

ABB DRIVES FOR HVAC

ACH531-01 drives

Hardware manual



ACH531-01 drives

Hardware manual

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Further information



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.

Safety messages

These safety messages help to prevent personal injury and damage to the equipment. The hazard levels comply with standard ANSI Z535.6.

The manual uses these warning symbols:



▲DANGER Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



▲WARNING Indicates a hazardous situation which, if not avoided, could result in death or serious injury.



▲CAUTION Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE Is used to address practices not related to physical injury, but which can result in equipment damage.

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, hearing protection, 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.
- 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, remain hot for a while after disconnection of the electrical supply.
- Vacuum clean the area around the drive before the start-up to prevent the drive cooling fan from drawing the dust inside the drive.
- Make sure that debris from drilling, cutting and grinding does not enter the drive during the installation. Electrically conductive debris inside the drive may cause damage or malfunction.
- Make sure that there is sufficient cooling. See the technical data.
- Before you connect voltage to the drive, make sure that all covers are in place. Do not remove the covers when voltage is connected.
- 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 supply break. If these functions are activated, the installation must be clearly

marked as defined in IEC/EN 61800-5-1, subclause 6.5.3, for example, "THIS MACHINE STARTS AUTOMATICALLY".

- The maximum drive power cycle is five times in ten minutes. Power cycling the drive too often can damage the charging circuit of the DC capacitors.
- Beware of hot air exiting from the air outlets.
- Do not cover the air inlet or outlet when the drive is running.

Note:

- If you select an external source for the start command and it is on, the drive will start immediately after fault reset unless you configure the drive for pulse start. See 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 allowed to repair a malfunctioning drive.

General safety in operation

These instructions are for all personnel that operate the drive.



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



- If you have a cardiac pacemaker or other electronic medical device, do not go near the 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 will start immediately after the fault reset, unless you configure the drive for pulse start. See 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 supply break.

Note:

- The maximum drive power cycle is five times in ten minutes. Power cycling the drive too often can damage the charging circuit of the DC capacitors. If you need to start or stop the drive, use the control panel keys or commands through the I/O terminals of the drive.
- If the drive is in remote control mode, you cannot stop or start the drive with the control panel.

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 electrical installation or maintenance work. Do these steps before you do 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.
 - If there is a permanent magnet motor connected 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 high-quality voltage tester.
 - 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 input power terminals of the drive (L1, L2, L3) and the grounding (PE) busbar is zero.
 - Make sure that the voltage between the output power terminals of the drive (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.

Note: If cables are not connected to the drive DC terminals, measuring the voltage from the DC terminal screws can give incorrect results.
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.

- 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 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.

Note:

- When the drive is connected to the input power, the motor cable terminals and the DC bus are at a dangerous voltage.
The brake circuit, including the brake chopper and brake resistor (if installed) are also at a dangerous voltage.
After disconnecting the drive from the input power, these remain at a dangerous voltage until the intermediate circuit capacitors have discharged.
- External wiring can supply dangerous voltages to the relay outputs of the control units of the drive.
- The terminals from 34 to 38 do not remove the voltage from the main and auxiliary circuits. These terminals are not effective against deliberate sabotage or misuse.



Printed circuit boards

NOTICE Use an antistatic wrist strap 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.

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- 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.



2

Introduction to the manual

Contents of this chapter

This chapter describes the purpose, applicability, available frame sizes, and target audience 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 in other manuals.

Applicability

This manual applies to the ACH531-01 drives.

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.

Purpose of the manual

This manual provides information needed for planning the installation, installing, and servicing the drive.

Categorization by frame size

The ACH531-01 is manufactured in frames (frame sizes) R1...R9. Some instructions and other information that concern only certain frames are marked with the symbol

of the frame (R1...R9). The frame is marked on the type designation label of the drive, refer [Type designation label \(page 32\)](#).

Quick installation and commissioning flowchart

Task	Refer
Identify the frame of your drive: R1...R9.	Type designation label (page 32)
↓	
Plan the installation: select the cables, etc. Examine the ambient conditions, ratings and required cooling air flow.	Guidelines for planning the electrical installation (page 55) Technical data (page 143)
↓	
Unpack and examine the drive. Make sure that all necessary optional modules and equipment are present and correct.	Mechanical installation (page 37)
↓	
If the drive will be connected to another system than symmetrically grounded TN-S system: Examine if you must disconnect the EMC filter or ground-to-phase varistor.	IEC: Grounding system compatibility check (page 75)
↓	
Install the drive on a wall.	Mechanical installation (page 37)
↓	
Route the cables.	Routing the cables (page 65)
↓	
Measure the insulation of the input cable and the motor and the motor cable.	IEC: Measuring the insulation (page 74)
↓	
Connect the power cables.	IEC: Connecting the power cables (page 83)
↓	
Connect the control cables.	IEC: Connecting the control cables (page 98)
↓	
Check the installation.	Installation checklist (page 125)
↓	
Commission the drive.	ACH531 HVAC control program firmware manual (3AXD50000810710 [English]) .

Terms and abbreviations

Term	Description
ACH-AP-H	Assistant control panel with Hand-Off-Auto functionality
ACH-AP-W	Assistant control panel with Hand-Off-Auto functionality and Bluetooth interface
BACnet™	A network protocol (Building Automation and Control Networks)
Brake chopper	Conducts the surplus energy from the intermediate circuit of the drive to the brake resistor when necessary. The chopper operates when the DC link voltage exceeds a certain maximum limit. The voltage rise is typically caused by deceleration (braking) of a high inertia motor.
Brake resistor	Dissipates the drive surplus braking energy conducted by the brake chopper to heat

Term	Description
CAIO-01	CAIO-01 optional bipolar analog input and unipolar analog output extension module
Capacitor bank	The capacitors connected to the DC link
CCA-01	Configuration adapter
CDPI-01	Communication adapter module
CHDI-01	115/230 V digital input extension module
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)
Control unit	Enclosure that contains the control board and related connector boards. The term is also used as a synonym for the control board.
CPTC-02	Multifunction extension module (external 24 V and ATEX/UKEX-certified PTC interface)
DC link	DC circuit between rectifier and inverter
DC link capacitors	Energy storage which stabilizes the intermediate circuit DC voltage
DPMP-01	Mounting platform for control panel (flush mounting)
DPMP-02, DPMP-03	Mounting platform for control panel (surface mounting)
DPMP-EXT	Optional mounting platform for door mounting of control panel
Drive	Frequency converter for controlling AC motors
EFB	Embedded fieldbus
EMC	Electromagnetic compatibility
FBA	Fieldbus adapter
FBIP-21	BACnet/IP adapter module
FEIP-21	Optional Ethernet adapter module for EtherNet/IP™
FENA-21	Optional Ethernet adapter module for EtherNet/IP™, Modbus TCP and PROFINET IO protocols, 2-port
FEPL-02	Optional Ethernet POWERLINK adapter module
FLON-01	Optional LonWorks® adapter module
FMBA-01	Optional Modbus RTU adapter module
FMBT-21	Optional Ethernet adapter module for Modbus TCP protocol
FPBA-01	Optional PROFIBUS DP® adapter module
FPNO-21	Optional PROFINET IO adapter module
Frame, frame size	Physical size of the drive or power module
FSCA-01	Optional RS-485 (Modbus/RTU) adapter
IGBT	Insulated gate bipolar transistor
Intermediate circuit	DC circuit between rectifier and inverter
Inverter unit	Inverter module(s) under control of one control unit, and related components. One inverter unit typically controls one motor.
LonWorks®	A networking platform
NETA-21	Remote monitoring tool
Network control	With fieldbus protocols based on the Common Industrial Protocol (CIP™), such as DeviceNet and Ethernet/IP, denotes the control of the drive using the Control Supervisor and AC/DC drive objects of the ODVA AC/DC Drive Profile. For more information, refer to www.odva.org .
Parameter	In the drive or converter control program, parameter is a user-adjustable setting, or a read-only monitoring signal. In some (for example fieldbus) contexts, a value that can be accessed as an object. For example, variable, constant, or signal.
PLC	Programmable logic controller
PTC	Positive temperature coefficient
Rectifier	Converts alternating current and voltage to direct current and voltage
STO	Safe torque off (IEC/EN 61800-5-2)

Related documents

Name	Code (English/ Multilingual)
Drive manuals and guides	
ACH531 HVAC control program firmware manual	3AXD50000810710
ACH531-01 drives hardware manual	3AXD50000815319
ACH531-01 Drive Quick installation and start-up guide Frames R1 to R5	3AXD50000815333
ACH531-01 Drive Quick installation and start-up guide R6 to R9	3AXD50000728190
ACS-BP-S Basic control panel user's manual	3AXD50000032527
Drive modules cabinet design and construction instructions	3AUA0000107668
Installation of drive module frames R6 to R9 in Rittal VX25 enclosure supplement	3AXD50000523191
Alternate Fuses, MMPs and Circuit Breakers for ABB Drives	3AXD50000645015
Option manuals and guides	
DPMP-02/03 mounting platform for control panels	3AUA0000136205
FPBA-01 PROFIBUS DP adapter module user's manual	3AFE68573271
FENA-21 Ethernet adapter module user's manual	3AUA0000093568
FSCA-01 RS-485 adapter module user's manual	3AUA0000109533
FEPL-02 Ethernet POWERLINK adapter module user's manual	3AUA0000123527
FOCH du/dt filters hardware manual	3AFE68577519
Tool and maintenance manuals and guides	
Drive Composer Start-up and maintenance PC tool user's manual	3AUA0000094606
Converter module capacitor reforming instructions	3BFE64059629
NETA-21 remote monitoring tool user's manual	3AUA0000096939
NETA-21 remote monitoring tool installation and start-up guide	3AUA0000096881
CCA-01 Configuration Adapter	3AXD50000018457

