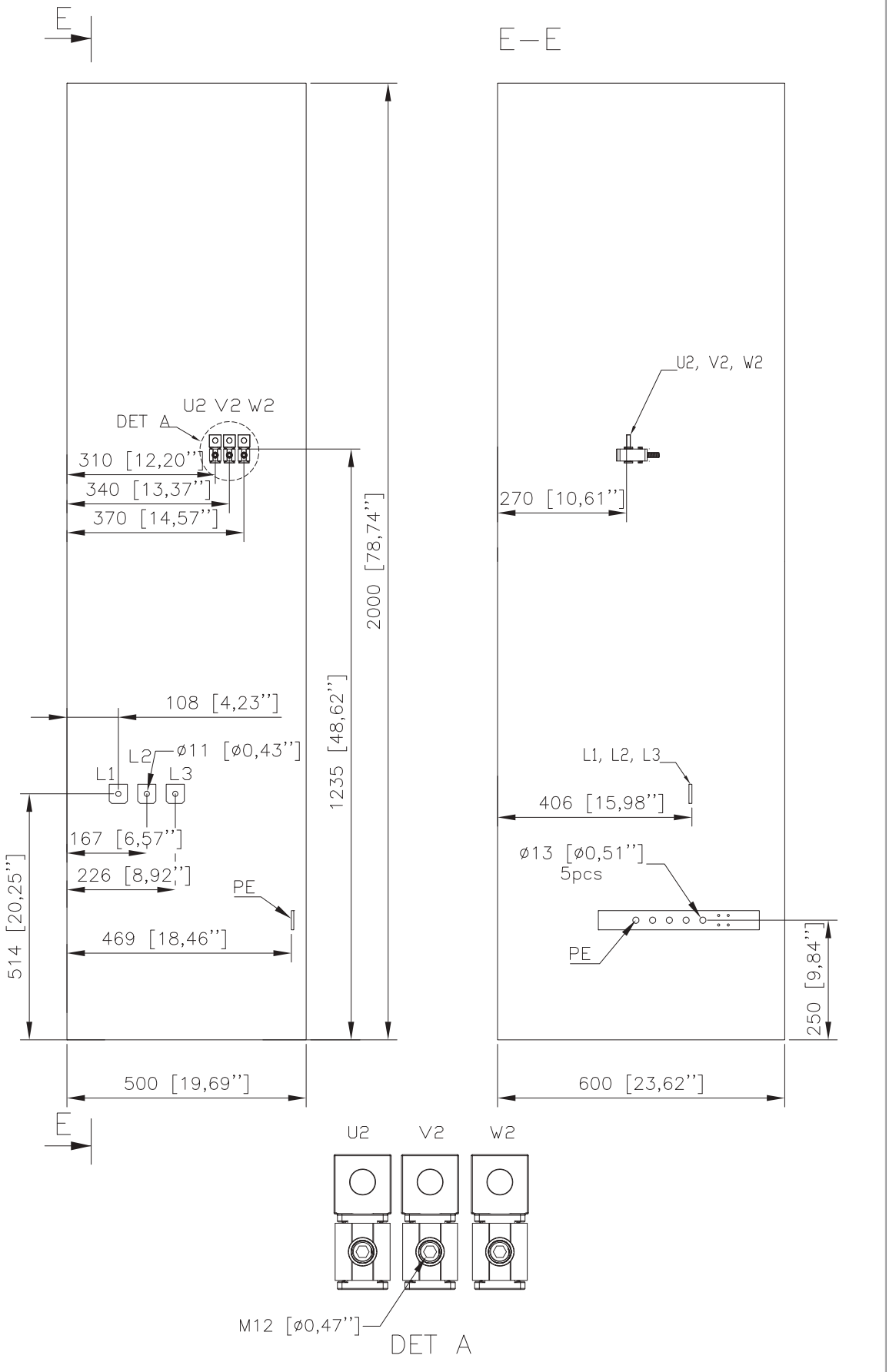
Frame R8: Input and motor cable terminal dimensions (bottom entry and exit, switch-disconnector OT400)



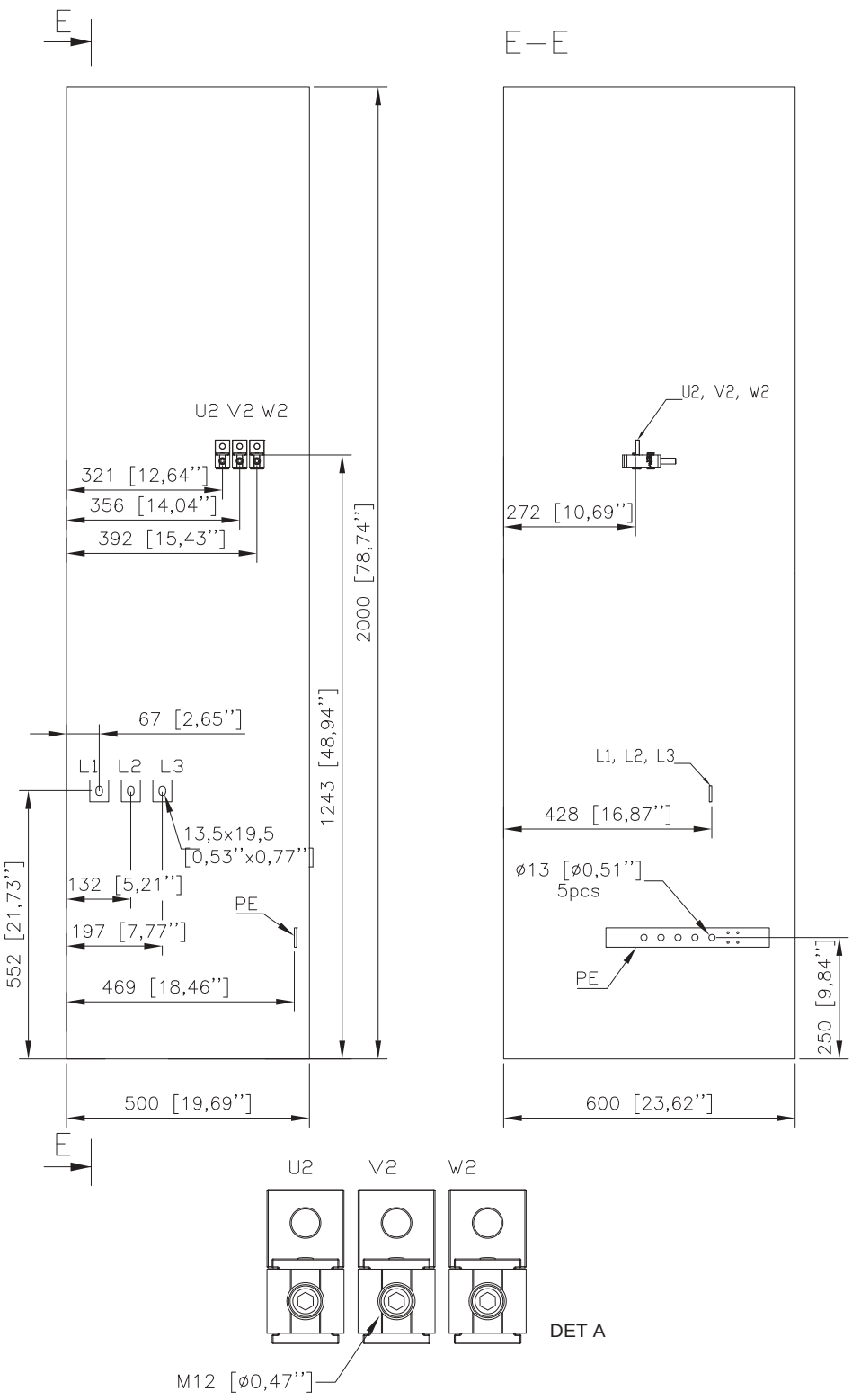
Frame R8: Input and motor cable terminal dimensions (bottom entry and exit, switch-disconnector OT400, du/dt filter [option +E205])



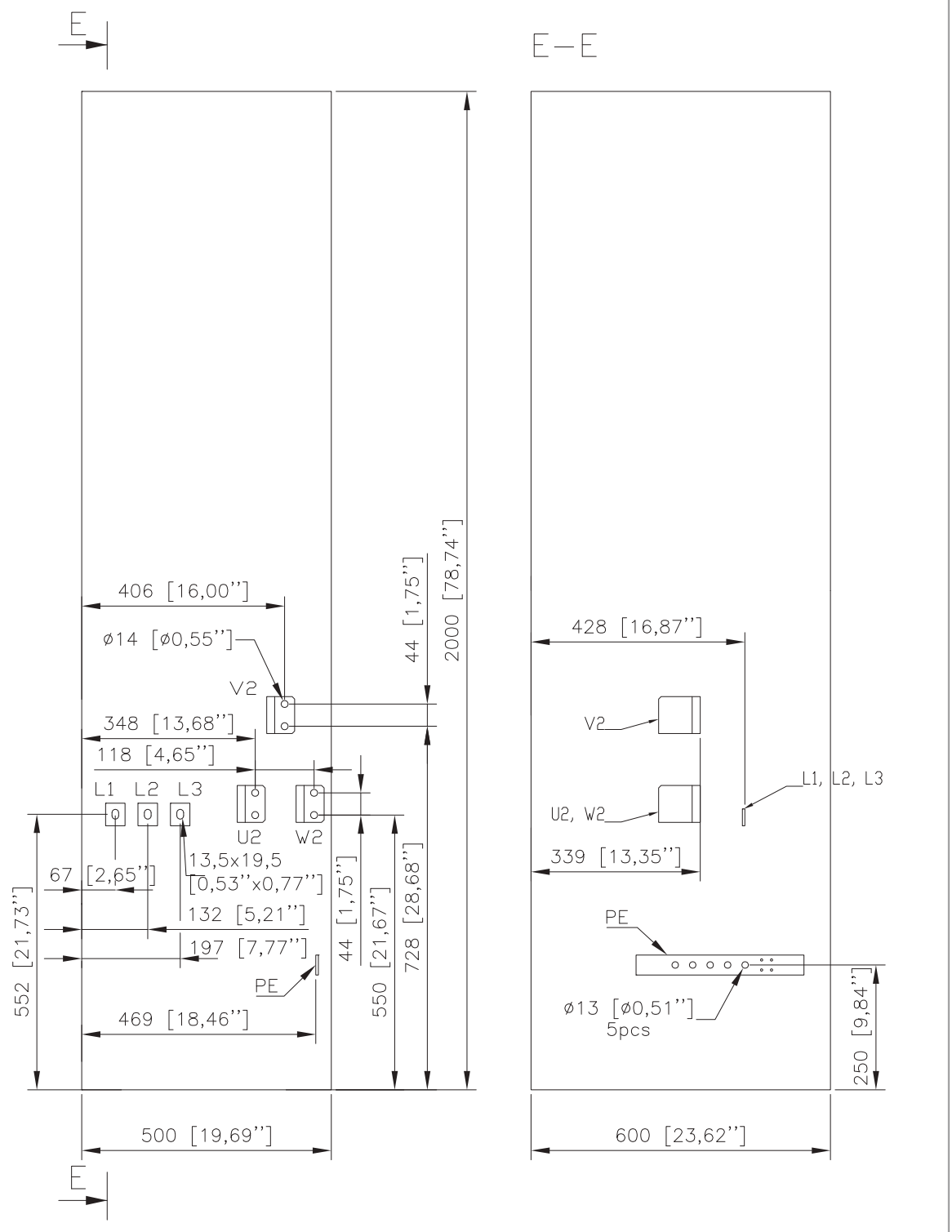
Frame R8: Input and motor cable terminal dimensions (bottom entry and exit, option +F289)



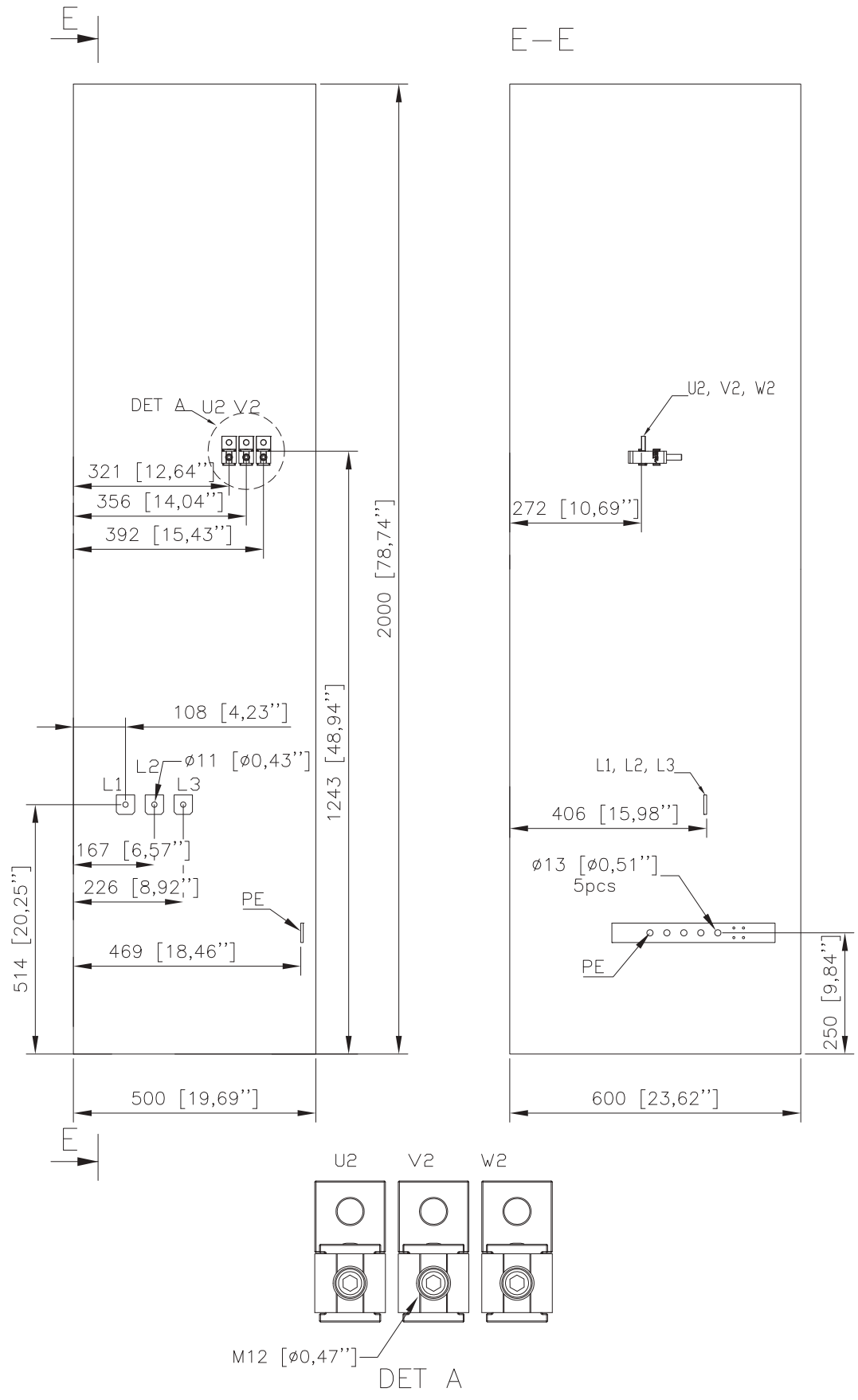
Frame R9: Input and motor cable terminal dimensions (bottom entry and exit, switch-disconnector OT630)