3

Operation principle and hardware description

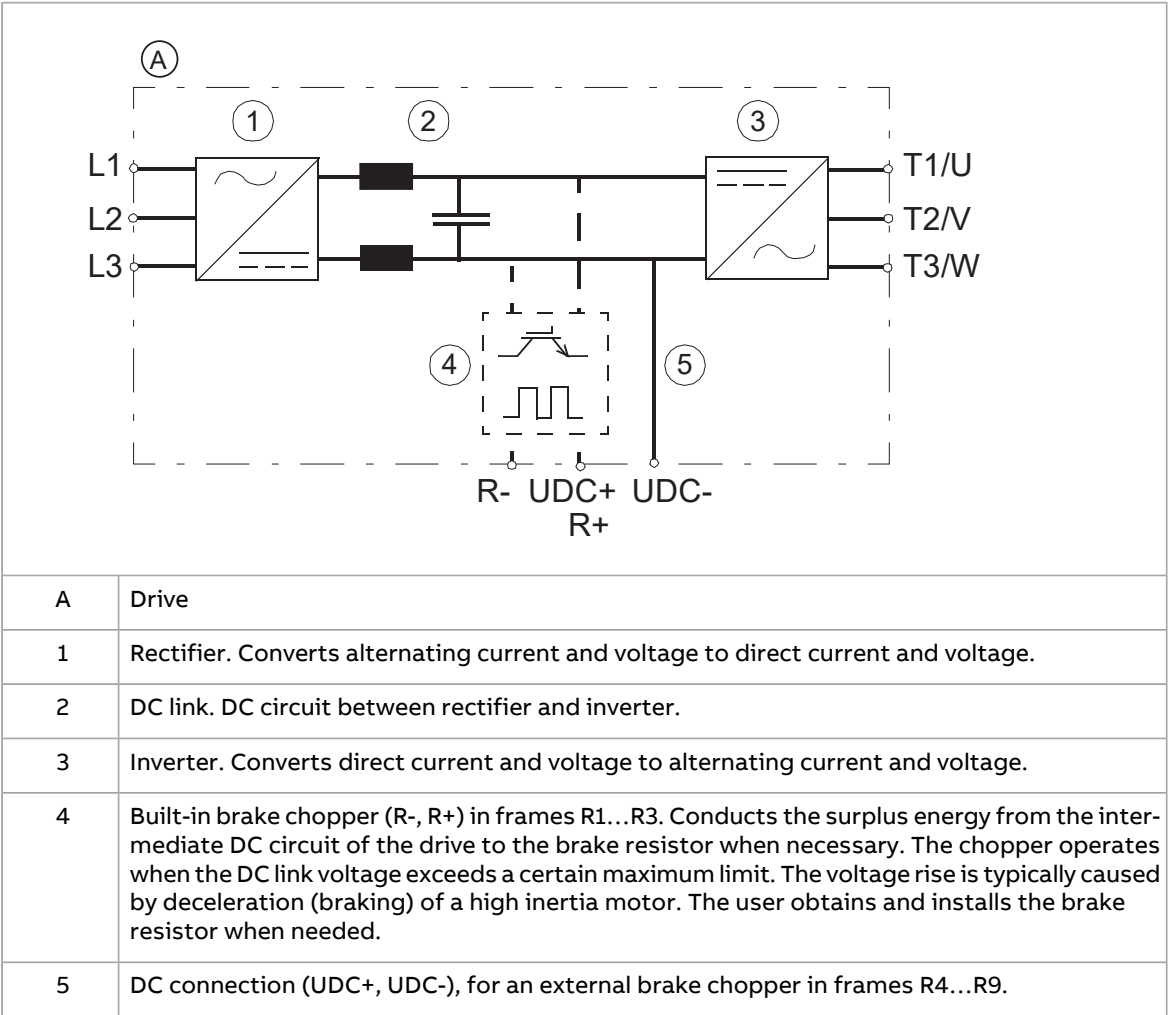
Contents of this chapter

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

Operation principle

The ACH531-01 is a drive for controlling asynchronous AC induction motors and permanent magnet motors.

The figure below shows the simplified main circuit diagram of the drive.

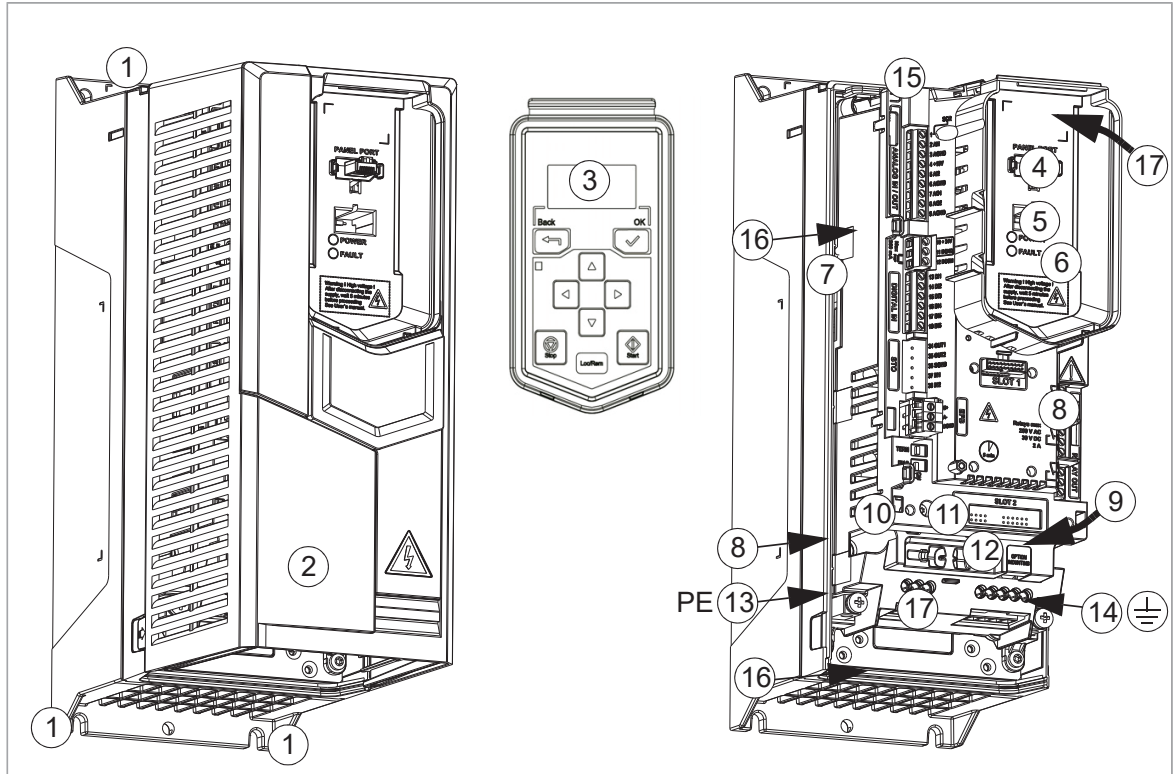


Layout

Frames R1...R2

The layout of frame R1 is shown in the table that follows. The main structure of frame R2 is similar to R1.

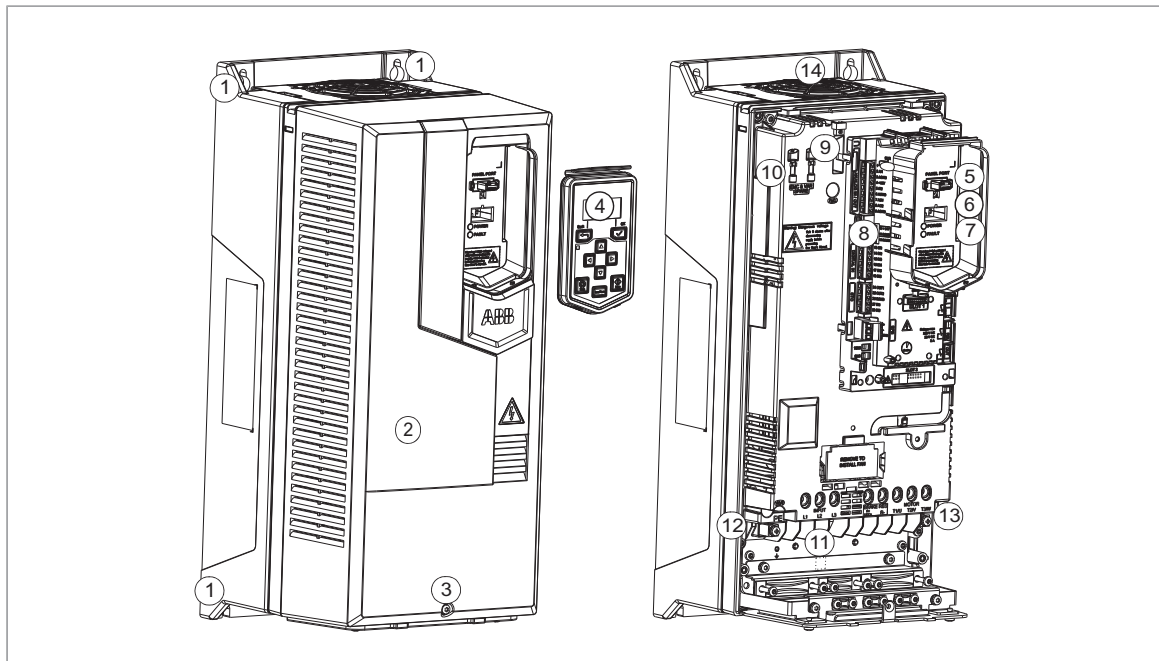
R1 IP20



1	Mounting points (4 pieces)	9	EMC filter grounding screw (EMC (DC)). For disconnecting, refer page 80 (IEC).
2	Cover	10	Place for storing the removed VAR screw
3	Control panel	11	Place for storing the removed EMC screw
4	Control panel connection	12	Input power connection (L1, L2, L3), motor connection (T1/U, T2/V, T3/W) and brake resistor connection (R-, R+)
5	Cold configuration connection for CCA-01	13	PE connection (power line)
6	Power OK and Fault LEDs. Refer section LEDs (page 140) .	14	Stripping length (8 mm) checker
7	I/O connections. Refer External control connection terminals, frames R1...R5 (page 30) .	15	Main cooling fan
8	Varistor grounding screw (VAR). For disconnecting, refer page 80 (IEC).	16	Cable tie mounts for /I/O cables
		17	Auxiliary cooling fan connector

Frame R3...R5

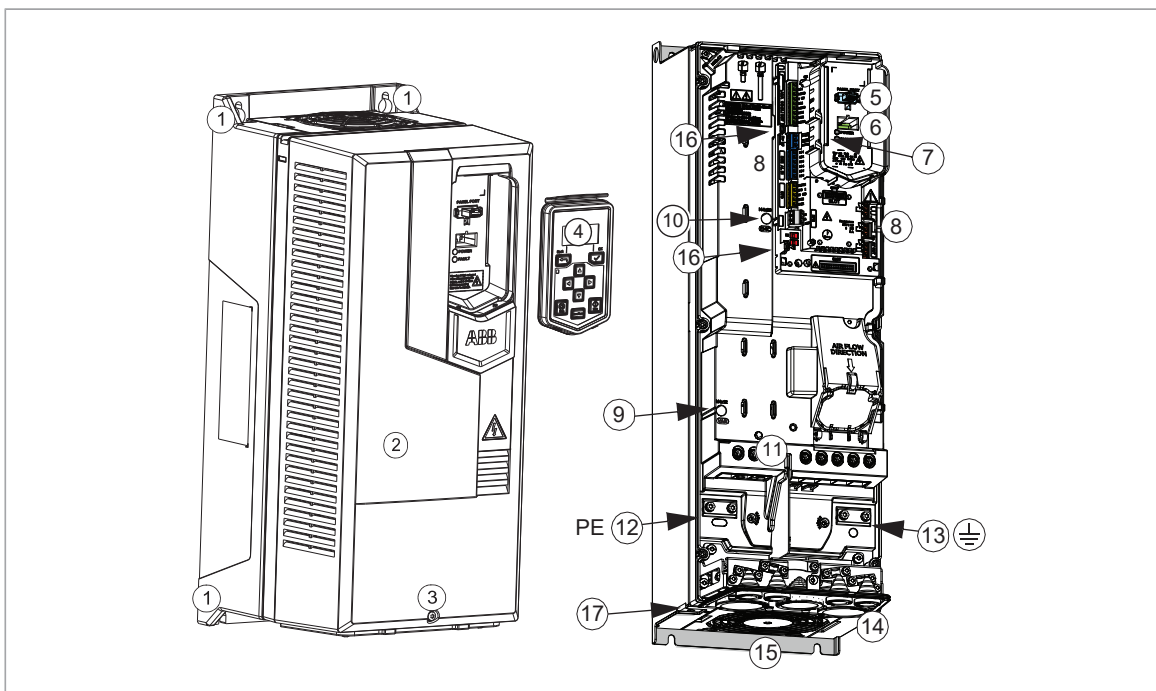
R3 IP20



1	Mounting points (4 pieces)	8	Varistor grounding screw (VAR). For disconnecting, refer page 80 (IEC).
2	Cover	9	EMC filter grounding screw (EMC (DC)). For disconnecting, refer page 80 (IEC).
3	Cover screw	10	Input power connection (L1, L2, L3), motor connection (T1/U, T2/V, T3/W) and brake connection (R-, R+)
4	Control panel	11	PE connection (power line)
5	Control panel connection	12	Grounding connection (motor)
6	Cold configuration connection for CCA-01	13	Main cooling fan
7	Power OK and Fault LEDs. Refer section LEDs (page 140).		
8	I/O connections. Refer External control connection terminals, frames R1...R5 (page 30).		

R4 v2 IP20

New design of frame R4 types 062A-4, 073A-4 and 089A-4 are marked as R4 v2.

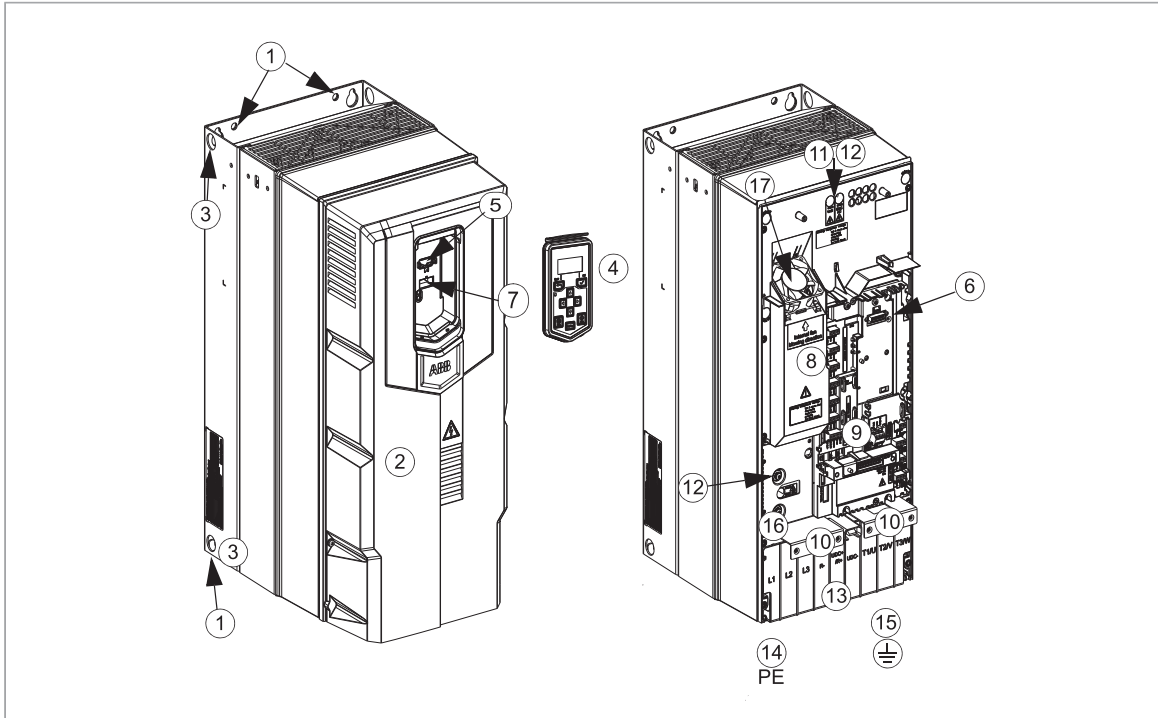


1	Mounting points (4 pieces)	10	EMC filter grounding screw (EMC). For disconnecting, refer page 80 (IEC).
2	Cover	11	Input power connection (L1, L2, L3), motor connection (T1/U, T2/V, T3/W) and DC connection (UDC+, UDC-)
3	Cover screw	12	PE connection (power line)
4	Control panel	13	Grounding connection (motor)
5	Control panel connection	14	Cable entry
6	Cold configuration connection for CCA-01	15	Main cooling fan
7	Power OK and Fault LEDs. Refer section LEDs (page 140) .	16	Cable tie mounts for /I/O cables
8	I/O connections. Refer External control connection terminals, frames R1...R5 (page 30) .	17	Additional grounding connection
9	Varistor grounding screw (VAR). For disconnecting, refer page 80 (IEC).		

Frame R6...R9

The layout of a frame R6 drive is presented below. The construction of frame R6 differs to some extent.

R6 IP20

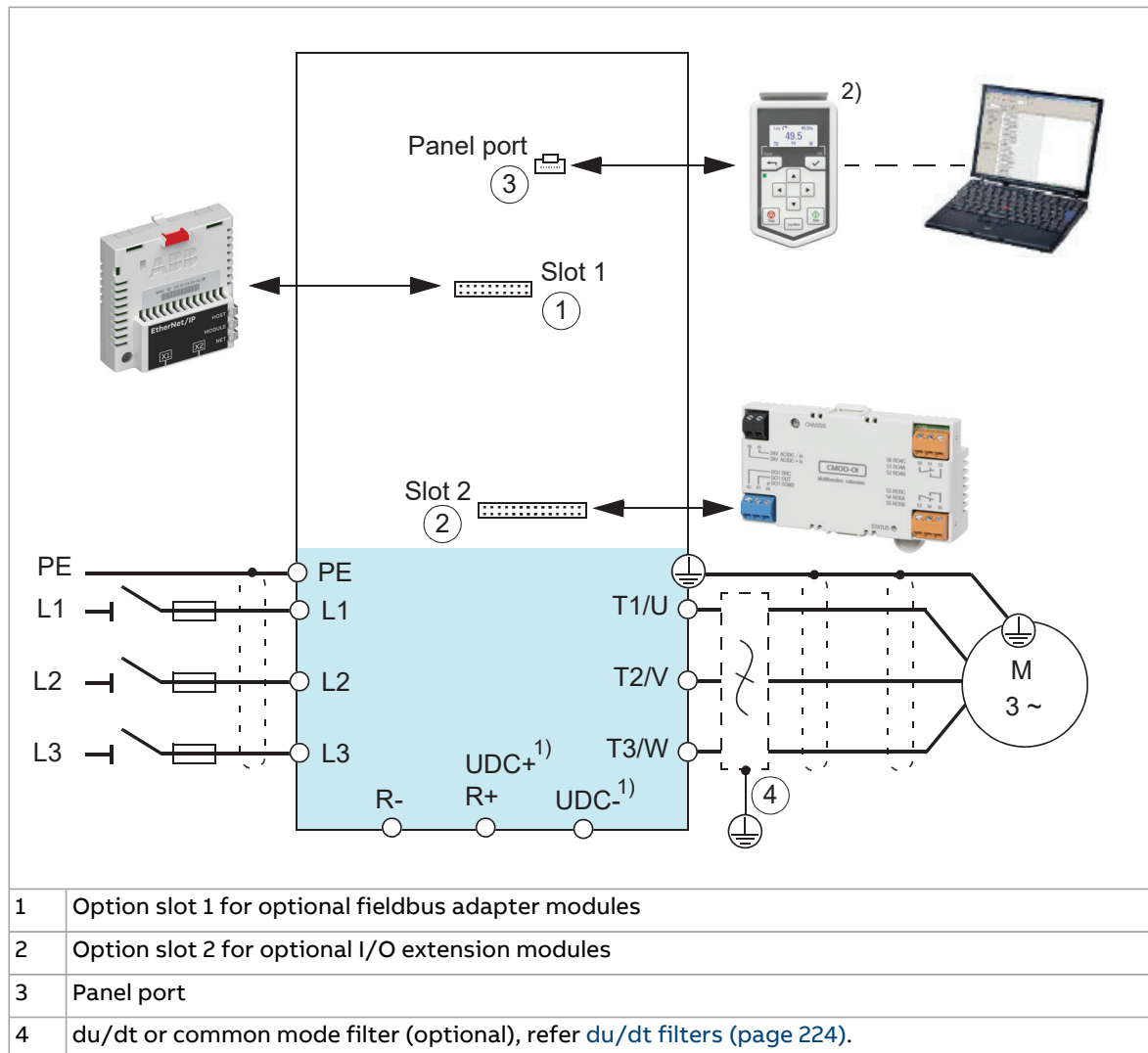


1	Mounting points (4 pieces: 2 at the top, 2 at the bottom of the main part of the frame)	11	Varistor grounding screw (VAR), under the control panel platform. For disconnecting, refer page 80 (IEC).
2	Cover	12	Two EMC filter grounding screws, 14a: EMC (DC) under the control panel platform and 14b: (EMC (AC) at the left, above the shroud. For disconnecting, refer page 80 (IEC).
3	Lifting holes (4 pieces)	13	Shroud. Under the shroud: Input power connection (L1, L2, L3), motor connection (T1/U, T2/V, T3/W) and DC connection (UDC+, UDC-)
4	Control panel	14*	PE connection (power line)
5	Control panel connection	15*	Grounding connection (motor), under the shroud (15)
6	Cold configuration connection for CCA-01	16	1 main cooling fan (R6...R8); 2 main cooling fans at the bottom (R9)
7	Power OK and Fault LEDs. Refer section LEDs (page 140).	17	Auxiliary cooling fan
8	I/O connections. Refer External control connection terminals, frames R1...R5 (page 30).		
9	Cable tie mounts for /I/O cables		
10	Clamps for I/O cable mechanical support		

*Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Overview of power and control connections

The logical diagram below shows the power connections and control interfaces of the drive.