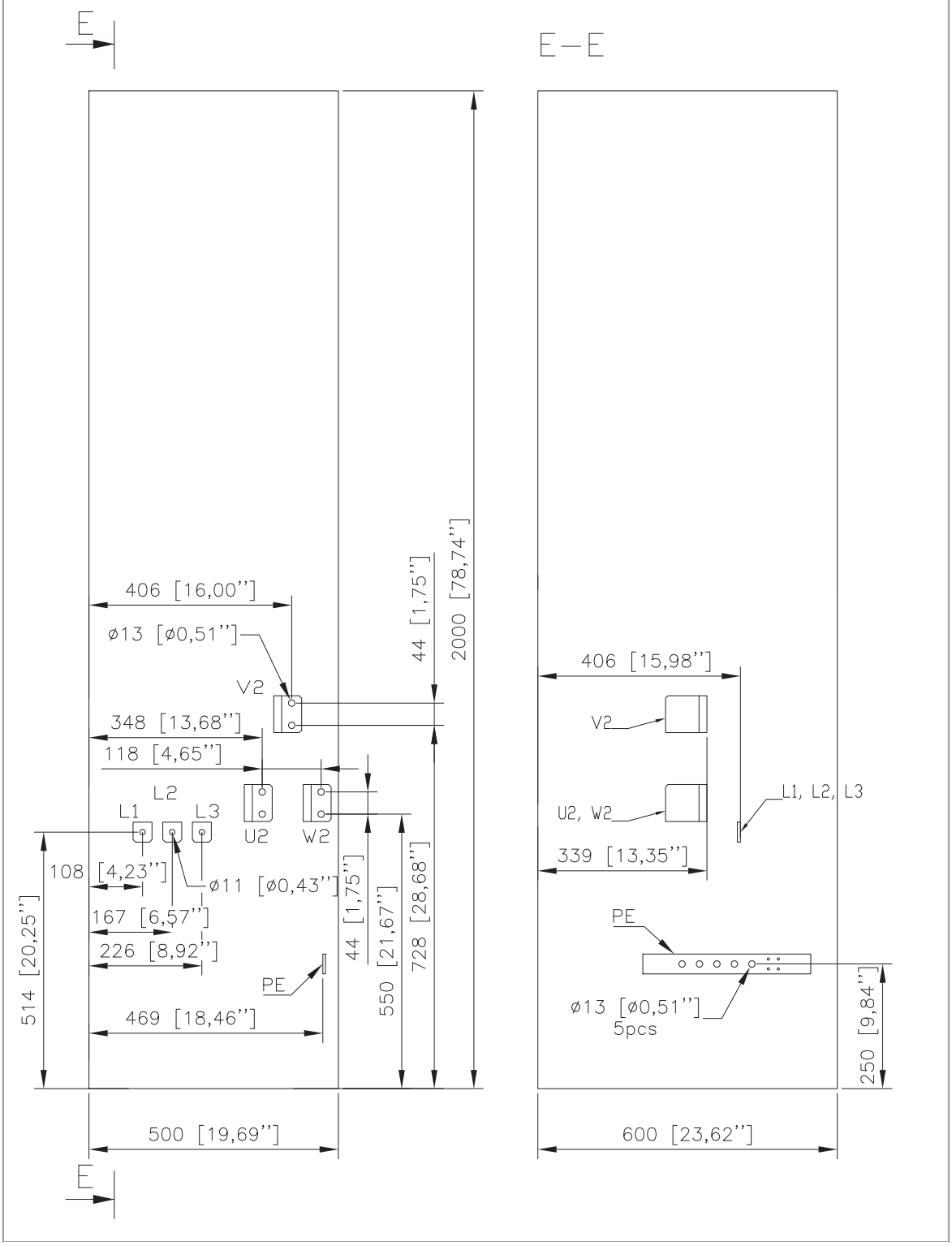
Frame R9: Input and motor cable terminal dimensions (bottom entry and exit, switch-disconnector OT630, du/dt filter [option +E205])



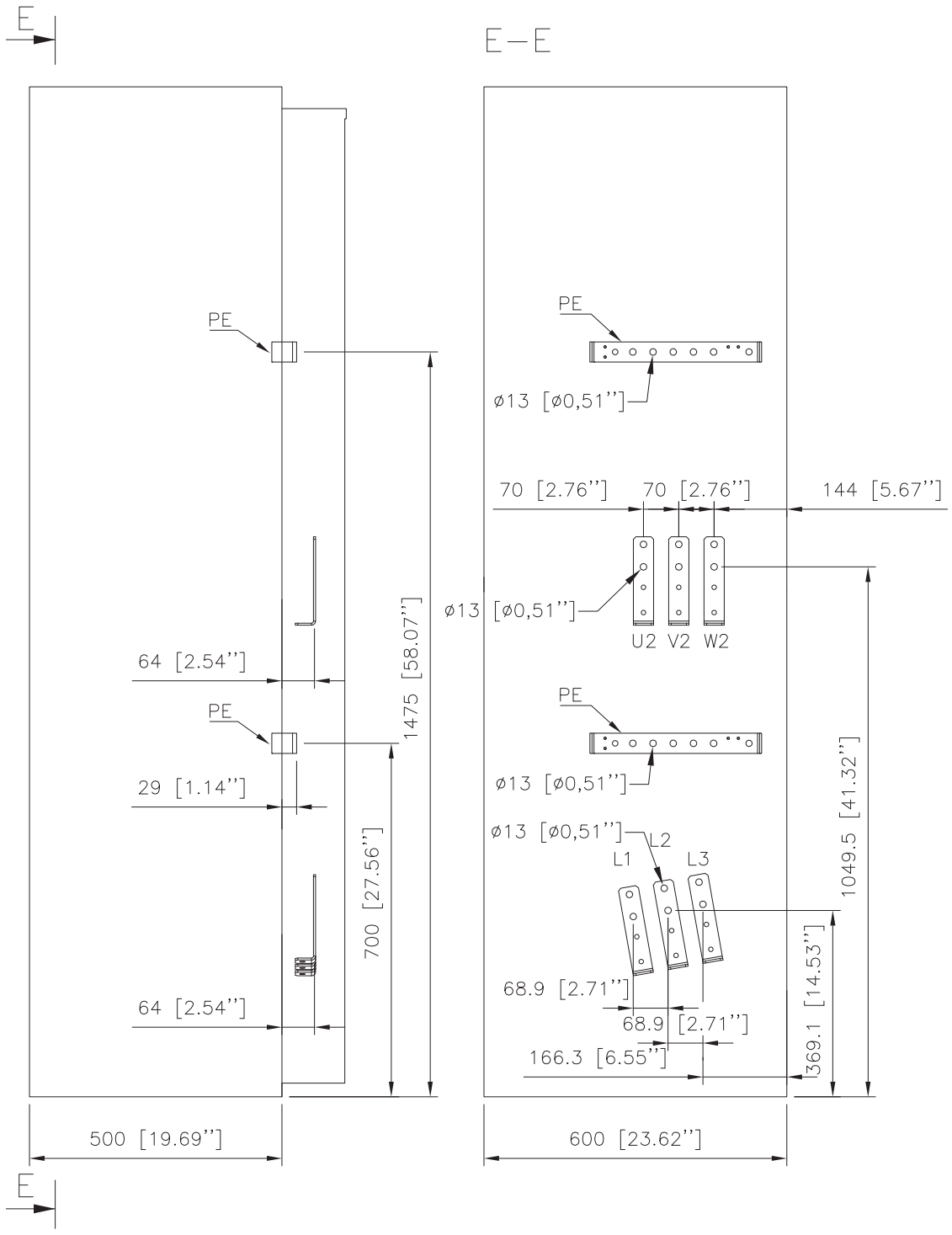
Frame R9: Input and motor cable terminal dimensions (option +F289)



Frames R8 and R9: Input and motor cable terminal dimensions (bottom entry and exit, options +F289 and +E205)



Frames R8 and R9: Input and motor cable terminal dimensions (top entry and exit, options +H351 and +H353)



Terminal and connection data for auxiliary control circuits

Maximum acceptable voltage and current values and wire sizes in terminal blocks are given below.

Terminal block	Maximum acceptable voltage and current values and wire sizes
X250	230V AC / 24V DC, 2A • Solid wire 0,14...4 mm2 (28...12 AWG) • Stranded wire 0,08...2,5 mm2 (28...14 AWG)
X289	230V AC / 24V DC, 2A • Solid wire 0,14...4 mm2 (28...12 AWG) • Stranded wire 0,08...2,5 mm2 (28...14 AWG)
X290	230V AC / 24V DC, 2A • Solid wire 0,14...4 mm2 (28...12 AWG) • Stranded wire 0,08...2,5 mm2 (28...14 AWG)
X300	230V AC, 4A • Solid wire 0,14...4 mm2 (28...12 AWG) • Stranded wire 0,08...2,5 mm2 (28...14 AWG)
X951	24V DC • Solid wire 0,14...4 mm2 (28...12 AWG) • Stranded wire 0,08...2,5 mm2 (28...14 AWG)
X969	24V DC • Solid wire 0,14...4 mm2 (28...12 AWG) • Stranded wire 0,08...2,5 mm2 (28...14 AWG)
X3	24V DC • Solid wire 0,14...4 mm2 (28...12 AWG) • Stranded wire 0,08...2,5 mm2 (28...14 AWG)
X504	230V AC / 24V DC, 2A • Solid wire 0,2...2,5 mm2 (24...12 AWG) • Stranded wire with ferrule 0,25...2,5 mm2 (24...14 AWG) • stranded wire without ferrule 0,2 to 2,5 mm2 (24 to 12 AWG). Stripping length: 10 mm (0.5 in).
X601.1	480V AC, 20A • Solid wire 0,75...16 mm2 (18...6 AWG) • Stranded wire 0,75...16 mm2 (18...6 AWG)
X601.1	230V AC / 24V DC, 2A • Solid wire 0,2...2,5 mm2 (24...14 AWG) • Stranded wire 0,2...2,5 mm2 (24...14 AWG)

Electrical power network specification

Voltage (U_1)	ACQ80-07-xxxxx-4 drives: AC voltage: 380…480 VAC 3-phase ±10%. This is indicated in the type designation label as typical input voltage levels 3~400/480 V AC. DC voltage: 390/800 V DC.
Network type	TN (grounded) and IT (ungrounded) systems
Short-circuit withstand strength *I*cc (IEC/EN 61439-1)	Maximum allowable prospective short-circuit current is 65 kA when the input cable is protected with gG type fuses (IEC 60269) having maximum current rating as follows: • 400 A for frames R6 to R8 • 630 A for frame R9
Frequency (f_1)	50/60 Hz. Variation ±5% of nominal frequency.
Imbalance	Max. ± 3% of nominal phase to phase input voltage
Fundamental power factor (cos phi$_1$)	0.98 (at nominal load)

Motor connection data

Motor types	Asynchronous AC induction motors, permanent magnet synchronous motors
Voltage (U_2)	0 to U_1, 3-phase symmetrical. This is indicated in the type designation label as typical output voltage level 3 ~ 0...U_1. U_{max} at the field weakening point.
Frequency (f_2)	0…500 Hz For drives with du/dt filter: 500 Hz
Current	See section Electrical ratings (page 157).
Switching frequency	3 kHz (typically)
Maximum recommended motor cable length	300 m (984 ft). Longer cables cause a motor voltage decrease which limits the available motor power. The decrease depends on the motor cable length and characteristics. Note that a sine filter (optional) at the drive output also causes a voltage decrease. Contact ABB for more information. **Note:** With motor cables longer than 100 m (328 ft), the EMC Directive requirements may not be fulfilled.

Control unit connection data

See chapter Control unit (page 115).

Efficiency

Approximately 98% at nominal power level

The efficiency is not calculated according to the ecodesign standard IEC 61800-9-2.

Energy efficiency data (ecodesign)

Energy efficiency data is not provided for the drive. The cabinet-installed drives comprising drive modules which are in conformity with the regulation are exempt

from the EU ecodesign requirements (Regulation EU/2019/1781, §2.3.e) and the UK ecodesign requirements (Regulation SI 2021 No. 745).

Protection classes

Degrees of protection (IEC/EN 60529)	IP42 (option +B054), IP54 (Standard)
Enclosure types (UL50)	UL Type 1 (option +B054), UL Type 12 (Standard). For indoor use only.
Arcing class (IEC TR 61641)	B – ASSEMBLY providing personnel and ASSEMBLY protection under arcing conditions. Tested at the following voltage with an arcing current of 65 kA for 300 milli-seconds: 400 V units (indicated by "-4" in drive type): 420 V
Overvoltage category (IEC/EN 60664-1)	III, except for auxiliary power connections (fan, control, heating, lighting etc) which are category II.
Protective class (IEC/EN 61800-5-1)	I

Ambient conditions

Environmental limits for the drive are given below. The drive is to be used in a heated, indoor, controlled environment.

	Operation installed for stationary use	**Storage** in the protective package	**Transportation** in the protective package
Installation site altitude	0 to 2000 m (6561 ft) above sea level. For altitudes over 2000 m, contact ABB. Output derated above 1000 m (3281 ft). See section Altitude derating.	-	-
Air temperature	-0 to +50 °C (32 to 122 °F). No condensation allowed. Output derated in the range +40 … +50 °C (+104 … +122 °F). See section Electrical ratings.	-40 to +70 °C (-40 to +158 °F)	-40 to +70 °C (-40 to +158 °F)
Relative humidity	5 to 95%	Max. 95%	Max. 95%
	No condensation allowed. Maximum allowed relative humidity is 60% in the presence of corrosive gases.		
Contamination (IEC 60721-3-x)	IEC/EN 60721-3-3:2002	IEC 60721-3-1:1997	IEC 60721-3-2:1997
Chemical gases	Class 3C2	Class 1C2	Class 2C2
Solid particles	Class 3S2. No conductive dust allowed.	Class 1S3. (packing must support this, otherwise 1S2)	Class 2S2
Atmospheric pressure	70 to 106 kPa (0.7 to 1.05 atmospheres)	70 to 106 kPa (0.7 to 1.05 atmospheres)	60 to 106 kPa (0.6 to 1.05 atmospheres)
Vibration IEC 61800-5-1 IEC 60068-2-6:2007, EN 60068-2-6:2008 Environmental testing Part 2: Tests –Test Fc: Vibration (sinusoidal)	IEC/EN 60721-3-3:2002 10…57 Hz: max. 0.075 mm amplitude 57…150 Hz: 1 g	IEC/EN 60721-3-1:1997 10…57 Hz: max. 0.075 mm amplitude 57…150 Hz: 1 g	IEC/EN 60721-3-2:1997 2…9 Hz: max. 3.5 mm amplitude 9…20 Hz: 10 m/s2 (32.8 ft/s2)
Shock IEC 60068-2-27:2008, EN 60068-2-27:2009 Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock	Not allowed	With packing max. 100 m/s2 (330 ft./s2), 11 ms	With packing max. 100 m/s2 (330 ft./s2), 11 ms

Transportation

The table below specifies the transportation methods and conditions for the drive. Seaworthy package (option +P912) is required for non-weather protected transportation conditions.

Package type	Method	Weather-protected conditions (IEC 60721-3-2)	Non-weather protected conditions (IEC 60721-3-2)
Standard package Wooden crate Vertical	Road, air, sea (in container). Special vehicle requirements: High-cube container. ABB recommends the use of container desiccant bags in sea transportation.	**2K12**: Transportation without temperature and humidity control allowed.	Not allowed.
Seaworthy package (option +P912) Wooden crate covered with plywood sheets Vertical	Road, air, sea (in container). Special vehicle requirements: High-cube container. ABB recommends the use of container desiccant bags in sea transportation.	**2K12**: Transportation without temperature and humidity control allowed.	**2K14:** Non-weather-protected transportation worldwide.
Standard package Cardboard box Horizontal[1)]	Road, rail, air, sea (in container). Special vehicle requirements: Preferred for air and courier. ABB recommends the use of container desiccant bags in sea transportation.	**2K12**: Transportation without temperature and humidity control allowed.	Not allowed.
Seaworthy package (option +P912) Wooden crate covered with plywood sheets Horizontal[1)]	Road, rail, air, sea. Special vehicle requirements: Preferred for sea transportation. ABB recommends the use of container desiccant bags in sea transportation.	**2K12**: Transportation without temperature and humidity control allowed.	**2K14:** Non-weather-protected transportation worldwide.

1) Drive widths up to 830 mm can be delivered in a horizontal package. Factory makes the final decision on the packing position. It depends, for example, on the drive size and options, and the transportation method.

Storage conditions

The table below specifies the storage conditions for the drive. Store the drive in its package. ABB recommends seaworthy package (option +P912) if the drive is in long-term storage. The storage conditions must also comply with the environmental limits specified in .

Package type	Storage conditions (IEC 60721-3-1)
Standard package Wooden crate Vertical	**1K20:** Up to 24 months in enclosed conditions (full temperature and humidity control). **1K22:** Up to 6 months in enclosed conditions (no temperature or humidity control). **1K23, 1K24**: Up to 3 months in sheltered conditions (roof providing protection from direct rain and sun). **1K25…1K27:** Up to 48 hours between loading operations in open-air conditions (no protection).
Seaworthy package (option +P912) Wooden crate covered with plywood sheets Vertical	**1K20:** Up to 24 months in enclosed conditions (full temperature and humidity control). **1K22:** Up to 12 months in enclosed conditions (no temperature or humidity control). **1K23, 1K24:** Up to 12 months in sheltered conditions (roof providing protection from direct rain and sun). **1K25…1K27:** Up to 1 month in open-air conditions (no protection). Not recommended, but can be temporarily allowed.
Standard package Cardboard box Horizontal	**1K20:** Up to 24 months in enclosed conditions (full temperature and humidity control). **1K22:** Up to 6 months in enclosed conditions (no temperature or humidity control). **1K23, 1K24:** Up to 2 months in sheltered conditions (roof providing protection from direct rain and sun). **1K25…1K27:** Storing in open-air conditions (no protection) is not allowed.
Seaworthy package (option +P912) Plywood box Horizontal	**1K20:** Up to 24 months in enclosed conditions (full temperature and humidity control). **1K22:** Up to 12 months in enclosed conditions (no temperature or humidity control). **1K23, 1K24:** Up to 6 months in sheltered conditions (roof providing protection from direct rain and sun). **1K25…1K27:** Up to 1 month in open-air conditions (no protection). Not recommended, but can be temporarily allowed.