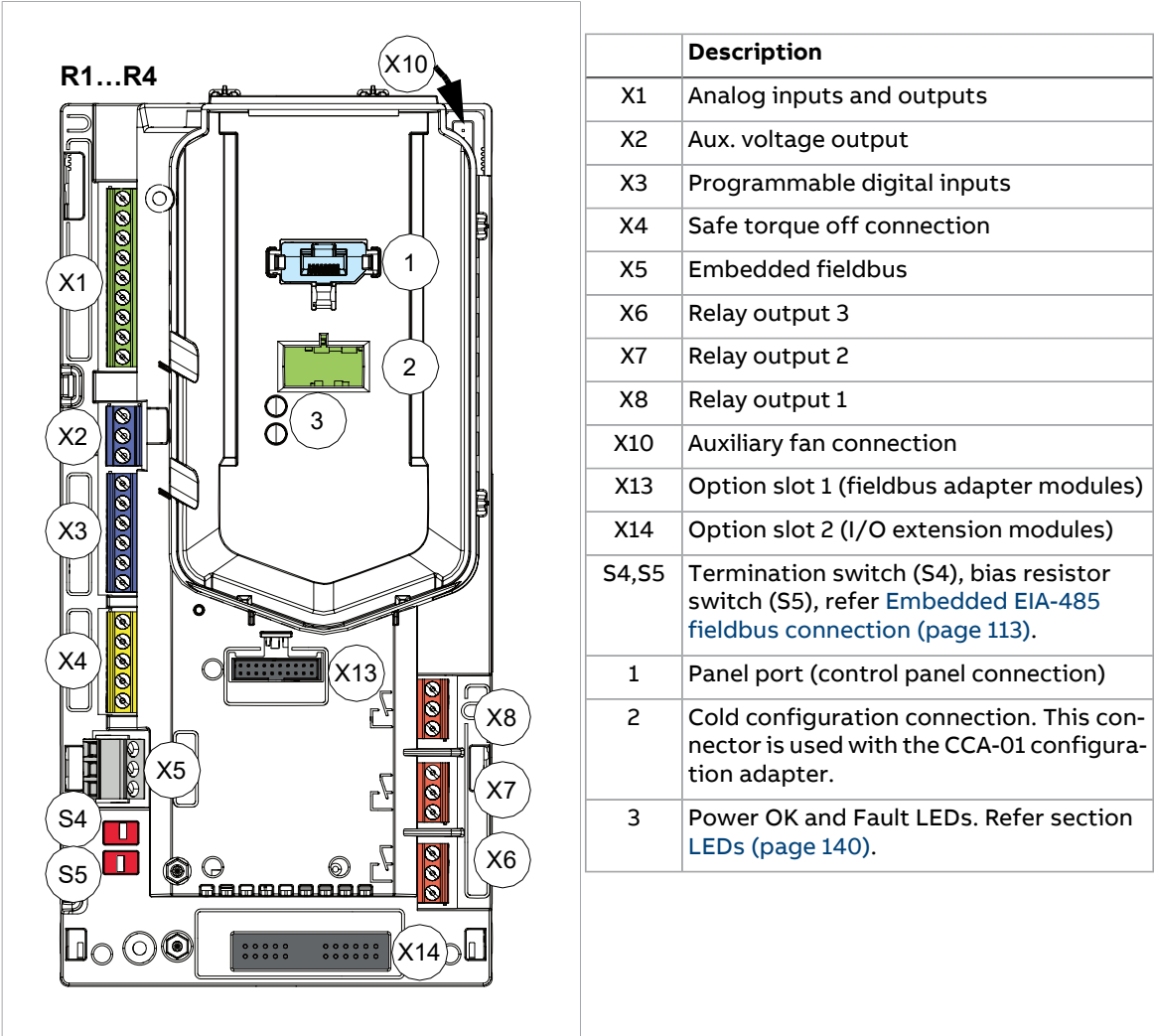


¹⁾Not in all frame sizes

²⁾To connect the PC tools, an assistant control panel is needed.

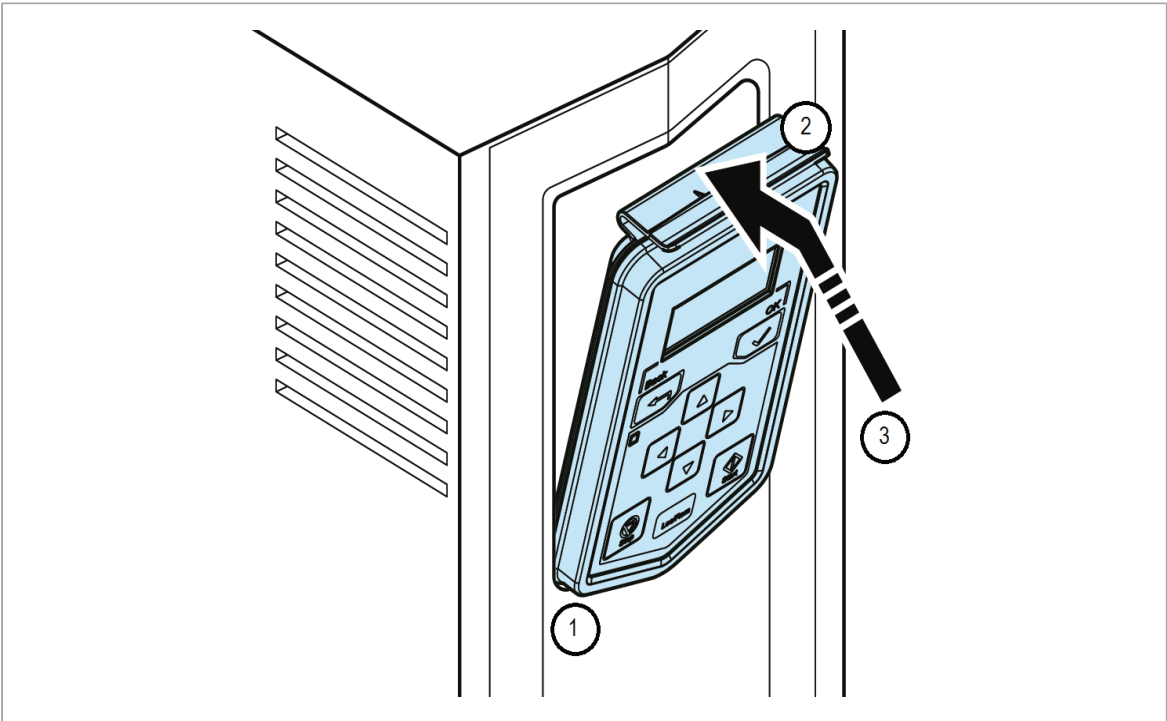
■ External control connection terminals, frames R1...R5

The layout of the external control connection terminals of the R1 frame is shown below. Layout of the external control connection terminals is identical in frames R1...R5 but the location of the control unit with the terminals is different in frames R3...R5.



Control Panel (optional)

To remove the control panel, press the retaining clip at the top (2) and pull the panel forward from the top edge (3).



To reinstall the control panel, put the bottom of the container in position (1), press the retaining clip at the top (2) and push the control panel in at the top edge (3).

For the use of the control panel, refer to the firmware manual and *ACS-AP-I, -S, -W and ACH-AP-H, -W Assistant control panel user's manual* ([3AUA0000085685](#) [English]) and *ACS-BP-S basic control panel user's manual* ([3AXD50000032527](#) [English]).

■ Control panel door mounting kits

You can use a mounting platform to mount the control panel on the cabinet door. Mounting platforms for control panels are available as options from ABB. For more information, refer

Manual	Code (English)
<i>DPMP-01 mounting platform for control panels installation guide</i>	3AUA0000100140
<i>DPMP-02/03 mounting platform for control panels installation guide</i>	3AUA0000136205

Type designation label

The type designation label includes IEC ratings, appropriate markings and the type designation and serial number, which allow identification of each drive. The type designation label is located on the left side of the drive, refer section [Locations of the labels on the drive \(page 34\)](#). An example label is shown below.



Origin India
Made in India
ABB India Limited
Bangalore, 560058,
Karnataka, India

Frame

R4

Air cooling
IP20
Multi-rated equipment see Hardware manual
IE2 (90,100) 2,0%

ACH531-01-073A-4

Input	U1	3~380...480 VAC
	I1	73/65 A
	f1	50/60 Hz
Output	U2	3~380...480 VAC
	I2	73/65 A
	f2	0.....500 Hz

ICC 65 kA
SCCR 100 kA

CE

TUV NORD
Safety Approved

S/N: 9250701690

③



⑨

⑧



⑧

No.	Description
1	Type designation, refer section Type designation key (page 34) .
2	Name and address of the manufacturer
3	Frame (size)
4	Type of the drive, for example, with Air cooling or Liquid cooling, and so on.
5	Degree of protection
6	Nominal ratings in the supply voltage range, refer Ratings (page 143) , Electrical power network specification (page 162) and Motor connection data (page 163) .
7	Valid markings
8	S/N: Serial number of format MYYWWXXXXX, where M: Manufacturing plant YY: 16, 17, 18, ... for 2016, 2017, 2018, ... WW: 01, 02, 03, ... for week 1, week 2, week 3, ... XXXXX: Digits making the serial number unique
9	Link to the product data sheet

The type designation contains information on the specifications and configuration of the drive. You find the type designation on the type designation label attached to

the drive. The first digits from the left express the basic configuration, for example, ACH531-01-12A7-4. The optional selections are given after that, separated by plus signs, for example, +L501. The main selections are described below. Not all selections are available for all types.

Code	Description
Basic codes	
ACH531-01	Product series
01	When no options are selected: IP20, ACS-BP-S Basic control panel, choke, EMC C2 filter (built-in EMC filter), safe torque off, braking chopper in frames R1, R2, R3, coated boards, cable entry from the bottom, cable box (optional) or the conduit plate with cable entries, quick installation and start-up guide.
Size	
xxxx	Refer the rating tables
Voltage rating	
4	4 = 380...480 V Refer the technical data for further information.

■ Option codes

Code	Description
C135	Flange mounting
J400	ACH-AP-H control panel
J424	Blank control panel cover (no control panel)
K452	FLON-01 LonWorks® adapter module
K454	FPBA-01 PROFIBUS DP adapter module
K458	FSCA-01 RS-485 (Modbus/RTU) adapter module
K462	FCNA-01 ControlNet™ adapter module
K465	FBIP-01 BACnet/IP adapter module, 2-port
K469	FECA-01 EtherCat adapter module
K470	FEPL-02 EtherPOWERLINK adapter module
K475	FENA-21 Ethernet adapter module for EtherNet/IP™, Modbus TCP and PROFINET IO protocols, 2-port
K490	FEIP-21 EtherNet/IP adapter module
K491	FMBT-21 Modbus/TCP adapter module
K492	FPNO-21 PROFINET IO adapter module
L501	CMOD-01 External 24 V AC/DC and digital I/O extension (2×RO and 1×DO)
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
P932	Extended warranty 60 months from delivery
P944	Version for cabinet mounting (drive module with front covers but without cable box)

4

Mechanical installation

Contents of this chapter

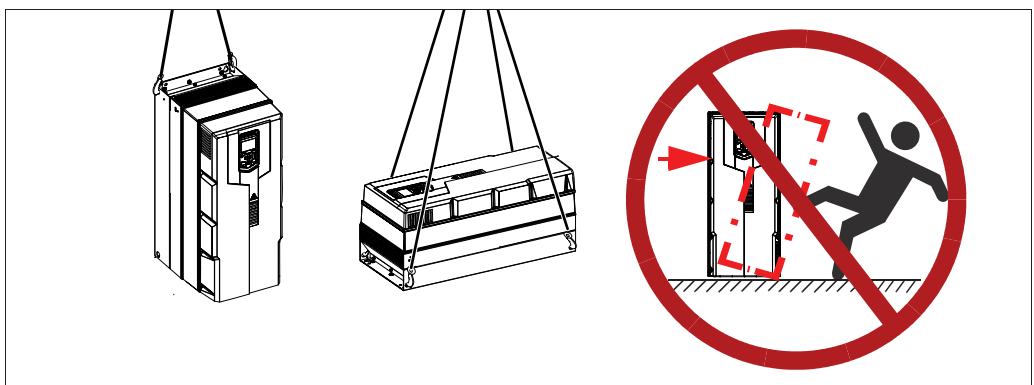
This chapter tells you how to examine the installation site, examine the delivery, and mechanically install the drive.



Safety



▲WARNING Frames R5...R9: Lift the drive with a lifting device. Use the lifting eyes of the drive. Do not tilt the drive. **The drive is heavy and its center of gravity is high. An overturning drive can cause physical injury.**



Examining the installation site

Make sure that:

- The installation site is sufficiently ventilated or cooled to remove heat from the drive. Refer the technical data.
- The ambient conditions of the drive meet the specifications. Refer the technical data.
- The material behind, above and below the drive is non-flammable.
- The installation surface is as close to vertical as possible and strong enough to support the drive.
- There is sufficient free space around the drive for cooling, maintenance, and operation. Refer the free space specifications for the drive.
- Make sure that there are no sources of strong magnetic fields such as high-current single-core conductors or contactor coils near the drive. A strong magnetic field can cause interference or inaccuracy in the operation of the drive.

Installation alternatives

The drive must be installed on the wall or an enclosure. There are three alternative ways to install it:

- Vertical

Note: Do not install the drive upside down.



Frame size	Vertical installation - Free space		
	IP20		
	Above (a) ¹⁾	Below (b) ²⁾	Beside (c) ³⁾
	mm	mm	mm
R1	65	86	150
R2	65	86	150
R3	65	53	150
R4	53	200	150
R5	75	200	150
R6	155	300	150
R7	155	300	150
R8	155	300	150
R9	200	300	150

¹⁾ Free space above is measured from the frame.

Note: The height of the hood for frame R4 exceeds the requirement of free space above for these frames

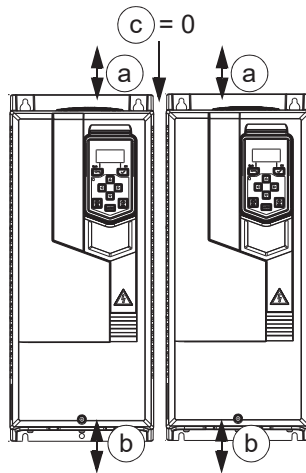
Frame size	Hood height (mm)
R4	72
R9	230

²⁾ Free space below is always measured from the drive frame, not from the cable box (optional).

³⁾ Free space between the drive and other objects, e.g. wall.

Note: The recommended free space above and below the drive is for installations where the drive is mounted on a wall indoors. For ABB cabinet-built drives, which are thermally tested and approved for a specified temperature range, free space could vary from this recommendation.

- Vertical side by side or between walls



Frame size	Vertical installation side by side - Free space, IP20		
	Above (a) ¹⁾	Below (b) ²⁾	Between (c) ³⁾
	mm	mm	mm
R1	200	200	0
R2	200	200	0
R3	200	200	0
R4	200	200	0
R5	200	200	0
R6	200	300	0
R7	200	300	0
R8	200	300	0
R9	200	300	0

¹⁾ Free space above is measured from the frame.

²⁾ Free space below is always measured from the drive frame, not from the cable box (optional).

³⁾ Free space between the drives.

Note: The recommended free space above and below the drive is for installations where the drive is mounted on a wall indoors. For ABB cabinet-built drives, which are thermally tested and approved for a specified temperature range, free space could vary from this recommendation.

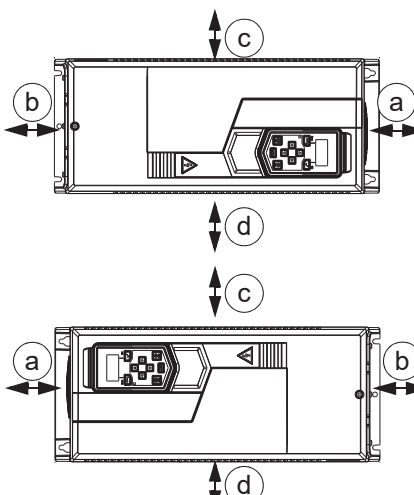
Note: IP20 frames R1...R2: The cover fastening clips can be removed to make the front cover opening easier.

- Horizontal, IP20, R1...R5 only

Note 1: You can install IP20 drives horizontally.

Note 2: In the horizontal mounting, the drive is not protected from dripping water.

Note 3: The vibration specification in [Ambient conditions \(page 168\)](#) may not be fulfilled.



Frame size	Horizontal installation - Free space			
	IP20			
	Above (a)	Below (b) ¹⁾	Side up (c)	Side down (d)
	mm	mm	mm	mm
R1	150	86	30	200
R2	150	86	30	200
R3	200	53	30	200
R4	30	200	30	200
R5	30	200	30	200

¹⁾ Free space below is always measured from the drive frame, not from the cable box (optional).

Make sure that the installation site complies with the requirements below:

- The installation site is sufficiently ventilated or cooled to remove the heat away from the drive. Refer [Losses, cooling data and noise \(page 158\)](#).
- The operation conditions of the drive meet the specifications given in [Ambient conditions \(page 168\)](#).
- The wall is as close to vertical as possible, of non-flammable material and strong enough to carry the weight of the drive, Refer [Dimensions, weights and free space requirements \(page 157\)](#).
- The floor/material below the installation is non-flammable.
- There is enough free space above and below the drive to enable cooling air flow, service and maintenance. Refer the required free space tables for each of the different mounting alignments on page [38](#) (or page [157](#)).

Necessary tools

To move a heavy drive, use a crane, forklift, or pallet truck (examine the load capacity).
To lift a heavy drive, use a lifting device.

To mechanically install the drive, make sure that you have these tools available:

42 Mechanical installation

- screwdriver set (Torx, Phillips, flat and/or Pozidriv, as necessary)
- torque wrench
- socket set, Hex key set (metric)
- tape measure, if you do not use the mounting template delivered with the drive.

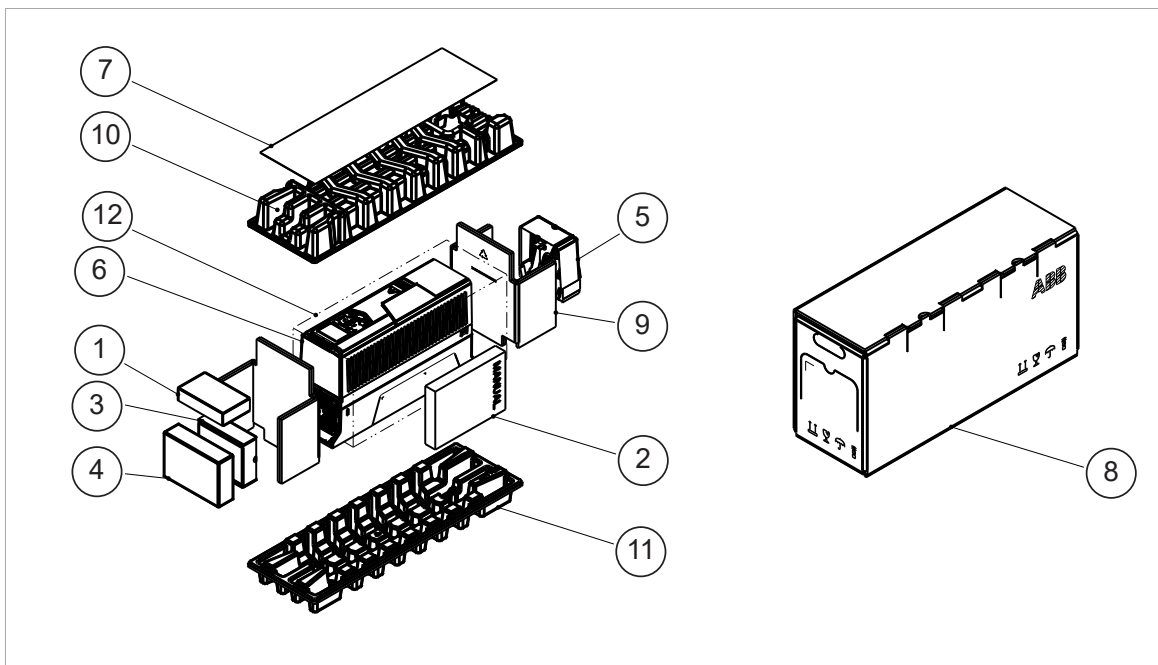
Moving the drive

Frames R5...R9: Move the transport package by pallet truck to the installation site.