Auxiliary circuit power consumption

Cabinet heater (option +G300)	100 W
External uninterruptible 150 W power supply (option +G307)	150 W
Motor heater (option +G313)	According to the heater type

Color

Cabinet: RAL Classic 7035

Materials

Package materials for cabinet-installed low-power single drives

- Cardboard heavy duty quality with wet strength glue
- Plywood[1)]
- Wood
- PET (strapping)
- PE (VCI film)
- Metal (fixing clamps, screws)
- Clay desiccant.

1) Horizontal package only: Also cardboard hoods are used instead.

Package materials for options, accessories and spare parts

- Cardboard
- Kraft paper
- PP (straps)
- PE (film, bubble wrap)
- Plywood, wood (only for heavy components).

Materials vary according to the item type, size and shape. Typical package consists of a cardboard box with paper filling or bubble wrap. ESD-safe packing materials are used for printed circuit boards and similar items.

Materials of manuals

Printed product manuals are made of recyclable paper. Product manuals are available on the Internet.

Disposal

The main parts of the drive can be recycled to preserve natural resources and energy. Product parts and materials should be dismantled and separated.

Generally all metals, such as steel, aluminum, copper and its alloys, and precious metals can be recycled as material. Plastics, rubber, cardboard and other packaging material can be used in energy recovery.

Printed circuit boards and DC capacitors need selective treatment according to IEC 62635 guidelines.

To aid recycling, most plastic parts are marked with an appropriate identification code. In addition, components containing substances of very high concern (SVHCs) are listed in European Chemicals Agency's SCIP database. SCIP is the database for information on Substances of Concern In articles as such or in complex objects (Products) established under the Waste Framework Directive (2008/98/EC). For further information, contact your local ABB distributor or consult European Chemicals Agency's SCIP database to find out which SVHCs are used in the drive, and to find out where those components are located.

Contact your local ABB distributor for further information on environmental aspects. End of life treatment must follow international and national regulations.

For more information on ABB end of life services, refer to new.abb.com/service/end-of-life-services.

Package dimensions and weights for drives without empty cubicles (without options +C196 ... +C201)

Frame size	Height	Width	Depth	Standard/Option	Material	Container type
	mm	mm	mm			
R6…R9	900	820	2520	Standard	Cardboard	20DC[1)]
				+P912	Plywood	20DC[1)]

1) All containers are ok, this is the most common.

Frame size	Height	Width	Depth	Standard/Option	Material	Container type
	in	in	in			
R6…R9	35.43	32.28	99.21	Standard	Cardboard	20DC[1)]
				+P912	Plywood	20DC[1)]

1) All containers are ok, this is the most common.

Package weights

Frame size	Standard		+P912	
	kg	lb	kg	lb
R6	210	463	210	463
R7	220	485	220	485
R8	255	562	255	562
R9	275	606	275	606

Applicable standards

The drive complies with the standards below. The compliance with the European Low Voltage Directive is verified according to standard EN 61800-5-1.

EN 61800-5-1:2007	Adjustable speed electrical power drive systems. Part 5-1: Safety requirements – electrical, thermal and energy
IEC 60146-1-1:2009 EN 60146-1-1:2010	Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements
IEC 60204-1:2005 +A1:2008 EN 60204-1:2006 +AC:2010	Safety of machinery. Electrical equipment of machines. Part 1: General requirements. Provisions for compliance: The final assembler of the machine is responsible for installing emergency-stop device.
IEC 60529:1989 EN 60529:1991	Degrees of protection provided by enclosures (IP code)

IEC/EN 60664-1:2007	Insulation coordination for equipment within low-voltage systems. Part 1: Principles, requirements and tests
IEC/EN 61439-1:2011	Low-voltage switchgear and control gear assemblies -- Part 1: General rules
CSA C22.2 No. 14-13: 2013	Industrial control equipment
CSA 22.2 No. 274-13: 2013	Adjustable speed drives
IEC 61800-3:2004/A1:2011 EN 61800-3/A1:2012	Adjustable speed electrical power drive systems. Part 3: EMC requirements and specific test methods

Markings

CE	CE mark Product complies with the applicable European Union legislation. For fulfilling the EMC requirements, see the additional information concerning the drive EMC compliance (IEC/EN 61800-3).
RoHS	Restriction of Hazardous Substances (RoHS) mark Product complies with the applicable European Union legislation. The product does not contain any hazardous electrical or electronic substances, and it is an environmentally-friendly product which can be recycled.
	TÜV Safety Approved mark (functional safety) Product contains Safe torque off and possibly other (optional) safety functions which are certified by TÜV according to the relevant functional safety standards. Applicable to drives and inverters; not applicable to supply, brake or DC/DC converter units or modules.
	WEEE mark At the end of life the product should enter the recycling system at an appropriate collection point and not placed in the normal waste stream.
SOLAR IMPULSE EFFICIENT SOLUTION	Solar Impulse mark Product complies with the regulations of Solar Impulse Foundation.

CE marking

A CE mark is attached to the drive to verify that the drive complies with the provisions of the European Low Voltage and EMC Directives. The CE marking also verifies that the drive, in regard to its safety functions (such as Safe torque off), conforms with the Machinery Directive as a safety component.

Compliance with the European Low Voltage Directive

The compliance with the European Low Voltage Directive has been verified according to standard EN 61800-5-1.

Compliance with the European EMC Directive

The EMC Directive defines the requirements for immunity and emissions of electrical equipment used within the European Union. The EMC product standard (EN 61800-3:2004) covers requirements stated for drives. See section Compliance with the EN 61800-3:2004 below.

Compliance with the European Machinery Directive

The drive is an electronic product which is covered by the European Low Voltage Directive. However, the drive includes the Safe torque off function and can be equipped with other safety functions for machinery which, as safety components, are in the scope of the Machinery Directive. These functions of the drive comply with European harmonized standards such as EN 61800-5-2. For the declaration of conformity, see chapter The Safe torque off function (page 205).

Compliance with the EN 61800-3:2004

Definitions

EMC stands for **E**lectro**m**agnetic **C**ompatibility. It is the ability of electrical/electronic equipment to operate without problems within an electromagnetic environment. Likewise, the equipment must not disturb or interfere with any other product or system within its locality.

First environment includes establishments connected to a low-voltage network which supplies buildings used for domestic purposes.

Second environment includes establishments connected to a network not supplying domestic premises.

Drive of category C3: drive of rated voltage less than 1000 V and intended for use in the second environment and not intended for use in the first environment.

Drive of category C4: drive of rated voltage equal to or above 1000 V, or rated current equal to or above 400 A, or intended for use in complex systems in the second environment.

Category C2

The drive frames R6 to R9 comply with the standard with the following provisions:

1. The motor and control cables are selected as specified in the hardware manual.
2. The drive is installed according to the instructions given in the hardware manual.
3. Maximum motor cable length is 150 meters.

WARNING!
The drive may cause radio interference if used in a residential or domestic environment. The user is required to take measures to prevent interference, in addition to the requirements for CE compliance listed above, if necessary.

Note: Do not install a drive equipped with EMC filter on IT (ungrounded) systems. The supply network becomes connected to ground potential through the EMC filter capacitors which may cause danger or damage the unit.

Category C3

The drive complies with the standard with the following provisions:

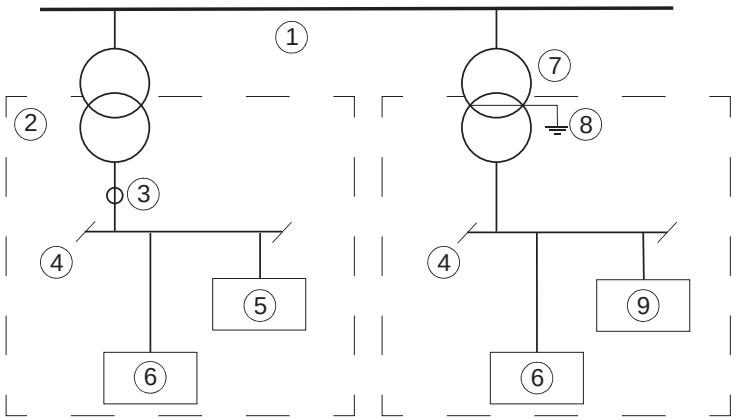
1. The motor and control cables are selected as specified in the hardware manual.
2. The drive is installed according to the instructions given in the hardware manual.
3. Maximum motor cable length is 100 meters.

WARNING!
A drive of category C3 is not intended to be used on a low-voltage public network which supplies domestic premises. Radio frequency interference is expected if the drive is used on such a network.

Category C4

The drive complies with the C4 category with these provisions:

1. It is made sure that no excessive emission is propagated to neighboring low-voltage networks. In some cases, the natural suppression in transformers and cables is sufficient. If in doubt, a supply transformer with static screening between the primary and secondary windings can be used.



1	Medium voltage network	6	Equipment
2	Neighboring network	7	Supply transformer
3	Point of measurement	8	Static screen
4	Low voltage	9	Drive
5	Equipment (victim)	-	-

2. An EMC plan for preventing disturbances is drawn up for the installation. A template is available in Technical guide No. 3 EMC compliant installation and configuration for a power drive system (3AFE61348280 [English]).
3. The motor and control cables are selected, and routed according to the electrical planning guidelines of the drive. The EMC recommendations are obeyed.
4. The drive is installed according to its installation instructions. The EMC recommendations are obeyed.

WARNING!
A drive of category C4 is not intended to be used on a low-voltage public network which supplies domestic premises. Radio frequency interference is expected if the drive is used on such a network.

Design lifetime expectancy

The design lifetime expectancy of the drive and its overall components exceeds ten (10) years in normal operating environments. In some cases, the drive can last 20 years or more. To achieve a long lifetime for the product the manufacturer’s instructions for sizing the drive, installation, operational conditions and preventive maintenance schedule shall be followed.

Disclaimers

Generic disclaimer

The manufacturer shall have no obligation with respect to any product which (i) has been improperly repaired or altered; (ii) has been subjected to misuse, negligence or accident; (iii) has been used in a manner contrary to the manufacturer’s instructions; or (iv) has failed as a result of ordinary wear and tear.

Cyber security disclaimer

This product is designed to be connected to and to communicate information and data via a network interface. It is Customer's sole responsibility to provide and continuously ensure a secure connection between the product and Customer network or any other network (as the case may be). Customer shall establish and maintain any appropriate measures (such as but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc.) to protect the product, the network, its system and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information.

ABB and its affiliates are not liable for damages and/or losses related to such security breaches, any unauthorized access, interference, intrusion, leakage and/or theft of data or information.

Declarations of conformity

Link to Declaration of conformity according to EU Machinery Directive 2006/42/EU (3AXD10000715412)

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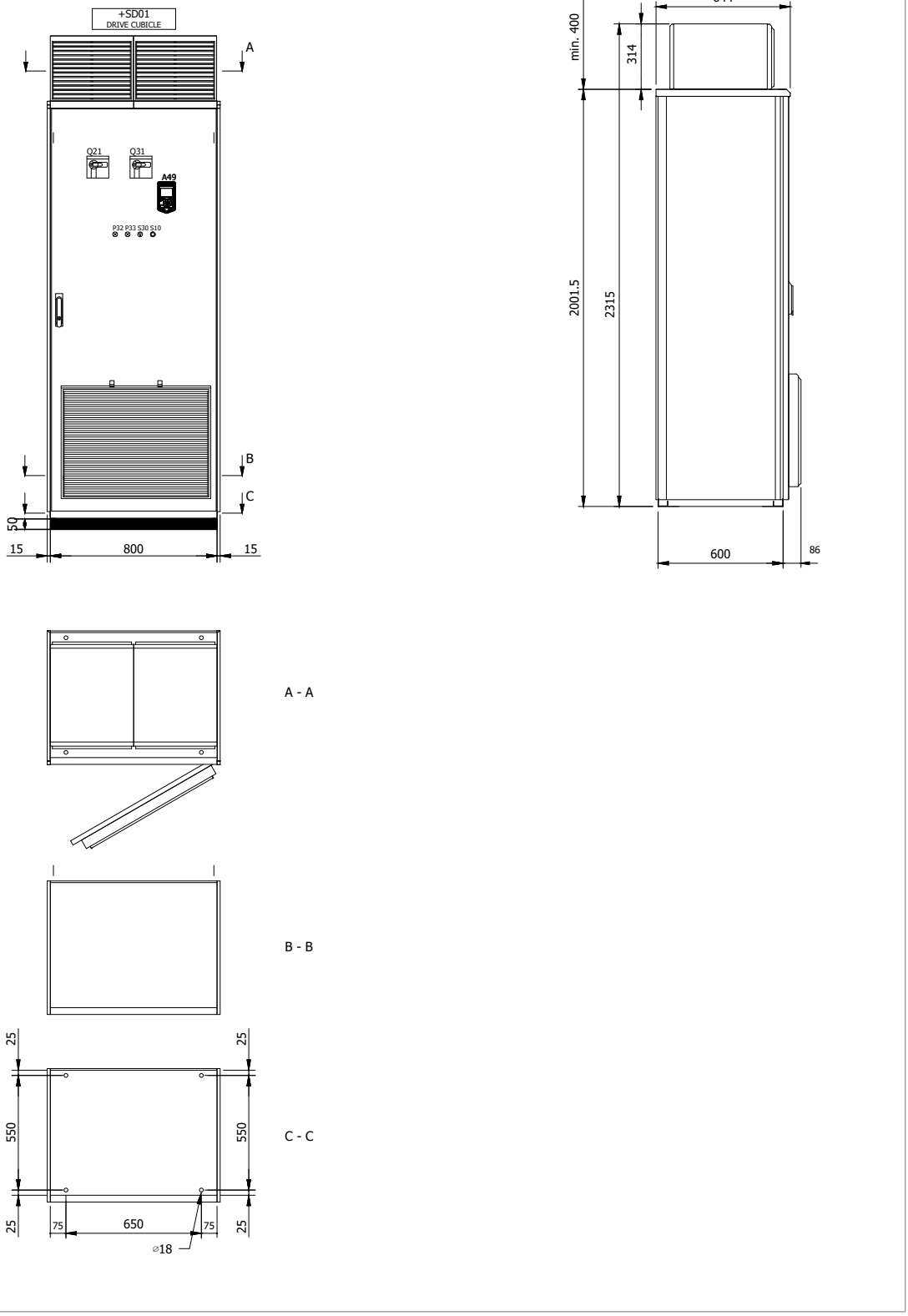
Dimension drawings

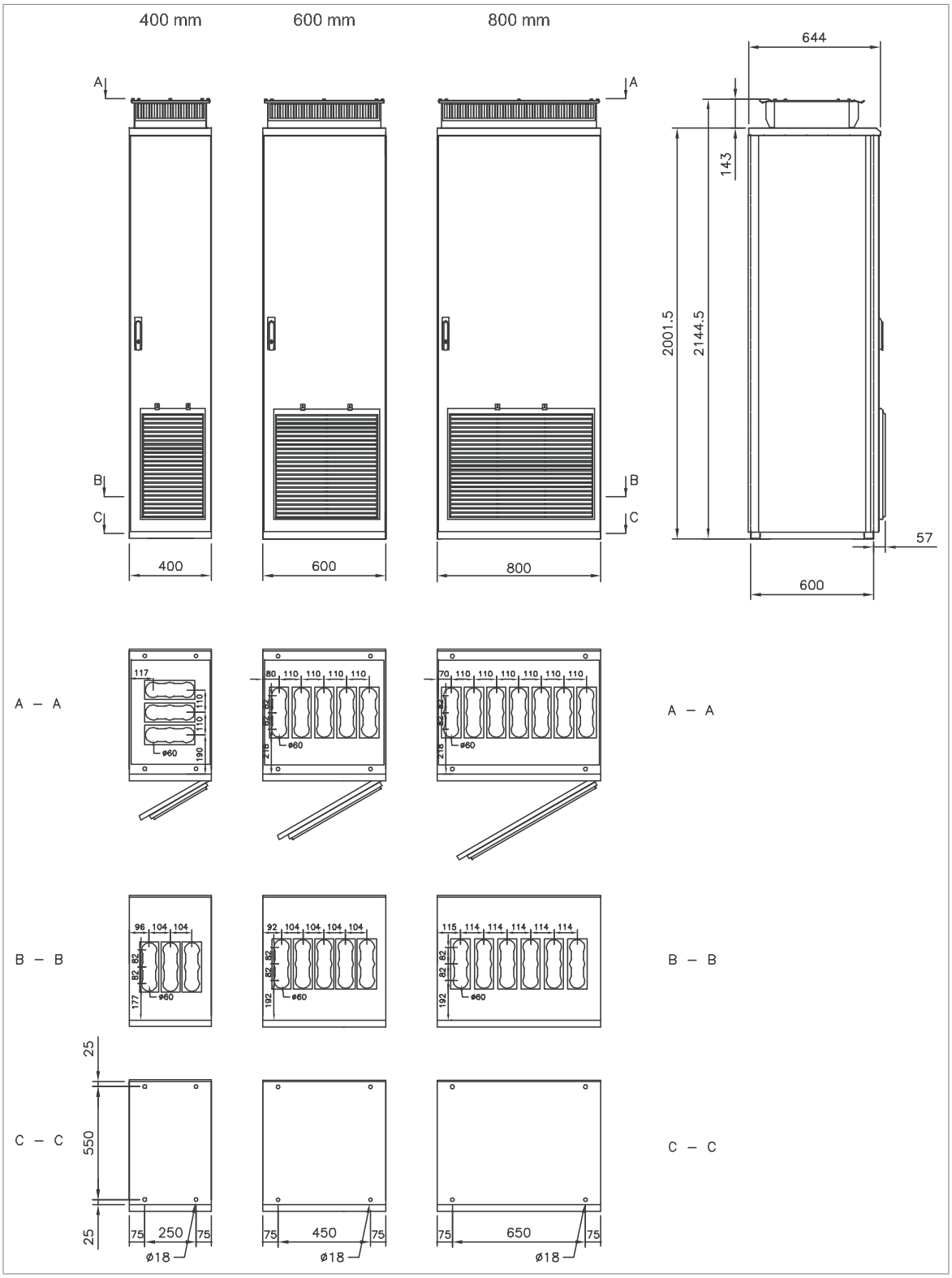
Frame R6...R9 (IP54, UL Type 12)

202 Dimension drawings

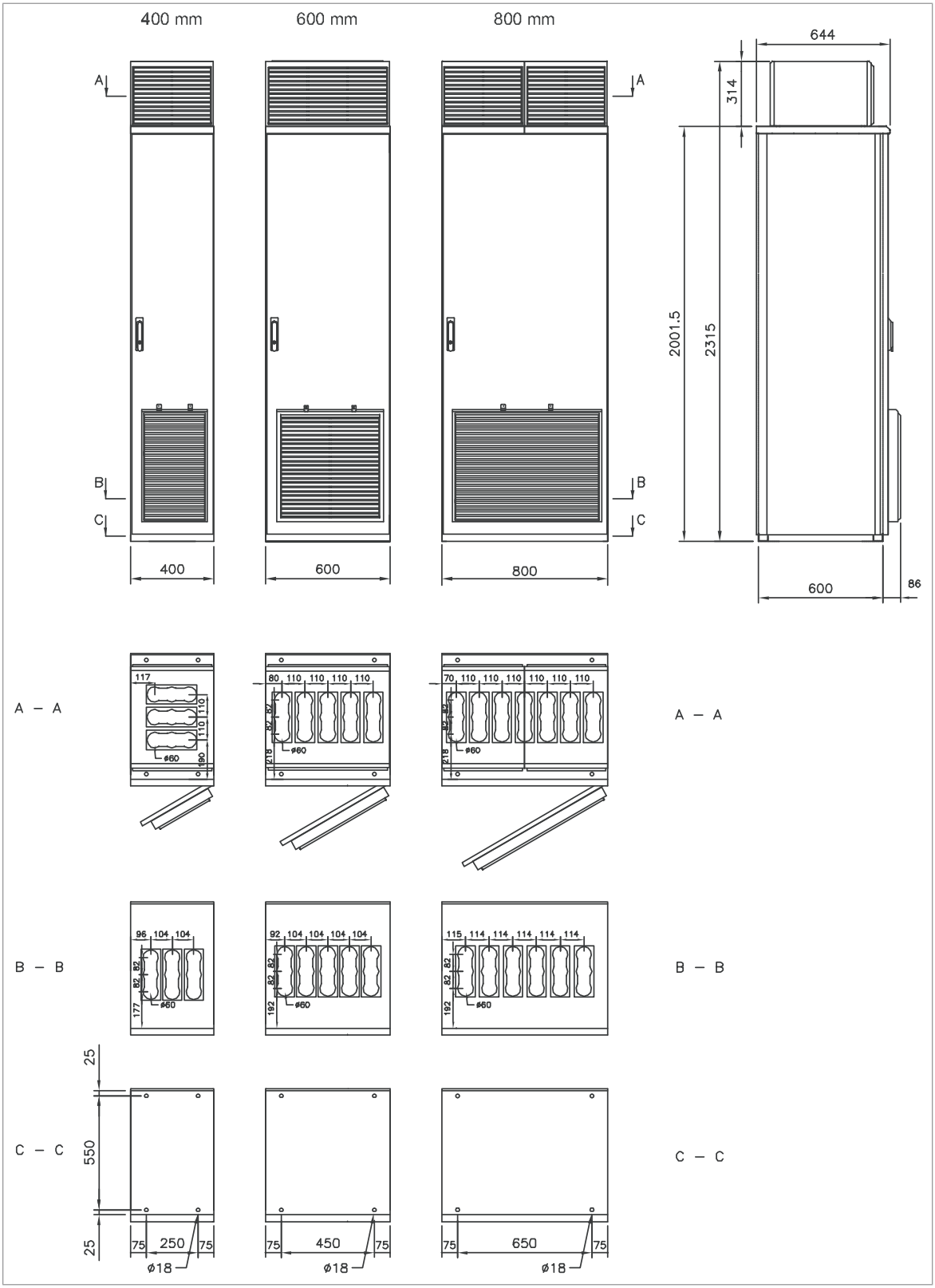


Dimensions of empty cubicles (options +C196...+C201)

IP22/IP42



IP54


400 mm
600 mm
800 mm
644
314
2001.5
2315
600
86
A
B
C
400
600
800
A – A
B – B
C – C
25
550
250
450
650
ø18
ø60

14

The Safe torque off function

Contents of this chapter

This chapter describes the Safe torque off (STO) function of the drive and gives instructions for its use.

Description

The Safe torque off function can be used, for example, as the final actuator device of safety circuits (such as an emergency stop circuit) that stop the drive in case of danger. Another typical application is a prevention of unexpected start-up function that enables short-time maintenance operations like cleaning or work on non-electrical parts of the machinery without switching off the power supply to the drive.

When activated, the Safe torque off function disables the control voltage for the power semiconductors of the drive output stage, thus preventing the drive from generating the torque required to rotate the motor. If the motor is running when Safe torque off is activated, it coasts to a stop.

The Safe torque off function has a redundant architecture, that is, both channels must be used in the safety function implementation. The safety data given in this manual is calculated for redundant use, and does not apply if both channels are not used.

The Safe torque off function complies with these standards:

Standard	Name
IEC 60204-1:2021 EN 60204-1:2018	Safety of machinery – Electrical equipment of machines – Part 1: General requirements
IEC 61000-6-7:2014	Electromagnetic compatibility (EMC) – Part 6-7: Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations

Standard	Name
IEC 61326-3-1:2017	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
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC 61511-1:2017	Functional safety – Safety instrumented systems for the process industry sector
IEC 61800-5-2:2016 EN 61800-5-2:2007	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional
EN IEC 62061:2021	Safety of machinery – Functional safety of safety-related control systems
EN ISO 13849-1:2015	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
EN ISO 13849-2:2012	Safety of machinery – Safety-related parts of control systems – Part 2: Validation

The function also corresponds to Prevention of unexpected start-up as specified by EN ISO 14118:2018 (ISO 14118:2017), and Uncontrolled stop (stop category 0) as specified in EN/IEC 60204-1.

Compliance with the European Machinery Directive and the UK Supply of Machinery (Safety) Regulations

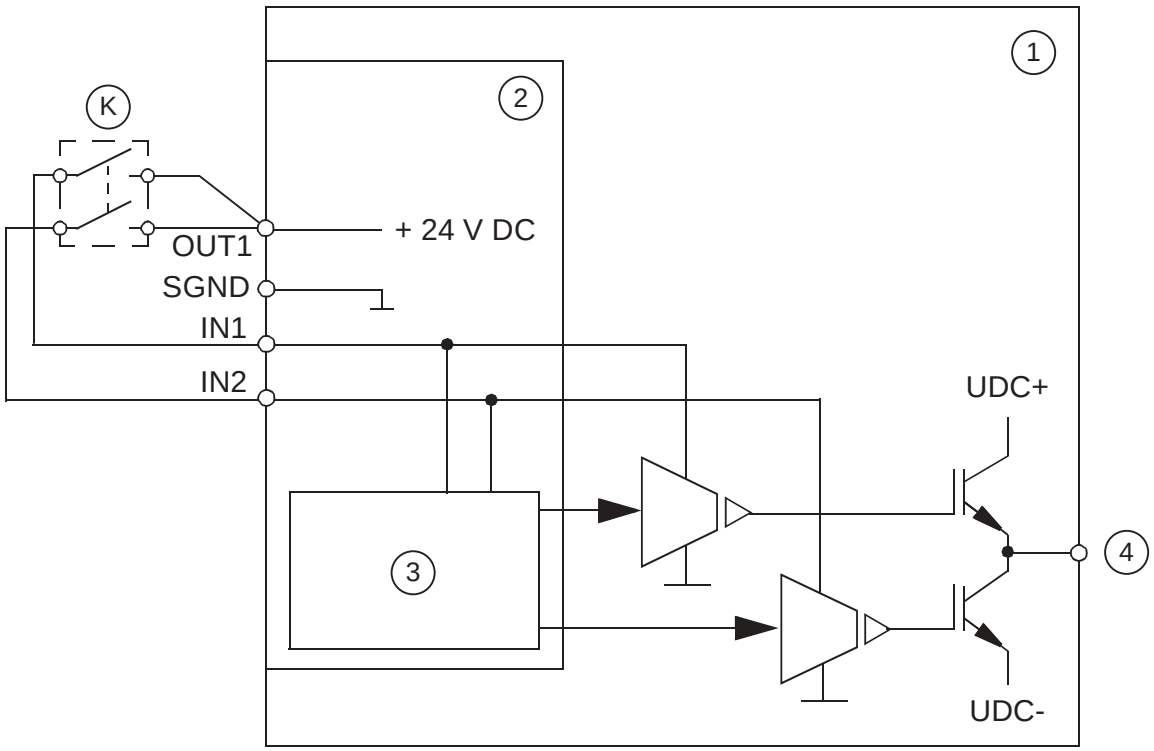
See the technical data.

Wiring

For the electrical specifications of the STO connection, see the technical data of the control unit.

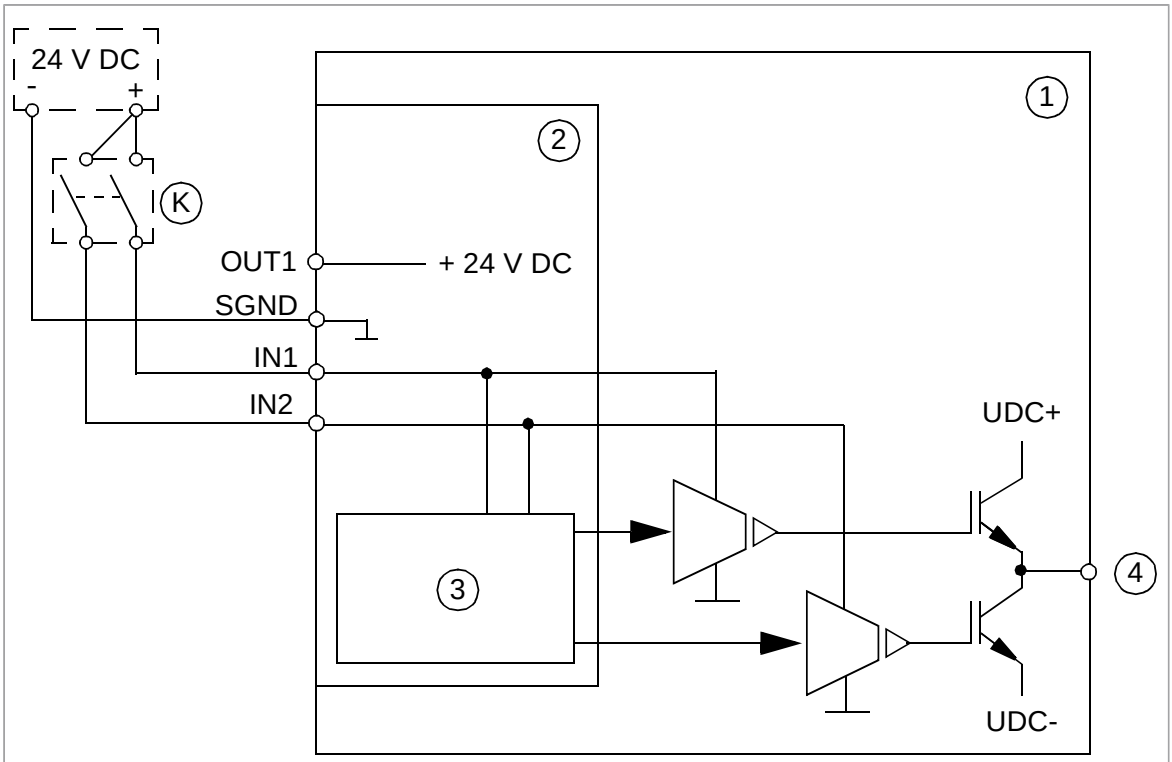
Connection principle

Single ACQ80-07 drive, internal power supply



1	Drive
2	Control unit
3	Control logic
4	To motor
K	Activation switch

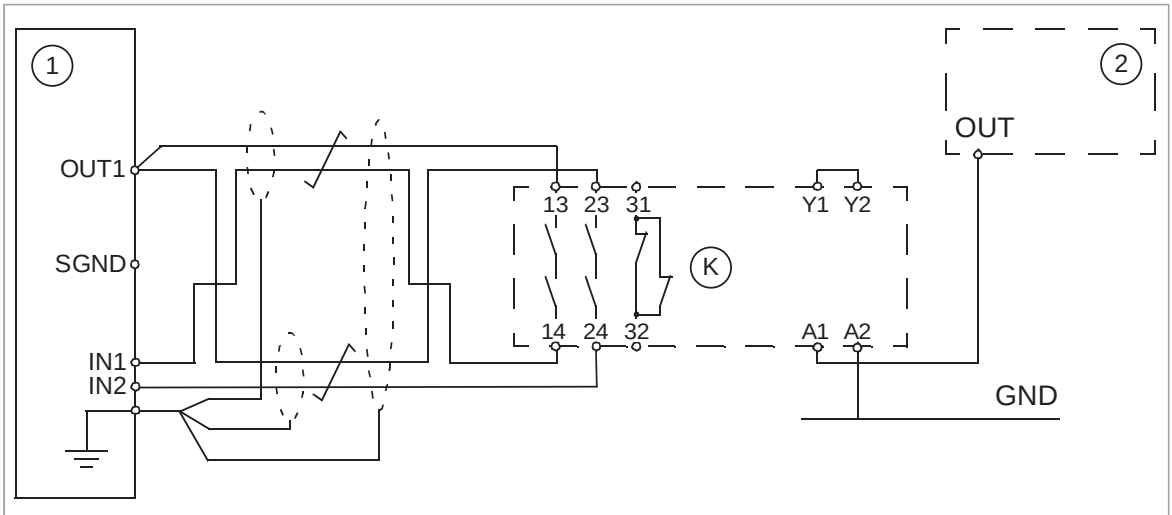
Single ACQ80-07 drive, external power supply