Unpacking and examining delivery, frames R1 and R2

The figure below shows the layout of the transport package. Examine that all items are present and there are no signs of damage. Read the data on the type designation label of the drive to make sure that the drive is of the correct type. Refer [Type designation label](#) (page 32).



1	Control panel selected in the order.
2	Quick installation and start-up guide (always), and hardware and firmware manuals (if ordered separately); Multilingual residual voltage warning stickers
3	I/O option box
4	Fieldbus option box
Note: Possible options in separate packages, if they have been ordered with a plus code, such as for example +K490 (FEIP-21 Two-port EtherNet/IP adapter module) in the fieldbus option box.	

5	Cable box (optional)
6	Drive
7	Mounting template
8	Cardboard box
9	End support (2 pcs)
10	Top cushion
11	Bottom cushion
12	Plastic bag

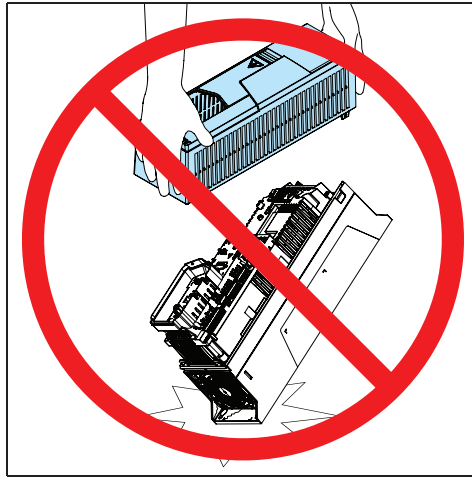
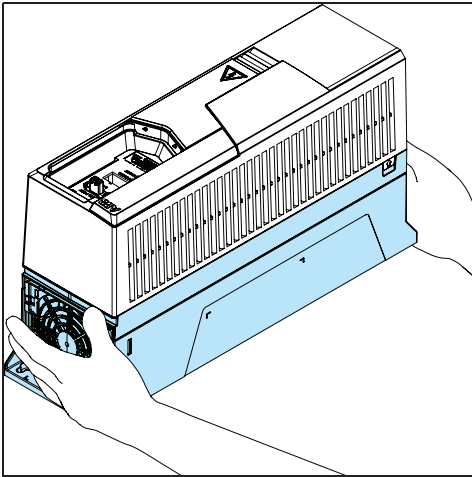


To unpack:

- Open the cardboard box (8)
- Remove the mounting template (7) and top cushion (10)
- Remove the control panel, option boxes and cable box (1,3,4,5; cable box is optional).
- Remove the end supports (9)
- Remove the plastic bag (12)
- Lift the drive (6).



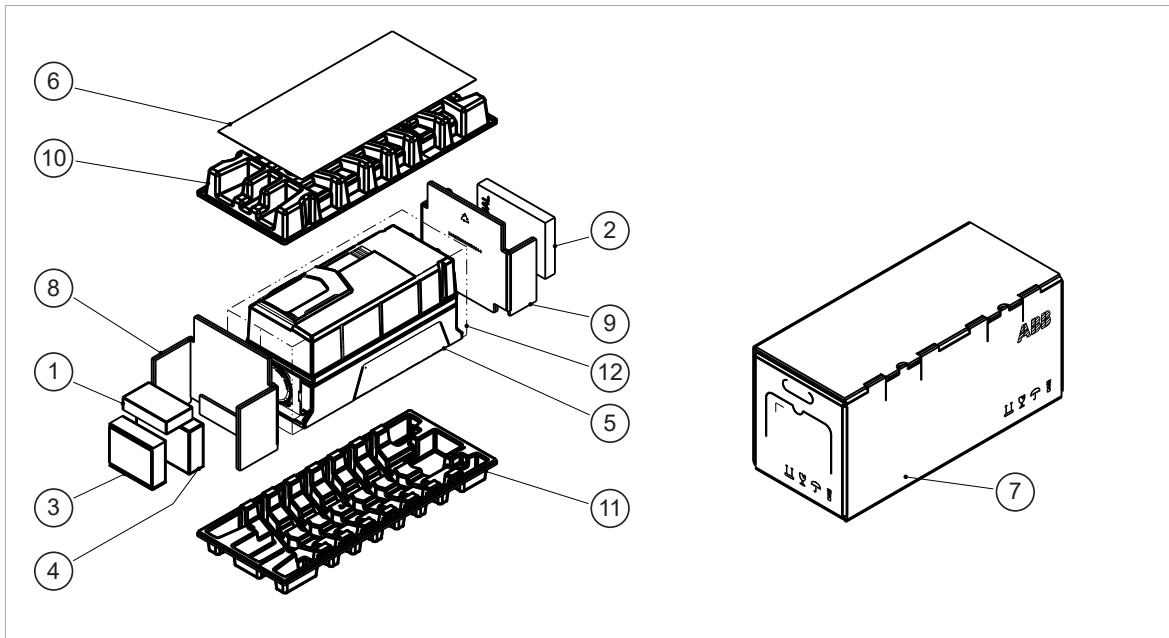
⚠ WARNING R1...R2, IP20: Do not lift the drive by holding it from the cover. The drive can fall and become damaged or damage the surroundings.



Recycle the package material according to local regulations.

Unpacking and examining delivery, frame R3

The figure below shows the layout of the transport package. Examine that all items are present and there are no signs of damage. Read the data on the type designation label of the drive to make sure that the drive is of the correct type. Refer [Type designation label \(page 32\)](#).



1	Control panel selected in the order.
2	Quick installation and start-up guide (always), and hardware and firmware manuals (if ordered separately); Multilingual residual voltage warning stickers
3	I/O option box
4	Fieldbus option box

5	Drive
6	Mounting template
7	Cardboard box
8	Option support
9	End support
10	Top cushion
11	Bottom cushion
12	Plastic bag

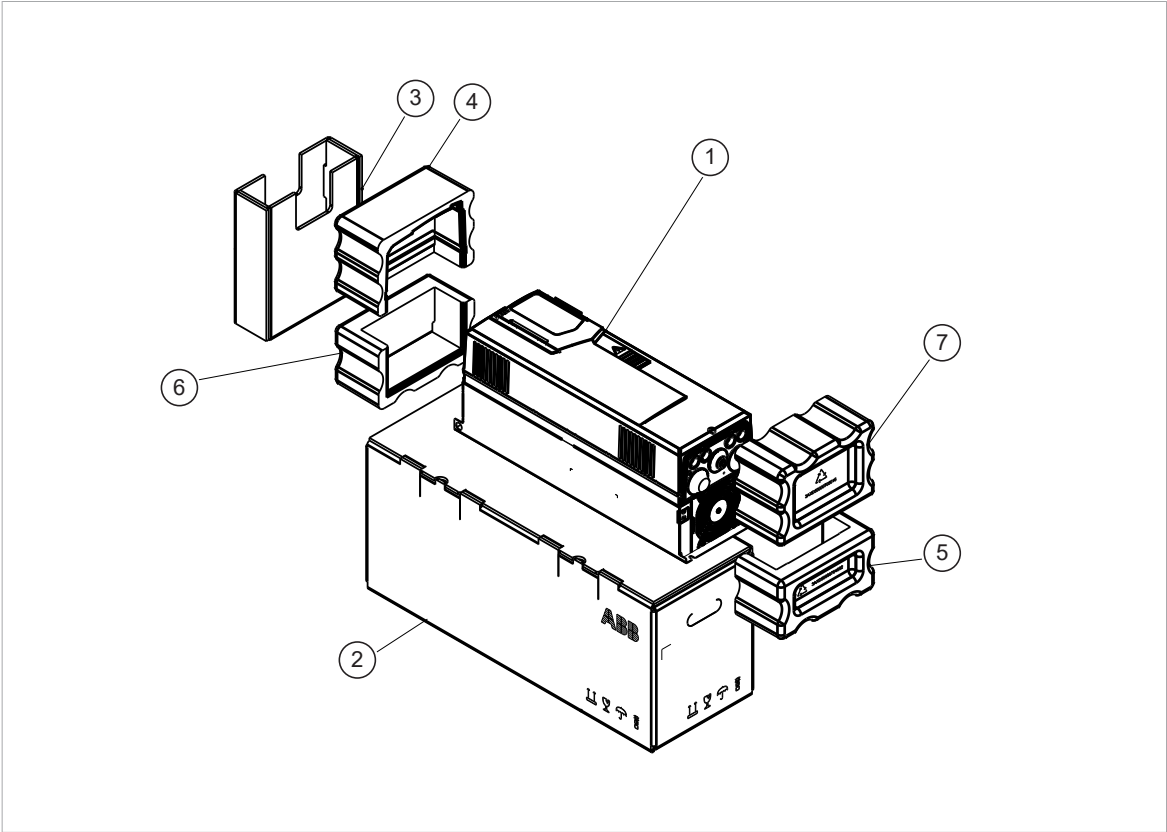
To unpack:

- Open the cardboard box (7)
- Remove the mounting template (6) and top cushion (10)
- Remove the control panel and option boxes (1,3,4)
- Remove the end supports (9)
- Remove the plastic bag (12)
- Lift the drive (2).

Recycle the package material according to local regulations.

Unpacking and examining delivery, frame R4

The figure below shows the layout of the transport package. Examine that all items are present and there are no signs of damage. Read the data on the type designation label of the drive to make sure that the drive is of the correct type. Refer [Type designation label \(page 32\)](#).