1	Drive
2	Control unit
3	Control logic
4	To motor
K	Activation switch

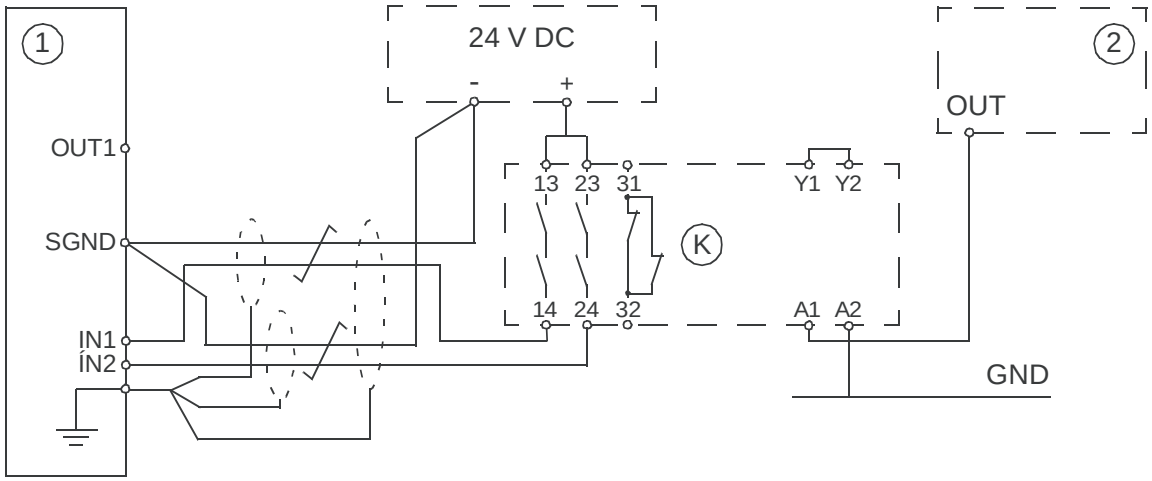
Wiring examples

Single ACQ80-07 drive, internal power supply



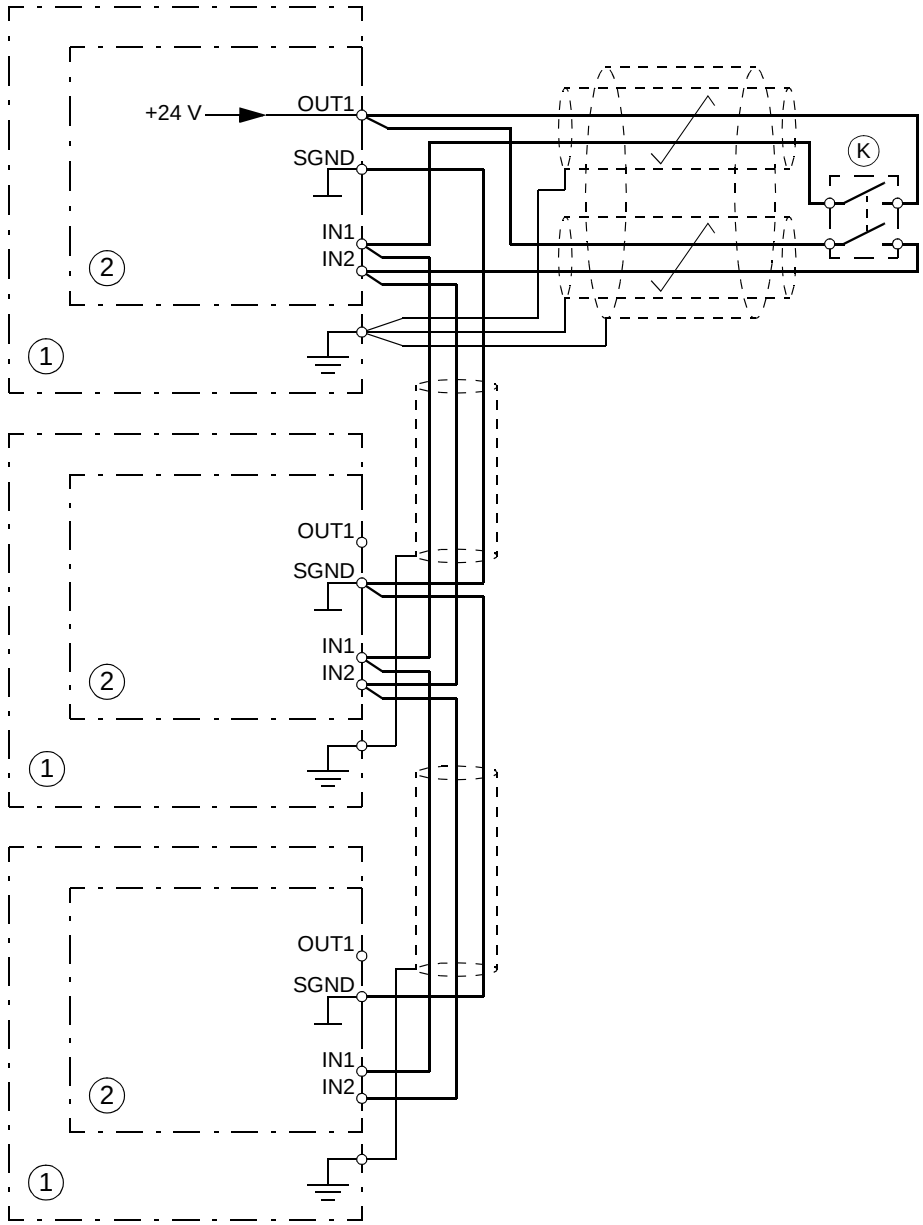
1	Drive
2	Safety PLC
K	Safety relay

Single ACQ80-07 drive, external power supply



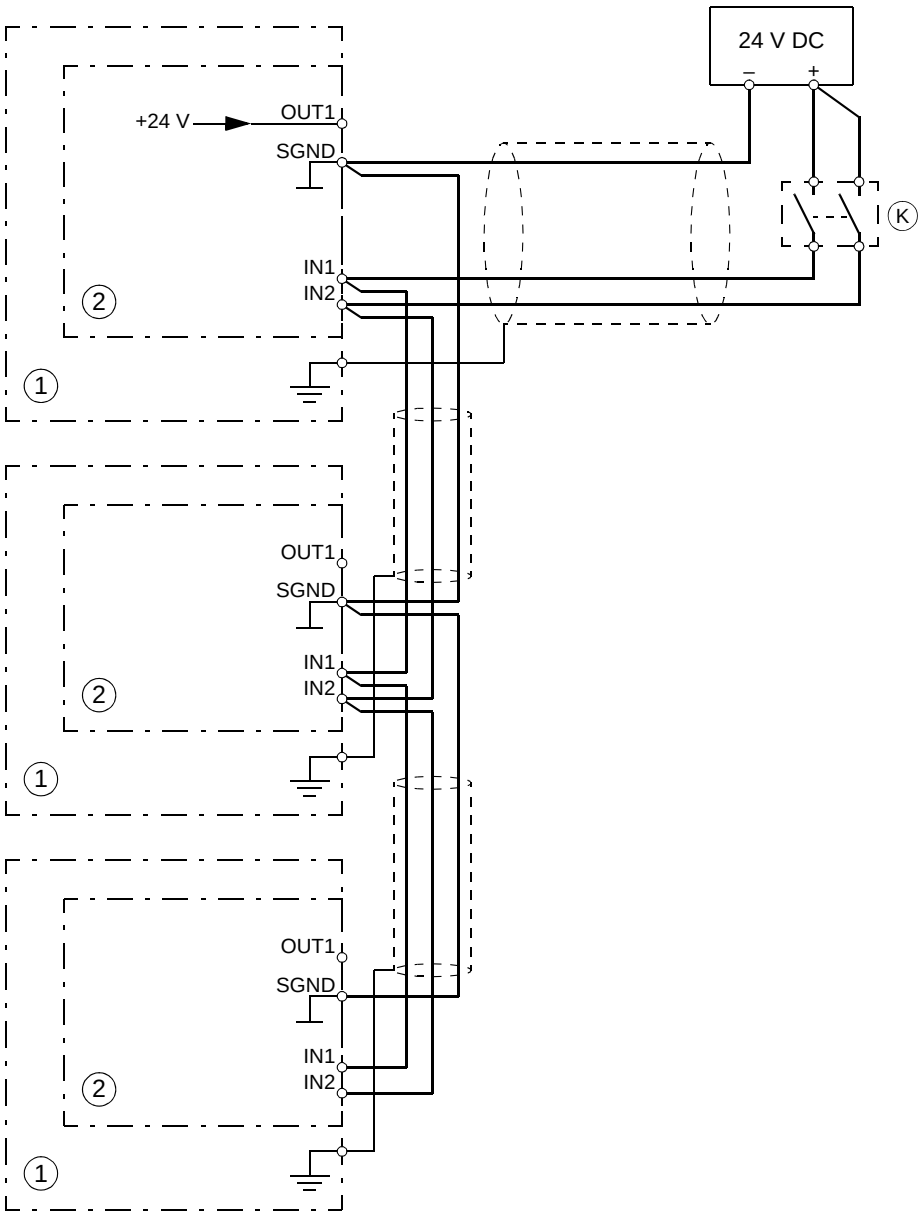
1	Drive
2	Safety PLC
K	Safety relay

Multiple ACQ80-07 drives, internal power supply



1	Drive
2	Control unit
K	Activation switch

Multiple ACQ80-07 drives, external power supply



1	Drive
2	Control unit
K	Activation switch

Activation switch

In the wiring diagrams, the activation switch has the designation [K]. This represents a component such as a manually operated switch, an emergency stop push button switch, or the contacts of a safety relay or safety PLC.

- In case a manually operated activation switch is used, the switch must be of a type that can be locked out to the open position.
- The contacts of the switch or relay must open/close within 200 ms of each other.

Cable types and lengths

- ABB recommends double-shielded twisted-pair cable.
- Maximum cable lengths:
  - 300 m (1000 ft) between activation switch [K] and drive control unit
  - 60 m (200 ft) between external power supply and control unit

Note: A short-circuit in the wiring between the switch and an STO terminal causes a dangerous fault. Therefore, it is recommended to use a safety relay (including wiring diagnostics) or a wiring method (shield grounding, channel separation) which reduces or eliminates the risk caused by the short-circuit.

Note: The voltage at the STO input terminals of the drive must be at least 13 V DC to be interpreted as “1”.

The pulse tolerance of the input channels is 1 ms.

Grounding of protective shields

- Ground the shield in the cabling between the activation switch and the control unit at the control unit only.
- Ground the shield in the cabling between two control units at one control unit only.

Operation principle

1. The Safe torque off activates (the activation switch is opened, or safety relay contacts open).
2. The STO inputs of the drive control unit de-energize.
3. The control unit cuts off the control voltage from the output IGBTs.
4. The control program generates an indication as defined by parameter 31.22 (see the firmware manual of the drive).
   The parameter selects which indications are given when one or both STO signals are switched off or lost. The indications also depend on whether the drive is running or stopped when this occurs.

   Note: This parameter does not affect the operation of the STO function itself. The STO function will operate regardless of the setting of this parameter: a running drive will stop upon removal of one or both STO signals, and will not start until both STO signals are restored and all faults reset.

   Note: The loss of only one STO signal always generates a fault as it is interpreted as a malfunction of STO hardware or wiring.
5. The motor coasts to a stop (if running). The drive cannot restart while the activation switch or safety relay contacts are open. After the contacts close, a reset may be needed (depending on the setting of parameter 31.22). A new start command is required to start the drive.

Start-up including validation test

To ensure the safe operation of a safety function, validation is required. The final assembler of the machine must validate the function by performing a validation test. The test must be performed

1. at initial start-up of the safety function
2. after any changes related to the safety function (circuit boards, wiring, components, settings, replacement of inverter module, etc.)
3. after any maintenance work related to the safety function
4. after a drive firmware update
5. at the proof test of the safety function.

Competence

The validation test of the safety function must be carried out by a competent person with adequate expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6. The test procedures and report must be documented and signed by this person.

Validation test reports

Signed validation test reports must be stored in the logbook of the machine. The report shall include documentation of start-up activities and test results, references to failure reports and resolution of failures. Any new validation tests performed due to changes or maintenance shall be logged into the logbook.

Validation test procedure

After wiring the Safe torque off function, validate its operation as follows.

Action	☑
WARNING! Obey the safety instructions. If you ignore them, injury or death, or damage to the equipment can occur.	☐
Make sure that the motor can be run and stopped freely during start-up.	☐
Stop the drive (if running), switch the input power off and isolate the drive from the power line using a disconnector.	☐
Check the STO circuit connections against the wiring diagram.	☐
Close the disconnector and switch the power on.	☐
Test the operation of the STO function when the motor is stopped. • Give a stop command for the drive (if running) and wait until the motor shaft is at a standstill. Make sure that the drive operates as follows: • Open the STO circuit. The drive generates an indication if one is defined for the 'stopped' state in parameter 31.22 (see the firmware manual). • Give a start command to verify that the STO function blocks the drive's operation. The motor should not start. • Close the STO circuit. • Reset any active faults. Restart the drive and check that the motor runs normally.	☐

Action	☑
Test the operation of the STO function when the motor is running. • Start the drive and make sure the motor is running. • Open the STO circuit. The motor should stop. The drive generates an indication if one is defined for the 'running' state in parameter 31.22 (see the firmware manual). • Reset any active faults and try to start the drive. • Make sure that the motor stays at a standstill and the drive operates as described above in testing the operation when the motor is stopped. • Close the STO circuit. • Reset any active faults. Restart the drive and check that the motor runs normally.	☐
Test the operation of the failure detection of the drive. The motor can be stopped or running. • Open the 1st input channel of the STO circuit. If the motor was running, it should coast to a stop. The drive generates an FA81 fault indication (see the firmware manual). • Give a start command to verify that the STO function blocks the drive's operation. The motor should not start. • Open the STO circuit (both channels). • Give a reset command. • Close the STO circuit (both channels). • Reset any active faults. Restart the drive and check that the motor runs normally. • Open the 2nd input channel of the STO circuit. If the motor was running, it should coast to a stop. The drive generates an FA82 fault indication (see the firmware manual). • Give a start command to verify that the STO function blocks the drive's operation. The motor should not start. • Open the STO circuit (both channels). • Give a reset command. • Close the STO circuit (both channels). • Reset any active faults. Restart the drive and check that the motor runs normally.	☐
Document and sign the validation test report which verifies that the safety function is safe and accepted for operation.	☐

Use

1. Open the activation switch, or activate the safety functionality that is wired to the STO connection.
2. The STO inputs on the drive control unit de-energize, and the control unit cuts off the control voltage from the output IGBTs.
3. The control program generates an indication as defined by parameter 31.22 (see the firmware manual of the drive).
4. The motor coasts to a stop (if running). The drive will not restart while the activation switch or safety relay contacts are open.
5. Deactivate the STO by closing the activation switch, or resetting the safety functionality that is wired to the STO connection.
6. Reset any faults before restarting.

WARNING!
The Safe torque off function does not disconnect the voltage of the main and auxiliary circuits from the drive. Therefore maintenance work on electrical parts of the drive or the motor can only be carried out after isolating the drive from the supply and all other voltage sources.

WARNING!
The drive cannot detect or memorize any changes in the STO circuitry when the drive control unit is not powered or when the main power to the drive is off. If both STO circuits are closed and a level-type start signal is active when the power is restored, it is possible that the drive starts without a fresh start command. Take this into account in the risk assessment of the system.

WARNING!
Permanent magnet or synchronous reluctance [SynRM] motors only:

In case of a multiple IGBT power semiconductor failure, the drive can produce an alignment torque which maximally rotates the motor shaft by 180/*p* degrees (with permanent magnet motors) or 180/2*p* degrees (with synchronous reluctance [SynRM] motors) regardless of the activation of the Safe torque off function. *p* denotes the number of pole pairs.

Notes:

- If a running drive is stopped by using the Safe torque off function, the drive will cut off the motor supply voltage and the motor will coast to a stop. If this causes danger or is not otherwise acceptable, stop the drive and machinery using the appropriate stop mode before activating the Safe torque off function.
- The Safe torque off function overrides all other functions of the drive.
- The Safe torque off function is ineffective against deliberate sabotage or misuse.
- The Safe torque off function has been designed to reduce the recognized hazardous conditions. In spite of this, it is not always possible to eliminate all potential hazards. The assembler of the machine must inform the final user about the residual risks.

Maintenance

After the operation of the circuit is validated at start-up, the STO function shall be maintained by periodic proof testing. In high demand mode of operation, the maximum proof test interval is 20 years. In low demand mode of operation, the maximum proof test interval is 10 years; see section Safety data (page 219). It is assumed that all dangerous failures of the STO circuit are detected by the proof test. To perform the proof test, do the Validation test procedure (page 214).