1	Drive	Possible options in separate packages, if they have been ordered with a plus code, such as for example +K490 (FEIP-21 Two-port EtherNet/IP adapter module) in the option box
2	Option tray	
3	In the option tray: - Quick installation and start-up guide (always), and hardware and firmware manuals (if ordered separately) - Multilingual residual voltage warning stickers; - Control panel selected in the order (in a separate package) in the option box	
4	Top cushion	
5	Bottom cushion	
6	Bottom cushion	
7	Top cushion	

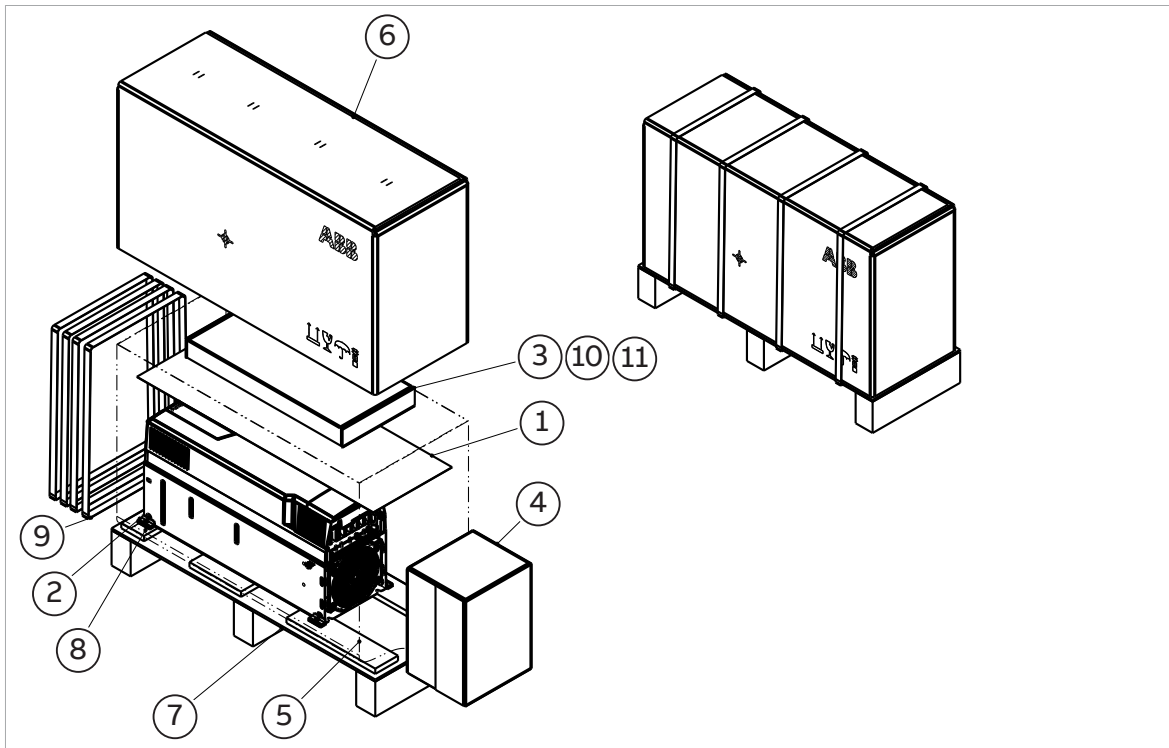
To unpack:

- Open box (2)
- Remove option support (3)
- Remove top cushions (4,7)
- Lift the drive (1) and remove bottom cushions (5,6).

Recycle the package material according to local regulations.

Unpacking and examining delivery, frame R5

The figure below shows the layout of the transport package. Examine that all items are present and there are no signs of damage. Read the data on the type designation label of the drive to make sure that the drive is of the correct type. Refer [Type designation label \(page 32\)](#).



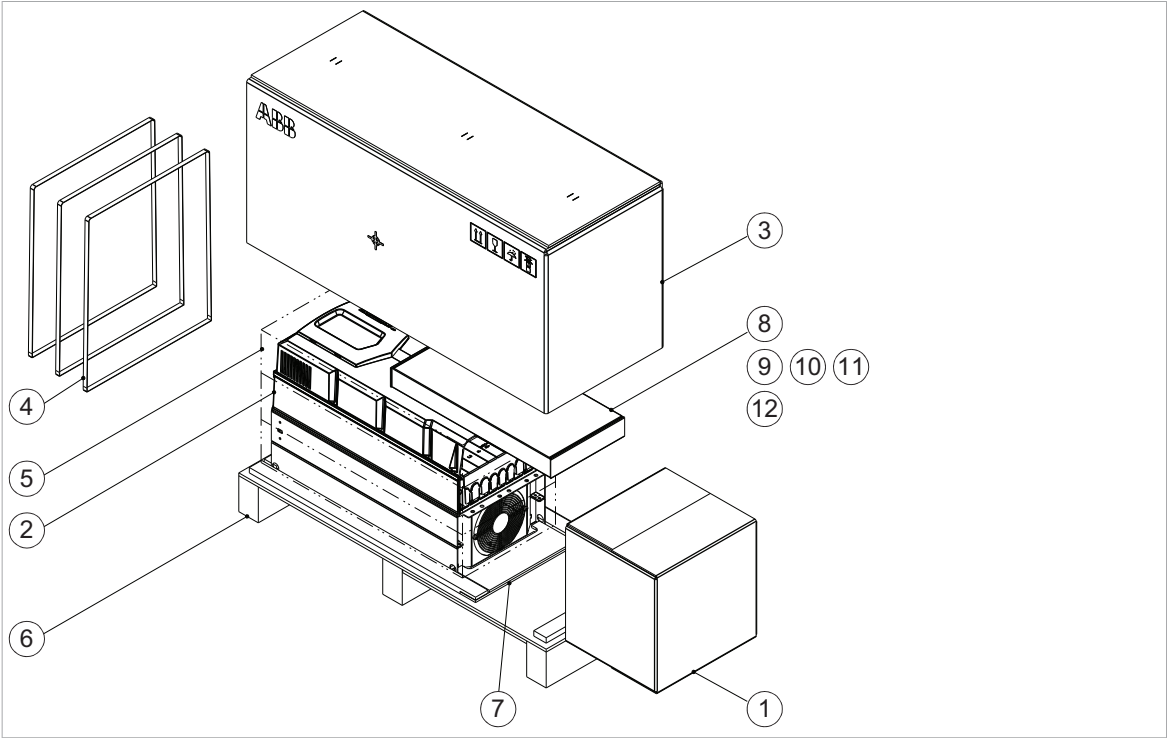
1	Cable box package (optional).	6	Cover protecting film
2	Drive	7	Straps
3	In the option box - Quick installation and start-up guide (always), and hardware and firmware manuals (if ordered separately) - Multilingual residual voltage warning stickers	8	Pallet
4	Cardboard box. Mounting template in the cardboard box.	9	Control panel selected in the order (in a separate package) in the option box
5	Stopper	10	Possible options in separate packages, if they have been ordered with a plus code, such as for example +K490 (FEIP-21 Two-port EtherNet/IP adapter module) in the option box.

To unpack:

- Cut the straps (7).
- Remove the cardboard box (4) and option box (3).
- Remove the cover protecting film (6).
- Lift the drive (2).

Unpacking and examining delivery, frames R6...R9

The figure below shows the layout of the transport package. Examine that all items are present and there are no signs of damage. Read the data on the type designation label of the drive to make sure that the drive is of the correct type. Refer [Type designation label \(page 32\)](#).



1	Cable box (optional). Power and control cable grounding shelves in a plastic bag, assembly drawing.	10	Control panel selected in the order (in a separate package) in the option tray
2	Drive with factory installed options	11	Possible options in separate packages, if they have been ordered with a plus code, such as for example +K490 (FEIP-21 Two-port Ether-Net/IP adapter module) in the option box.
3	Cardboard box	12	Mounting template on top of the option tray
4	Straps		
5	VCI bag for protecting against corrosion		
6	Pallet		
7	Stopper		
8	Option tray		
9	In the option tray - Quick installation and start-up guide (always), and hardware and firmware manuals (if ordered separately) - Multilingual residual voltage warning stickers		

To unpack:

- Cut the straps (4).
- Remove the cardboard box (3) and option tray (8).
- Remove the VCI bag (5).

- Attach lifting hooks to the lifting eyes of the drive (refer the figure in section [Safety \(page 37\)](#)).
- Lift the drive with a hoist.

Recycle the package material according to local regulations.



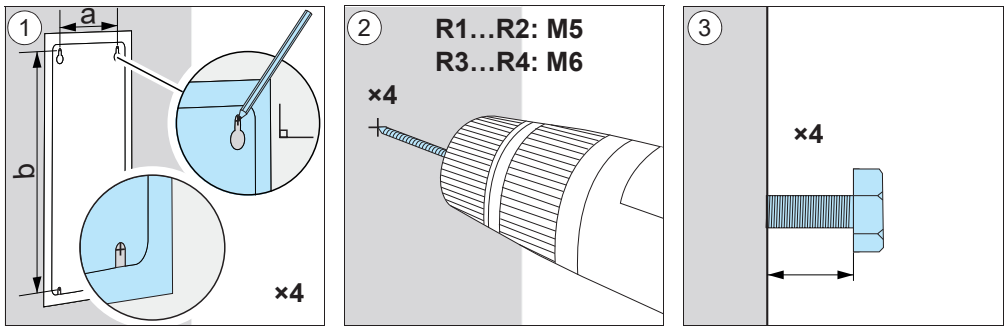
Installing the drive

■ Installing the drive vertically, frames R1...R4

The figures show frame R3 as an example.

Select fasteners and their application to meet local requirements appropriate to wall surface materials, drive weight and application.

1. Mark the hole locations using the mounting template included in the package. Do not leave the mounting template under the drive. The drive dimensions and hole locations are also shown in the drawings in chapter [Dimension drawings \(page 175\)](#).
2. Drill the mounting holes.
3. Insert anchors or plugs into the holes and start the bolts into the anchors or plugs.

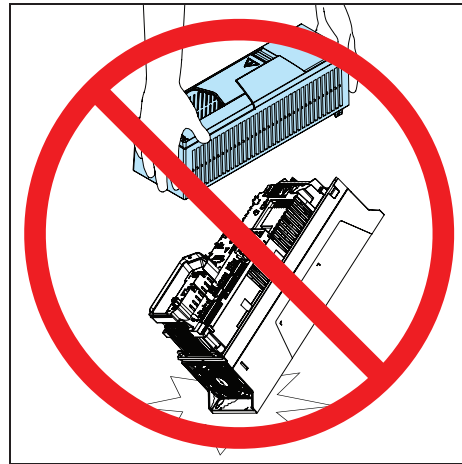
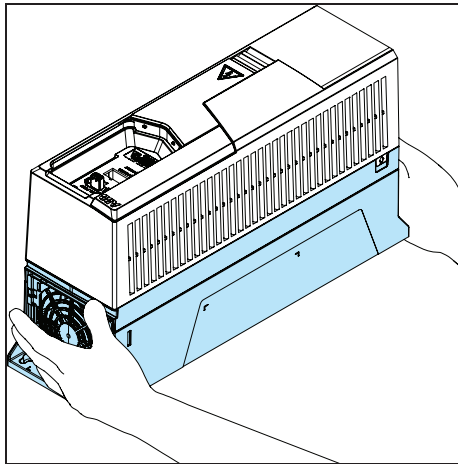


	R1	R2	R3	R4	R4 v2
	mm	mm	mm	mm	mm
a	98	98	160	160	160
b	317	417	473	619	619
Weight IP20	kg	kg	kg	kg	kg
	4	6	11.3	18.5	21.5