Note: See also the Recommendation of Use CNB/M/11.050 (published by the European co-ordination of Notified Bodies) concerning dual-channel safety-related systems with electromechanical outputs:

- When the safety integrity requirement for the safety function is SIL 3 or PL e (cat. 3 or 4), the proof test for the function must be performed at least every month.
- When the safety integrity requirement for the safety function is SIL 2 (HFT = 1) or PL d (cat. 3), the proof test for the function must be performed at least every 12 months.

The STO function of the drive does not contain any electromechanical components.

In addition to proof testing, it is a good practice to check the operation of the function when other maintenance procedures are carried out on the machinery.

Include the Safe torque off operation test described above in the routine maintenance program of the machinery that the drive runs.

If any wiring or component change is needed after start-up, or the parameters are restored, do the test given in section Validation test procedure (page 214).

Use only spare parts approved by ABB.

Record all maintenance and proof test activities in the machine logbook.

Competence

The maintenance and proof test activities of the safety function must be carried out by a competent person with adequate expertise and knowledge of the safety function as well as functional safety, as required by IEC 61508-1 clause 6.

Fault tracing

The indications given during the normal operation of the Safe torque off function are selected by drive control program parameter 31.22.

The diagnostics of the Safe torque off function cross-compare the status of the two STO channels. In case the channels are not in the same state, a fault reaction function is performed and the drive trips on an FA81 or FA82 fault. An attempt to use the STO in a non-redundant manner, for example activating only one channel, will trigger the same reaction.

See the firmware manual of the drive control program for the indications generated by the drive, and for details on directing fault and warning indications to an output on the control unit for external diagnostics.

Any failures of the Safe torque off function must be reported to ABB.

Safety data

The safety data for the Safe torque off function is given below.

Note: The safety data is calculated for redundant use, and applies only if both STO channels are used.

Frame size	SIL	SC	PL	SFF (%)	PFH (T_1 = 20 a) (1/h)	PFD_{avg} (T_1 = 2 a)	PFD_{avg} (T_1 = 5 a)	PFD_{avg} (T_1 = 10 a)	$MTTF_D$ (a)	DC (%)	Cat.	HFT	CCF	T_M (a)	PFH_{diag} (1/h)	λ_{Diag_s} (1/h)	λ_{Diag_d} (1/h)
3-phase U_N = 500 V																	
R6	3	3	e	>99	3.92E-09	3.44E-05	8.59E-05	1.72E-04	4802	≥90	3	1	80	20	1.40E-12	64.33	0.14
R7	3	3	e	>99	3.92E-09	3.44E-05	8.59E-05	1.72E-04	4802	≥90	3	1	80	20	1.40E-12	64.33	0.14
R8	3	3	e	>99	4.22E-09	3.69E-05	9.24E-05	1.85E-04	2805	≥90	3	1	80	20	3.00E-12	195.87	0.30
R9	3	3	e	>99	4.22E-09	3.69E-05	9.24E-05	1.85E-04	2805	≥90	3	1	80	20	3.00E-12	195.87	0.30
																	3AXD10001613533 C

- The STO is a type B safety component as defined in IEC 61508-2.
- Relevant failure modes:
  - The STO trips spuriously (safe failure)
  - The STO does not activate when requested
  - A fault exclusion on the failure mode “short circuit on printed circuit board” has been made (EN 13849-2, table D.5). The analysis is based on an assumption that one failure occurs at one time. No accumulated failures have been analyzed.
- STO response times:
  - STO reaction time (shortest detectable break): 1 ms
  - Fault detection time: Channels in different states for longer than 200 ms
  - Fault reaction time: Fault detection time + 10 ms.
- Indication delays:
  - STO fault indication (parameter 31.22) delay: < 500 ms
  - STO warning indication (parameter 31.22) delay: < 1000 ms.

Terms and abbreviations

Term or abbreviation	Reference	Description
Cat.	EN ISO 13849-1	Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection and/or by their reliability. The categories are: B, 1, 2, 3 and 4.
CCF	EN ISO 13849-1	Common cause failure (%)
DC	EN ISO 13849-1	Diagnostic coverage (%)
HFT	IEC 61508	Hardware fault tolerance
$MTTF_D$	EN ISO 13849-1	Mean time to dangerous failure: (Total number of life units) / (Number of dangerous, undetected failures) during a particular measurement interval under stated conditions
PFD_{avg}	IEC 61508	Average probability of dangerous failure on demand, that is, mean unavailability of a safety-related system to perform the specified safety function when a demand occurs
PFH	IEC 61508	Average frequency of dangerous failures per hour, that is, average frequency of a dangerous failure of a safety related system to perform the specified safety function over a given period of time
PFH_{diag}	IEC/EN 62061	Average frequency of dangerous failures per hour for the diagnostic function of STO
PL	EN ISO 13849-1	Performance level. Levels a…e correspond to SIL
Proof test	IEC 61508, IEC 62061	Periodic test performed to detect failures in a safety-related system so that, if necessary, a repair can restore the system to an "as new" condition or as close as practical to this condition
SC	IEC 61508	Systematic capability (1…3)
SFF	IEC 61508	Safe failure fraction (%)
SIL	IEC 61508	Safety integrity level (1…3)
STO	IEC/EN 61800-5-2	Safe torque off

Term or abbreviation	Reference	Description
T_1	IEC 61508-6	Proof test interval. T_1 is a parameter used to define the probabilistic failure rate (PFH or PFD) for the safety function or subsystem. Performing a proof test at a maximum interval of T_1 is required to keep the SIL capability valid. The same interval must be followed to keep the PL capability (EN ISO 13849) valid. See also section Maintenance.
T_M	EN ISO 13849-1	Mission time: the period of time covering the intended use of the safety function/device. After the mission time elapses, the safety device must be replaced. Note that any T_M values given cannot be regarded as a guarantee or warranty.
λ_{Diag_d}	IEC 61508-6	Dangerous failure rate (per hour) of the diagnostics function of STO
λ_{Diag_s}	IEC 61508-6	Safe failure rate (per hour) of the diagnostics function of STO

TÜV certificate

The TÜV certificate is available on the Internet.

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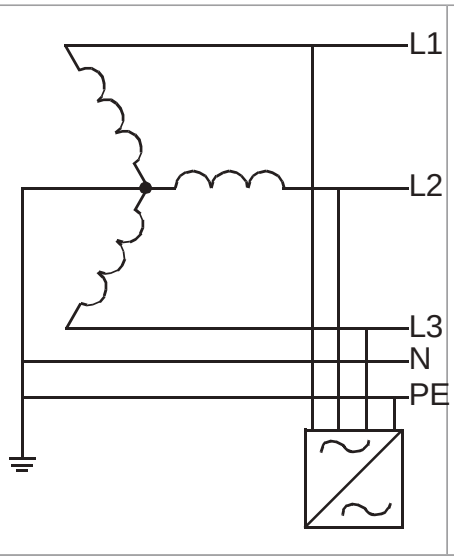
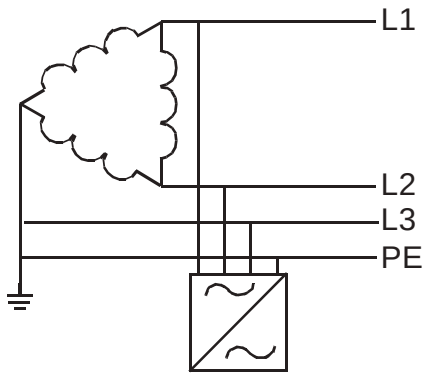
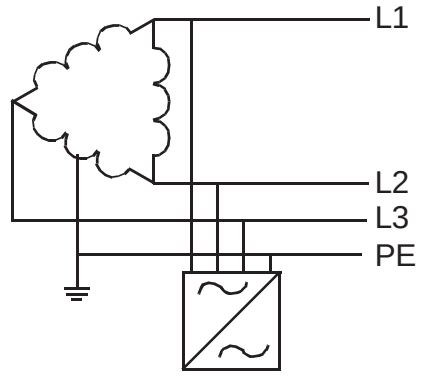
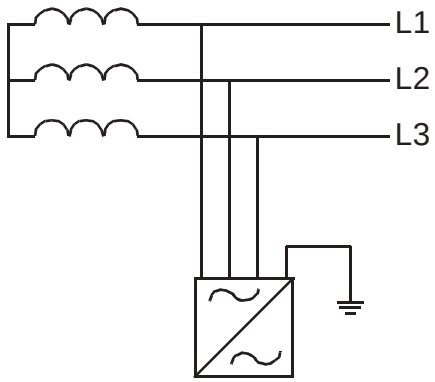
Disconnecting EMC filter and ground-to-phase varistor

When to disconnect the ground-to-phase varistor: TN-S, IT, corner-grounded delta and midpoint-grounded delta systems

Symmetrically grounded TN systems (TN-S systems, ie, center-grounded wye)	
	R6…R9: Do not remove EMC or VAR screws.
Corner-grounded delta systems	

	R6…R9: Do not remove EMC AC or VAR screws. Remove EMC DC screw.
Midpoint-grounded delta systems	
	R6…R9: Do not remove EMC AC or VAR screws. Remove EMC DC screw.
IT systems (ungrounded or high-resistance grounded [>30 ohms])	
	R6…R9: Remove EMC screws (2 pcs) and VAR screw.

These are the EMC filter and varistor screws in different drive frame sizes.

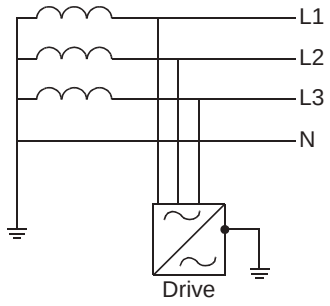
Frame size	EMC filter (+E200) screws	Ground-to-phase varistor screws
R6..R9	Two EMC screws	VAR

Guidelines for installing the drive to a TT system

The drive can be connected to a TT system under these conditions:

1. Residual current device has been installed in the supply system.
2. This wire has been disconnected. Otherwise EMC filter and ground-to-phase varistor capacitor leakage current will cause the residual current device to trip.

Frame size	EMC filter screws	Ground-to-phase varistor screws
R6...R9	Two EMC screws	VAR



Note:

- Because the varistor wire has been disconnected, ABB does not guarantee the EMC category.
- ABB does not guarantee the functioning of the ground leakage detector built inside the drive.
- In large systems the residual current device can trip without a real reason.

Identifying the grounding system of the electrical power network

WARNING!
Only a qualified electrical professional may do the work instructed in this section. Depending on the installation site, the work may even be categorized as live working. Continue only if you are an electrical professional certified for the work. Obey the local regulations. If you ignore them, injury or death can occur.

To identify the grounding system, examine the supply transformer connection. See the applicable electrical diagrams of the building. If that is not possible, measure these voltages at the distribution board, and use the table to define the grounding system type.

1. input voltage line to line (U_{L-L})
2. input voltage line 1 to ground (U_{L1-G})
3. input voltage line 2 to ground (U_{L2-G})
4. input voltage line 3 to ground (U_{L3-G}).

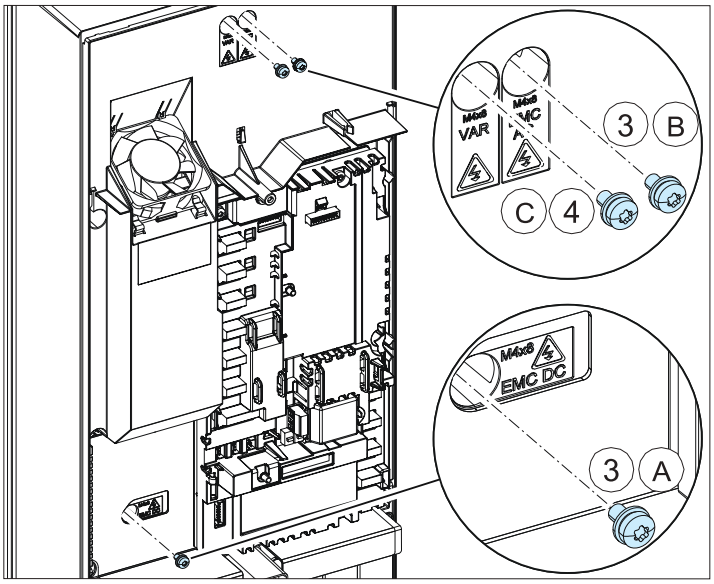
The table below shows the line-to-ground voltages in relation to the line-to-line voltage for each grounding system.

U_{L-L}	U_{L1-G}	U_{L2-G}	U_{L3-G}	Electrical power system type
X	0.58·X	0.58·X	0.58·X	TN-S system (symmetrically grounded)
X	1.0·X	1.0·X	0	Corner-grounded delta system (nonsymmetrical)
X	0.866·X	0.5·X	0.5·X	Midpoint-grounded delta system (nonsymmetrical)
X	Varying level versus time	Varying level versus time	Varying level versus time	IT systems (ungrounded or high-resistance-grounded [>30 ohms]) nonsymmetrical
X	Varying level versus time	Varying level versus time	Varying level versus time	TT system (the protective earth connection for the consumer is provided by a local earth electrode, and there is another independently installed at the generator)

Disconnecting the EMC filter and ground-to-phase varistor (frames R6...R9)

To disconnect the internal EMC filter or ground-to-phase varistor, do as follows:

1. Switch off the power from the drive.
2. Open the cover, if not already opened.
3. To disconnect the internal EMC filter, remove the two EMC screws.
4. To disconnect the ground-to-phase varistor, remove the varistor screw.



A	EMC (DC)
B	EMC (AC)
C	VAR

16

CAIO-01 bipolar analog I/O adapter module

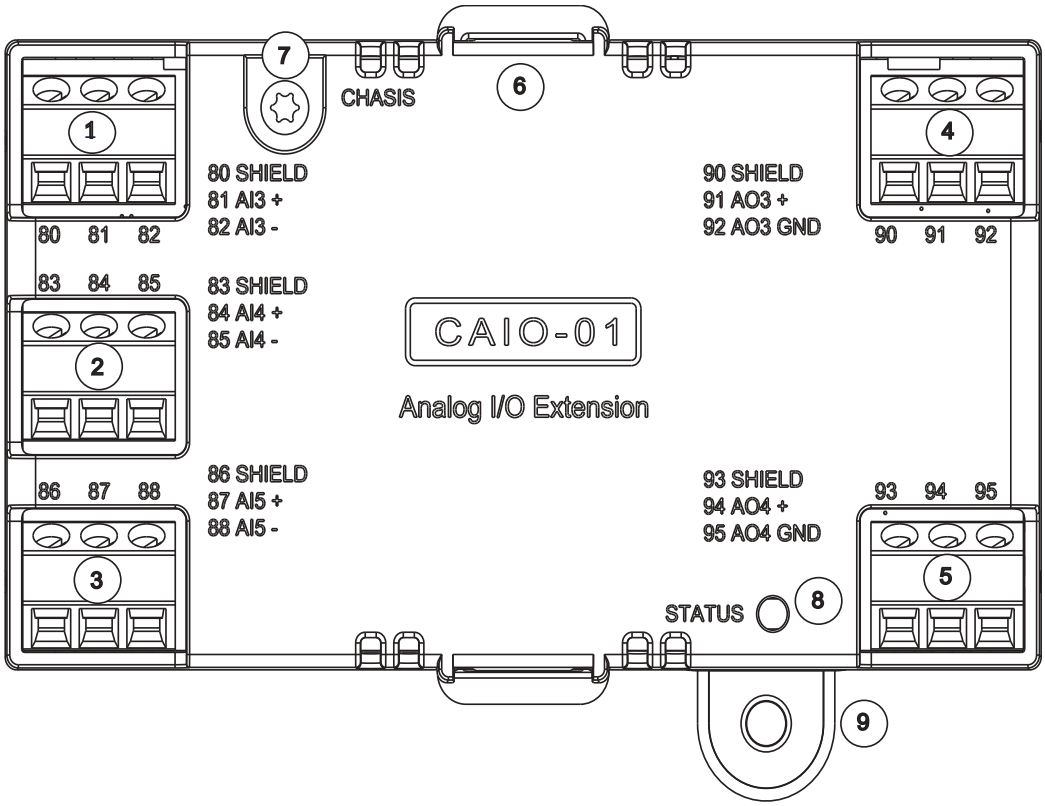
Contents of this chapter

This chapter describes how to install and start up the optional CAIO-01 multifunction extension module. The chapter also contains diagnostics and technical data.

Product overview

The CAIO-01 bipolar analog I/O module expands the inputs and outputs of the drive control unit. It has three bipolar current/voltage inputs and two unipolar current/voltage outputs. The inputs can handle positive and negative signals. The way the drive interprets the negative range of the inputs depends on the parameter settings of the drive. The voltage/current selection of the inputs is done with a parameter.

Layout



1, 2, 3	Analog inputs		4, 5	Analog outputs	
80	SHIELD	Cable shield connection	90	SHIELD	Cable shield connection
81	AI3+	Analog input 3 positive signal	91	AO3	Analog output 3 signal
82	AI3-	Analog input 3 negative signal	92	AGND	Analog ground potential
83	SHIELD	Cable shield connection	93	SHIELD	Cable shield connection
84	AI4+	Analog input 4 positive signal	94	AO4	Analog output 4 signal
85	AI4-	Analog input 4 negative signal	95	AGND	Analog ground potential
86	SHIELD	Cable shield connection			
87	AI5+	Analog input 5 positive signal			
88	AI5-	Analog input 5 negative signal			
6	Control unit slot interface				
7	Grounding hole				
8	Diagnostic LED				
9	Mounting hole				

Mechanical installation

Necessary tools

- Screwdriver and a set of suitable bits.

Unpacking and examining the delivery

1. Open the option package. Make sure that the package contains:
   - the option module
   - a mounting screw.
2. Make sure that there are no signs of damage.

Installing the module

See section Installing option modules (page 113).

Electrical installation

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.

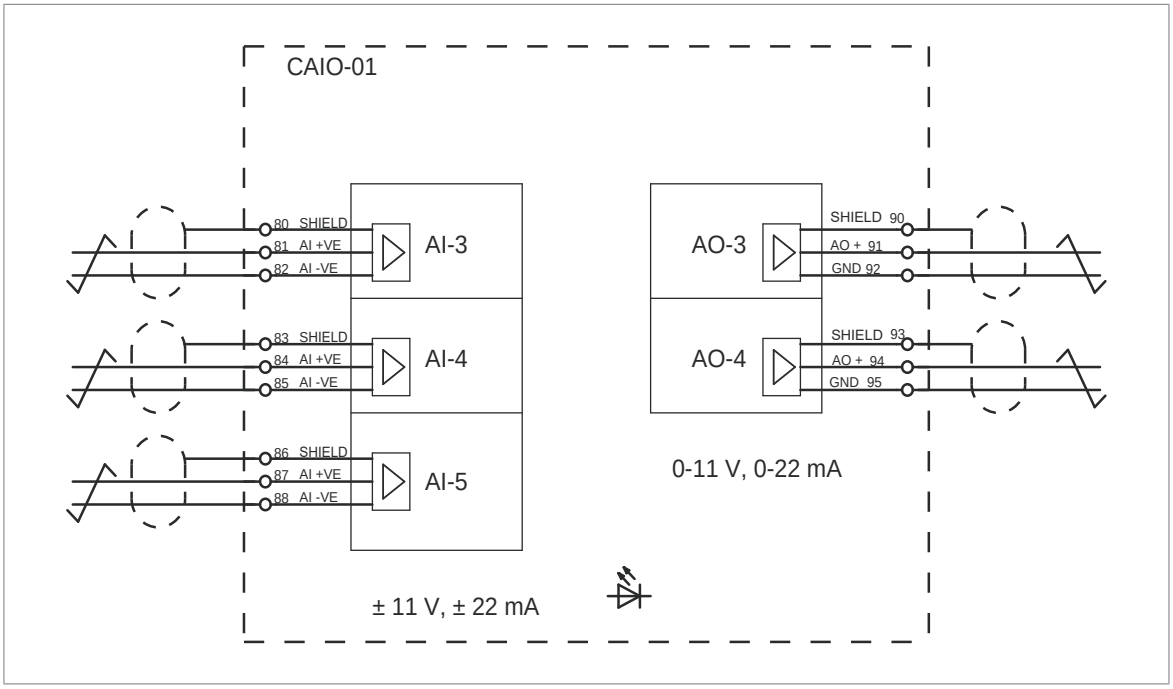
Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.

Necessary tools

- Screwdriver and a set of suitable bits.

Wiring

Connect the external cables to the applicable module terminals. Ground the outer shield of the cables to the SHIELD terminal.



Start-up

Setting the parameters

1. Power up the drive.
2. If no warning is shown,
   - make sure that the value of both parameters 15.01 Extension module type and 15.02 Detected extension module is CAIO-01.

   If warning A7AB Extension I/O configuration failure is shown,
   - make sure that the value of 15.02 is CAIO-01
   - set the value of parameter 15.01 to CAIO-01.

   You can now see the parameters of the extension module in group 15 I/O extension module.
3. Set the parameters of analog inputs AI3, AI4, AI5 or analog outputs AO3 or AO4 to applicable values, see the firmware manual.

Example: To connect supervision 1 to AI3 of the extension module:

- Select the mode of the supervision function (32.05 Supervision function 1).
- Set limits for the supervision function (32.09 Supervision 1 low and 32.10 Supervision 1 high).
- Select the supervision action (32.06 Supervision 1 action).
- Connect 32.07 Supervision 1 signal to 15.52 AI3 scaled value.

Diagnostics

LEDs

The adapter module has one diagnostic LED.

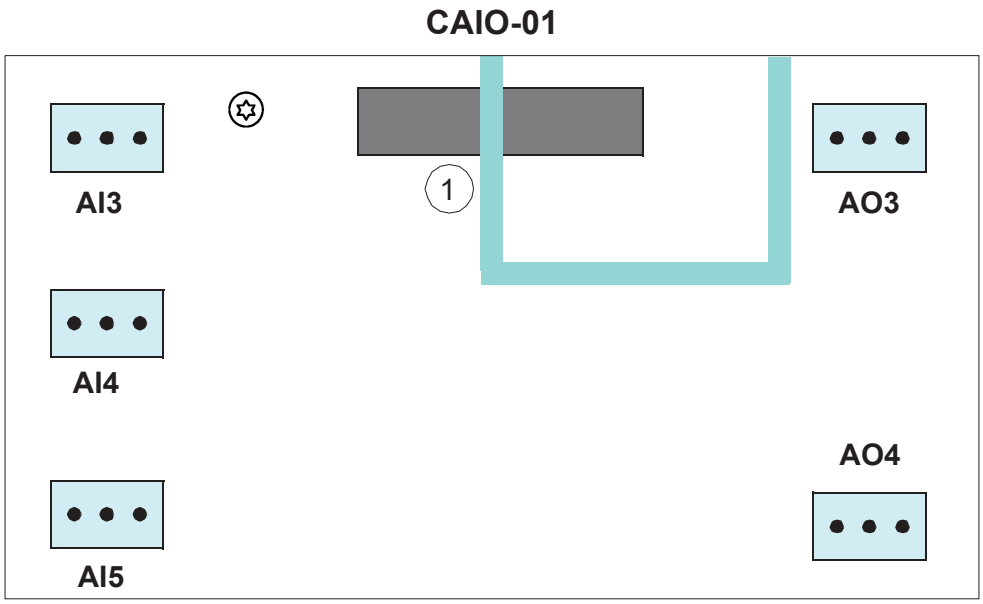
Color	Description
Green	The adapter module is powered up.
Red	There is no communication with the drive control unit or the adapter module has detected an error.

Technical data

Installation	Into slot 2 of drive control unit
Degree of protection	IP20 / UL 1 Type
Ambient conditions	See the drive technical data.
Package	Cardboard
Analog inputs (80..82, 83..85, 86..88)	
Maximum wire size	1.5 mm^2
Input voltage (AI+ and AI-)	-11 V … +11 V
Input current (AI+ and AI-)	-22 mA … +22 mA
Input resistance	>200 kohm (voltage mode), 100 ohm (current mode)
Optional cable shield connections	
Analog outputs (90..92, 93..95)	

Maximum wire size	1.5 mm^2
Output voltage (AO+ and AO-)	0 V … +11 V
Output current (AO+ and AO-)	0 mA … +22 mA
Output resistance	< 20 ohm
Recommended load	>10 kohm
Inaccuracy	± 1% Typical, ± 1.5% Max of full-scale value
Optional cable shield connections	

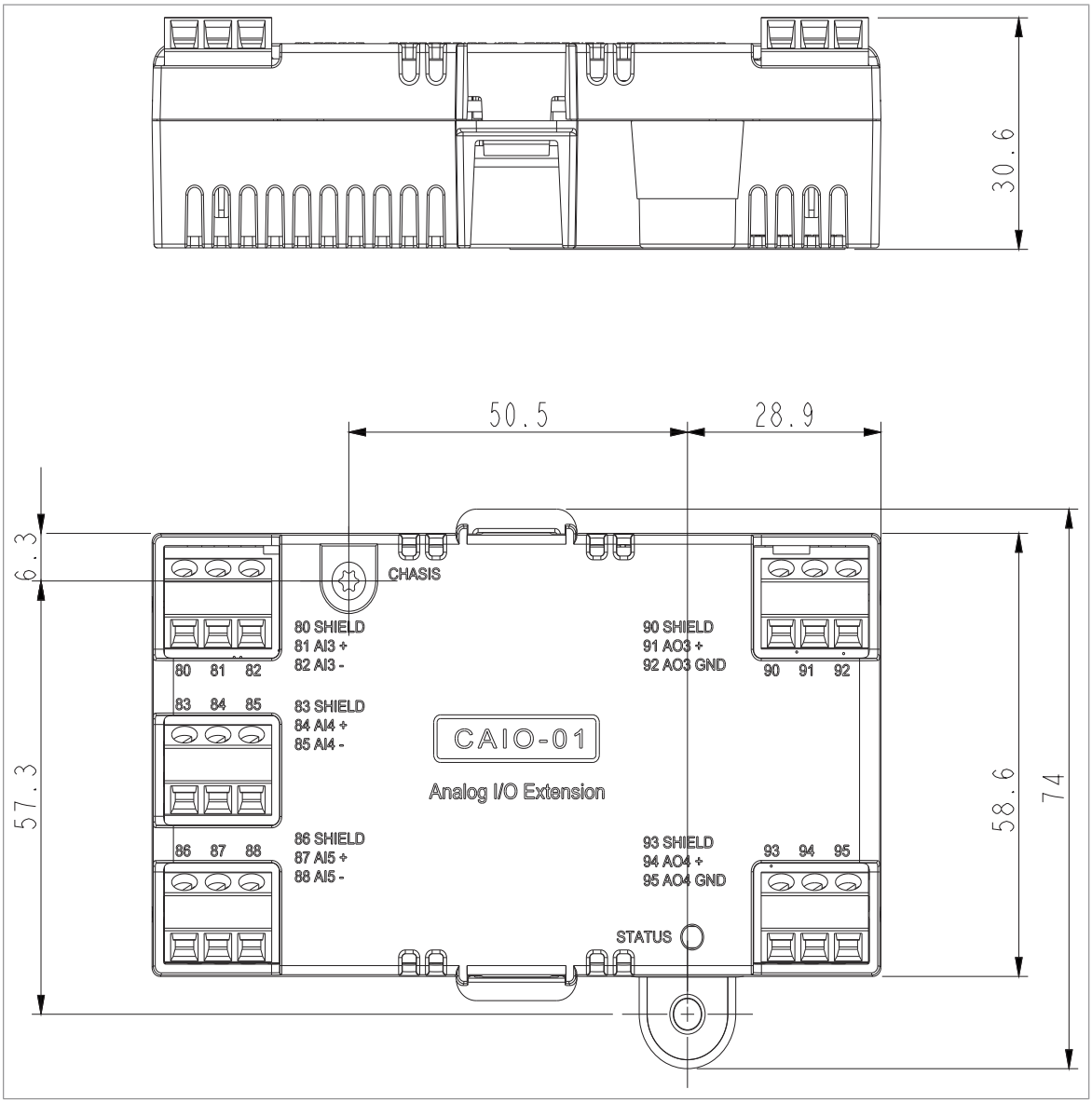
Isolation areas



1	Plugged to drive control unit SLOT 2
	Reinforced insulation (IEC 61800-5-1:2007)

Dimension drawings

The dimensions are in millimeters.



17

CMOD-01 multifunction extension module (external 24 V AC/DC and digital I/O)

Contents of this chapter

This chapter describes how to install and start up the optional CMOD-01 multifunction extension module. The chapter also contains diagnostics and technical data.

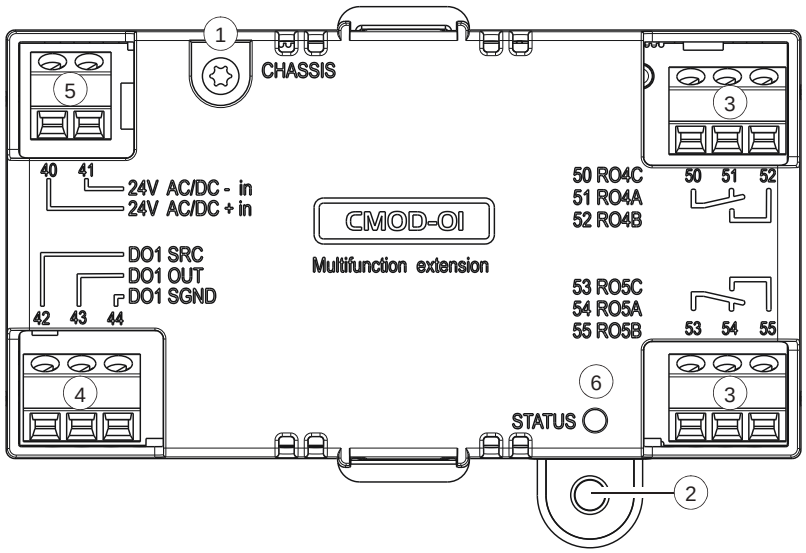
Product overview

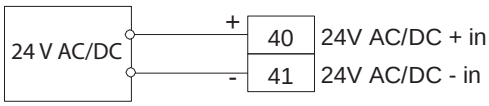
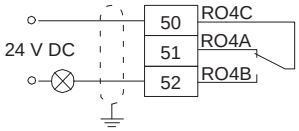
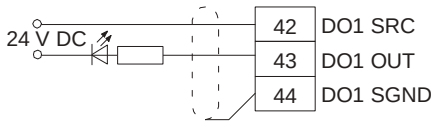
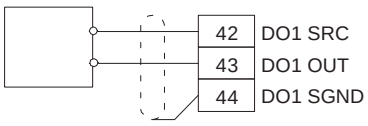
The CMOD-01 multifunction extension module (external 24 V AC/DC and digital I/O) expands the outputs of the drive control unit. It has two relay outputs and one transistor output, which can operate as a digital or frequency output.

In addition, the extension module has an external power supply interface, which can be used to power up the drive control unit in case the drive power supply is not on. If you do not need the backup power supply, you do not have to connect it because the module is powered from the drive control unit by default.

With CCU-24 control unit, a CMOD-01 module is not necessary for external 24 V AC/DC supply connection. The external supply is connected directly to terminals 40 and 41 on the control unit.

Layout and example connections



1	**Grounding screw**		**6**	**Diagnostic LED**	
2	**Hole for mounting screw**				
5	**2-pin terminal block for external power supply**		**3**	**3-pin terminal blocks for relay outputs**	
					
40	24 V AC/DC + in	External 24 V (AC/DC) input	50	RO4C	Common, C
41	24 V AC/DC - in	External 24 V (AC/DC) input	51	RO4A	Normally closed, NC
4	**3-pin terminal block for for transistor output**		52	RO4B	Normally open, NO
 1)  2)					
42	DO1 SRC	Source input	53	RO5C	Common, C
43	DO1 OUT	Digital or frequency output	54	RO5A	Normally closed, NC
44	DO1 SGND	Ground (earth) potential	55	RO5B	Normally open, NO

1) Digital output connection example

2) An externally supplied frequency indicator which provides, for example:
- a 40 mA / 12 V DC power supply for the sensor circuit (CMOD frequency output)
- suitable voltage pulse input (10 Hz … 16 kHz).

Mechanical installation

Necessary tools

- Screwdriver and a set of suitable bits.

Unpacking and examining the delivery

1. Open the option package. Make sure that the package contains:
   - the option module
   - a mounting screw.
2. Make sure that there are no signs of damage.

Installing the module

See section Installing option modules (page 113).

Electrical installation

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.

Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.

Necessary tools

- Screwdriver and a set of suitable bits

Wiring

Connect the external control cables to the applicable module terminals. Ground the outer shield of the control cables at the cabinet entry.

WARNING!
Do not connect the +24 V AC cable to the control unit ground when the control unit is powered using an external 24 V AC supply.

Start-up

Setting the parameters

1. Power up the drive.
2. If no warning is shown,
   - make sure that the value of both parameters 15.01 Extension module type and 15.02 Detected extension module is CMOD-01.

   If the warning A7AB Extension I/O configuration failure is shown,
   - make sure that the value of parameter 15.02 is CMOD-01.
   - set the parameter 15.01 value to CMOD-01.

   You can now see the parameters of the extension module in parameter group 15 I/O extension module.
3. Set the parameters of the extension module to applicable values.

Examples are given below.

Parameter setting example for relay output

This example shows how make relay output RO4 of the extension module indicate the reverse direction of rotation of the motor with a one-second delay.

Parameter	Setting
15.07 RO4 source	Reverse
15.08 RO4 ON delay	1 s
15.09 RO4 OFF delay	1 s

Parameter setting example for digital output

This example shows how to make digital output DO1 of the extension module indicate the reverse direction of rotation of the motor with a one-second delay.

Parameter	Setting
15.22 DO1 configuration	Digital output
15.23 DO1 source	Reverse
15.24 DO1 ON delay	1 s
15.25 DO1 OFF delay	1 s

Parameter setting example for frequency output

This example shows how to make digital output DO1 of the extension module indicate the motor speed 0…1500 rpm with a frequency range of 0…10000 Hz.

Parameter	Setting
15.22 DO1 configuration	Frequency output
15.33 Freq out 1 source	01.01 Motor speed used
15.34 Freq out 1 src min	0
15.35 Freq out 1 src max	1500.00
15.36 Freq out 1 at src min	0 Hz
15.37 Freq out 1 at src max	10000 Hz

Diagnostics

Faults and warning messages

Warning A7AB Extension I/O configuration failure.

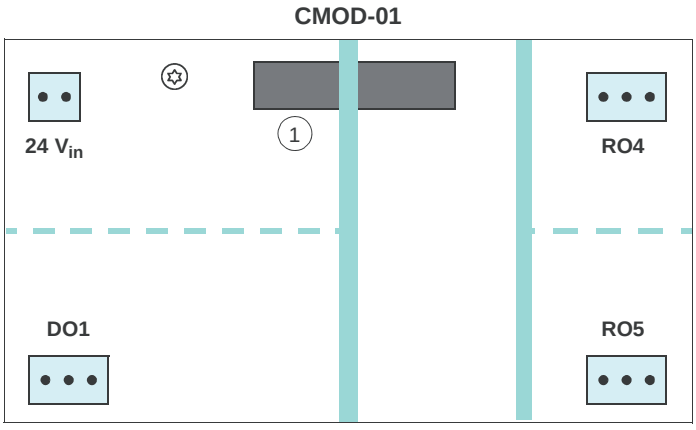
LEDs

The extension module has one diagnostic LED.

Color	Description
Green	The extension module is powered up.

Technical data

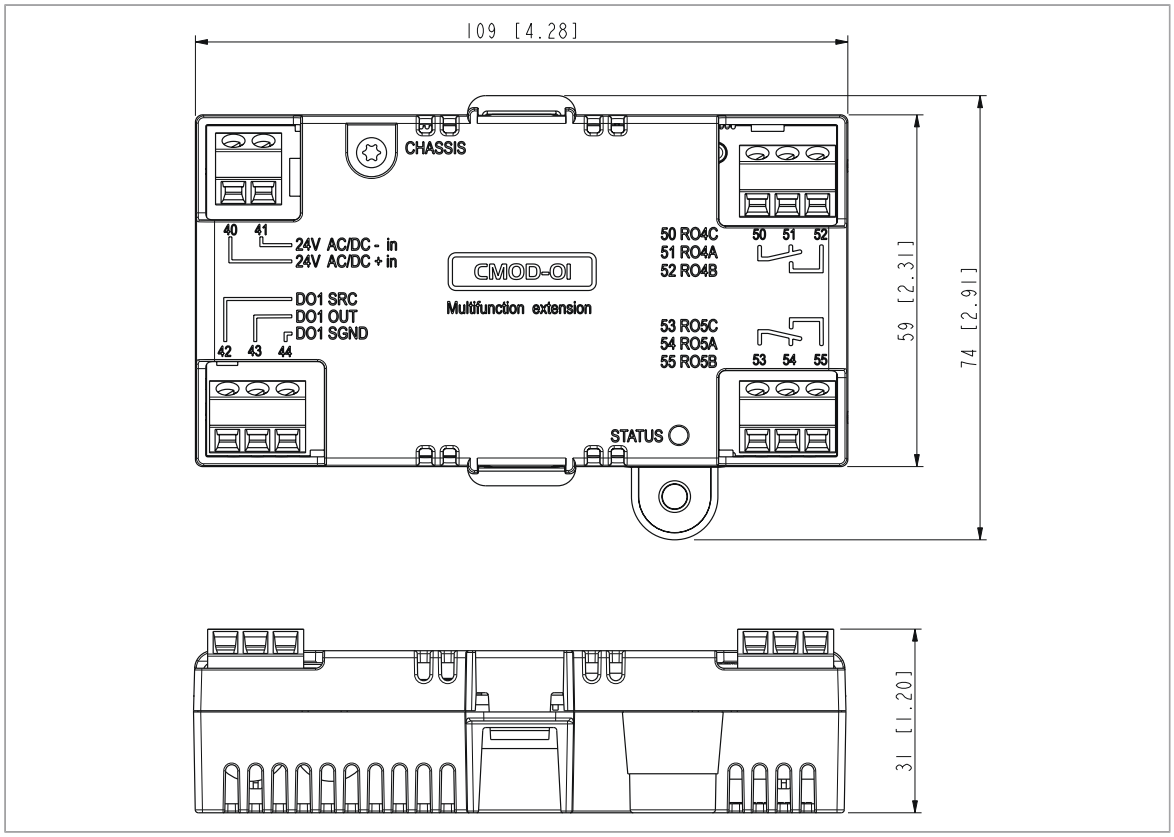
Installation	Into an option slot on the drive control unit
Degree of protection	IP20 / UL Type 1

Ambient conditions	See the drive technical data.
Package	Cardboard
Reley outputs (50…52, 53…55)	
Maximum wire size	1.5 mm²
Minimum contact rating	12 V / 10 mA
Maximum contact rating	250 V AC / 30 V DC / 2 A
Maximum breaking capacity	1500 VA
Transistor output (42…44)	
Maximum wire size	1.5 mm²
Type	Transistor output PNP
Maximum load	4 kohm
Maximum switching voltage	30 V DC
Maximum switching current	100 mA / 30 V DC, short-circuit protected
Frequency	10 Hz … 16 kHz
Resolution	1 Hz
Inaccuracy	0.2%
External power supply (40…41)	
Maximum wire size	1.5 mm²
Input voltage	24 V AC / V DC ±10% (GND, user potential)
Maximum power consumption	25 W, 1.04 A at 24 V DC
Isolation areas	
	
1	Plugged to drive **SLOT2**
	Reinforced insulation (IEC 61800-5-1:2007)
	Functional insulation (IEC 61800-5-1:2007)

Dimension drawing

The dimensions are in millimeters and [inches].

238 CMOD-01 multifunction extension module (external 24 V AC/DC and digital I/O)



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CMOD-02 multifunction extension module (external 24 V AC/DC and isolated PTC interface)

Contents of this chapter

This chapter describes how to install and start up the optional CMOD-02 multifunction extension module. The chapter also contains diagnostics and technical data.

Product overview

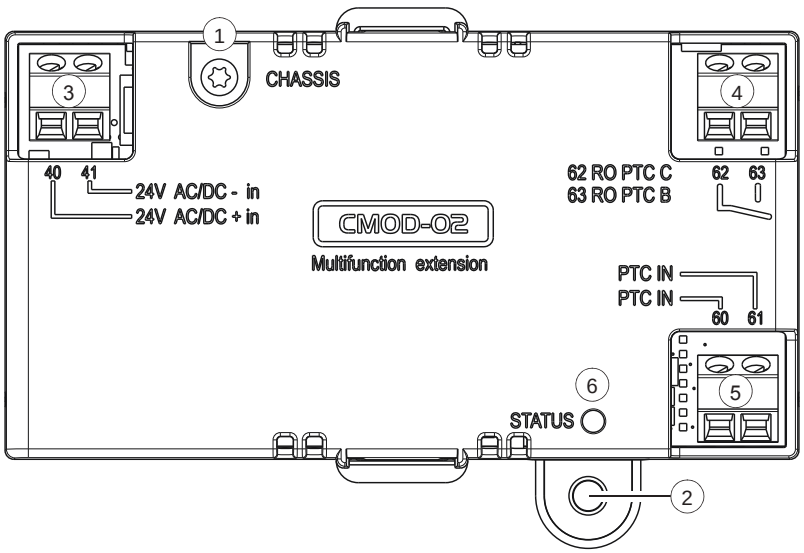
The CMOD-02 multifunction extension module (external 24 V AC/DC and isolated PTC interface) has a motor thermistor connection for supervising the motor temperature and one relay output, which indicates the thermistor status. In case the thermistor overheats, the drive trips on motor overtemperature. If Safe torque off tripping is required, the user must wire the overtemperature indication relay to the certified Safe torque off input of the drive.

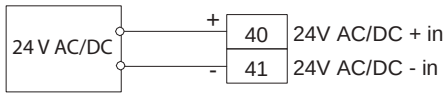
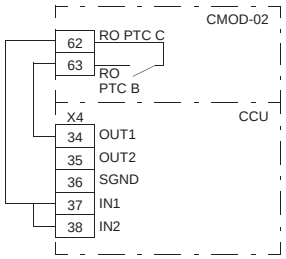
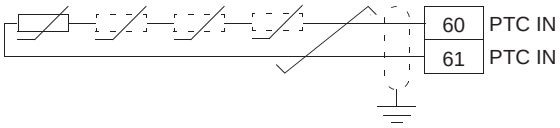
In addition, the extension module has an external power supply interface, which can be used to power up the drive control unit in case the drive power supply is not on. If you do not need the back-up power supply, you do not have to connect it because the module is powered from the drive control unit by default.

There is reinforced insulation between the motor thermistor connection, the relay output and the drive control unit interface. Thus, you can connect a motor thermistor to the drive through the extension module.

With CCU-24 control unit, a CMOD-02 module is not necessary for external 24 V AC/DC supply connection. The external supply is connected directly to terminals 40 and 41 on the control unit.

Layout and example connections



3	2-pin terminal block for external power supply		4	2-pin terminal block for relay output	
					
40	24 V AC/DC + in	External 24 V (AC/DC) input	62	RO PTC C	Common, C
41	24 V AC/DC - in	External 24 V (AC/DC) input	63	RO PTC B	Normally open, NO
5	**Motor thermistor connection**		**1**	**Grounding screw**	
 One to six PTC thermistors connected in series.					
60	PTC IN	PTC connection	**2**	**Hole for mounting screw**	
61	PTC IN	Ground (earth) potential	**6**	**Diagnostic LED**	

Mechanical installation

Necessary tools

- Screwdriver and a set of suitable bits.

Unpacking and examining the delivery

1. Open the option package. Make sure that the package contains:
   - the option module
   - a mounting screw.
2. Make sure that there are no signs of damage.

Installing the module

See section Installing option modules (page 113).

Electrical installation

WARNING!
Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.

Stop the drive and do the steps in section Electrical safety precautions (page 19) before you start the work.

Necessary tools

- Screwdriver and a set of suitable bits

Wiring

Connect the external control cables to the applicable module terminals. Ground the outer shield of the control cables at the cabinet entry.

WARNING!
Do not connect the +24 V AC cable to the control unit ground when the control unit is powered using an external 24 V AC supply.

Start-up

Setting the parameters

1. Power up the drive.
2. If no warning is shown,
   - make sure that the values of both parameters 15.01 Extension module type and 15.02 Detected extension module are CMOD-02.

   If the warning A7AB Extension I/O configuration failure is shown,
   - make sure that the value of parameter 15.02 is CMOD-02.
   - set the parameter 15.01 value to CMOD-02.

   You can now see the parameters of the extension module in parameter group 15 I/O extension module.

Diagnostics

Faults and warning messages

Warning A7AB Extension I/O configuration failure.

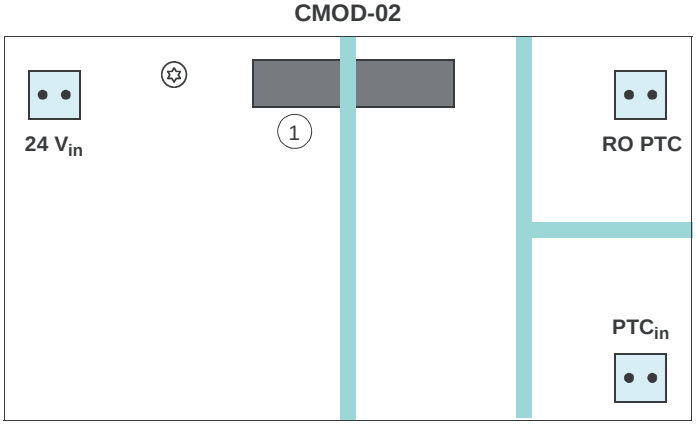
LEDs

The extension module has one diagnostic LED.

Color	Description
Green	The extension module is powered up.

Technical data

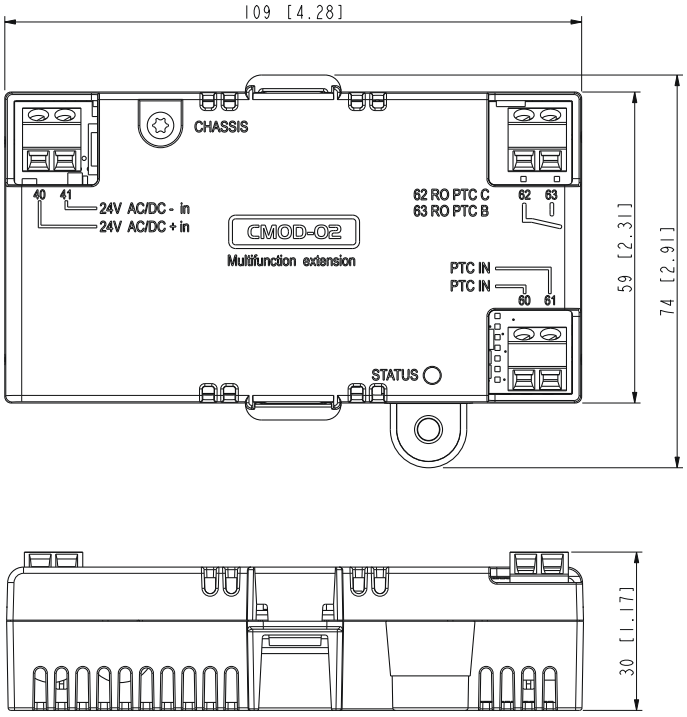
Installation	Into option slot 2 on the drive control unit
Degree of protection	IP20 / UL Type 1
Ambient conditions	See the drive technical data.
Package	Cardboard
Motor thermistor connection (60…61)	
Maximum wire size	1.5 mm^2
Supported standards	DIN 44081 and DIN 44082
Triggering threshold	3.6 kohm ±10%
Recovery threshold	1.6 kohm ±10%
PTC terminal voltage	≤ 5.0 V
PTC terminal current	< 1 mA
Short-circuit detection	< 50 ohm ±10%
The PTC input is reinforced/double insulated. If the motor part of the PTC sensor and wiring are reinforced/double insulated, voltages on the PTC wiring are within SELV limits. If the motor PTC circuit is not reinforced/double insulated (ie, it is basic insulated), it is mandatory to use reinforced/double insulated wiring between the motor PTC and CMOD-02 PTC terminal.	
Relay output (62…63)	
Maximum wire size	1.5 mm^2
Maximum contact rating	250 V AC / 30 V DC / 5 A
Maximum breaking capacity	1000 VA
External power supply (40…41)	
Maximum wire size	1.5 mm^2
Input voltage	24 V AC / V DC ±10% (GND, user potential)
Maximum power consumption	25 W, 1.04 A at 24 V DC
Isolation areas	



1	Plugged to drive **SLOT2**
	Reinforced insulation (IEC 61800-5-1:2007)
	Functional insulation (IEC 61800-5-1:2007)

Dimension drawing

The dimensions are in millimeters and [inches].



Further information

Product and service inquiries

Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to www.abb.com/contact-centers.

Product training

For information on ABB product training, navigate to new.abb.com/service/training.

Providing feedback on ABB manuals

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