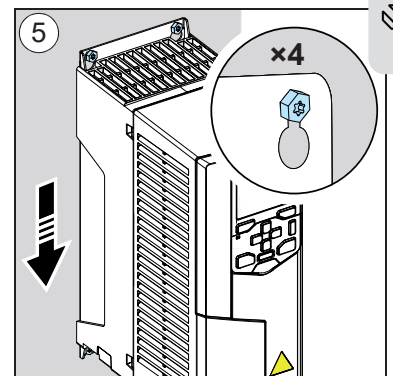
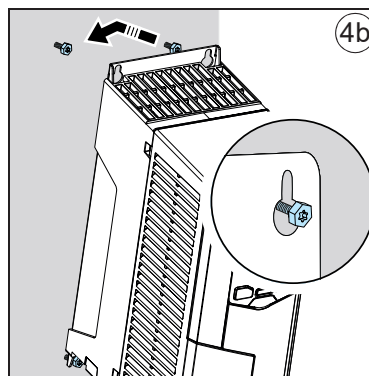
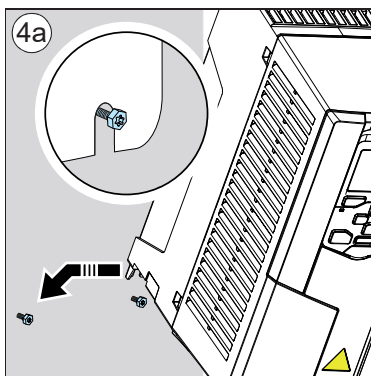
4. Position the drive onto the lower bolts (4a) on the wall to support the weight of the drive. Rotate drive to the wall and place drive over the upper bolts (4b).



⚠ WARNING R1...R4, IP20: Do not lift the drive by holding it from the cover. The drive can fall and become damaged or damage the surroundings.



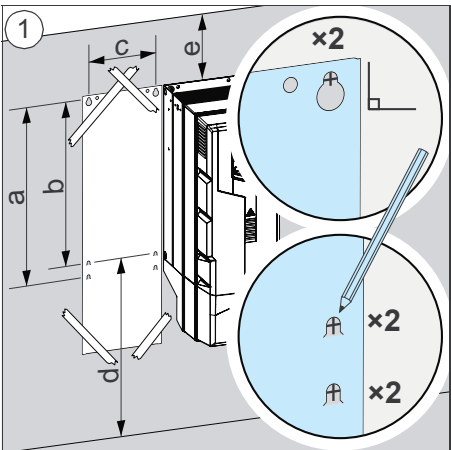
5. Tighten the bolts in the wall securely.



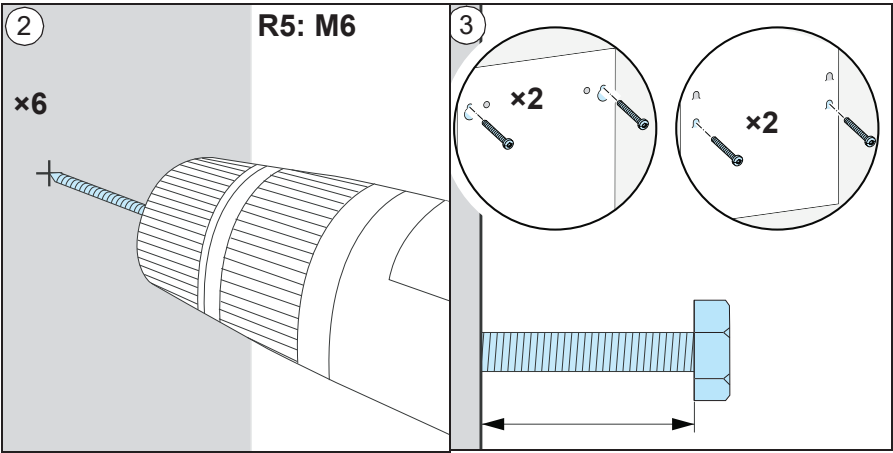
■ Installing the drive vertically, frame R5

Select fasteners and their application to meet local requirements appropriate to wall surface materials, drive weight and application.

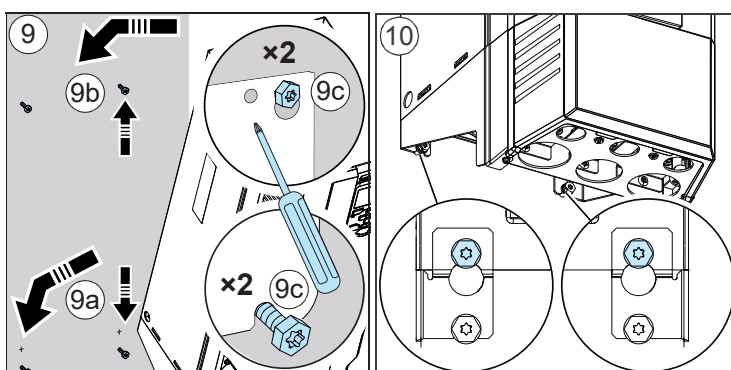
- 1. Mark the hole locations using the mounting template included in the package. Do not leave the mounting template under the drive. The drive dimensions and hole locations are also shown in the drawings in chapter [Dimension drawings \(page 175\)](#).
- 2. Drill the mounting holes.
- 3. Insert fixing anchors or plugs into the holes. Start the two upper bolts and the two lowest bolts into the anchors or plugs.



	R5 IP20
	mm
a	612
b	581
c	160
d >	200
e >	100
	kg
	26.5



4. Remove the front cover: Remove the fastening screws with a T20 Torx screwdriver and lift the cover from the bottom upwards and then to the top side.
5. Put the tabs at the top of the front cover in their counterparts on the housing and then press at the bottom and tighten the retaining screws.
6. Position the drive onto the lower bolts (9a) on the wall to support the weight of the drive. Rotate drive to the wall and place drive over the upper bolts (9b). Lift the drive with another person or with a lifting device as it is heavy. Tighten the bolts in the wall securely (9c).
7. Tighten the two remaining bolts securely.

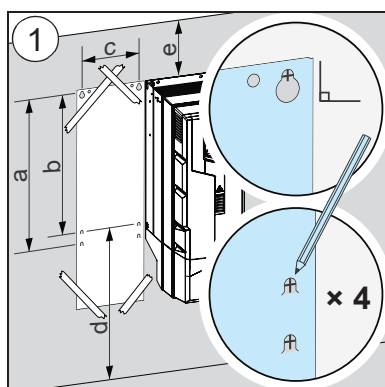


■ Installing the drive vertically, frames R6...R9

Select fasteners and their application to meet local requirements appropriate to wall surface materials, drive weight and application.

1. Mark the hole locations for the six mounting holes using the mounting template included in the package. Do not leave the mounting template under the drive. The drive dimensions and hole locations are also shown in the drawings in chapter [Dimension drawings \(page 175\)](#).

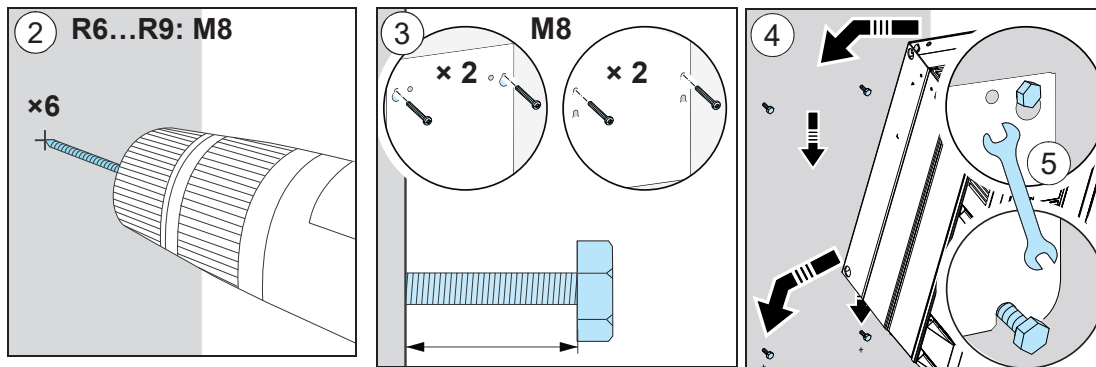
Note: You can use only two bolts instead of four to attach the lower part of the drive.



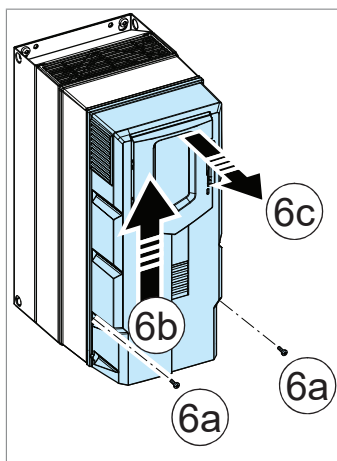
	R6	R7	R8	R9
	mm	mm	mm	mm
a	571	623	701	718
b	531	583	658	658
c	213	245	263	345
d	300	300	300	300
e	155	155	155	200
IP20	kg	kg	kg	kg
⚠	42.6	49.6	62.8	84.4

2. Drill the mounting holes.

3. Insert fixing anchors or plugs into the holes and start the bolts into the anchors or plugs.
4. Position the drive onto the bolts on the wall. Lift the drive with a lifting device as it is heavy.
5. Tighten the top two bolts in the wall securely.



6. Remove the front cover: Remove the fastening screws (a) with a T20 Torx screwdriver, move the cover to the top side (b) and then up (c).



■ Installing the drive vertically side by side, frames R1...R9

Install the drive following the steps in the appropriate section [Installing the drive vertically, frames R1...R4](#) (page 50), [Installing the drive vertically, frame R5](#) (page 52) or [Installing the drive vertically, frames R6...R9](#) (page 53).

■ Installing the drive horizontally, frames R1...R5

The drive can be installed either with the left or right side up. Refer to the steps in [Installing the drive vertically, frames R1...R4](#) (page 50) or [Installing the drive vertically, frame R5](#) (page 52).

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 main supply disconnecting device

You must equip the drive with a main supply disconnecting device which meets the local safety regulations. You must be able to lock the disconnecting device to the open position for installation and maintenance work.

■ European Union

To meet the European Union Directives, according to standard EN 60204-1, *Safety of Machinery*, the disconnecting device must be one of the following types:

- switch-disconnector of utilization category AC-23B (IEC 60947-3)
 - disconnector that has an auxiliary contact that in all cases causes switching devices to break the load circuit before the opening of the main contacts of the disconnector (EN 60947-3)
 - circuit-breaker suitable for isolation in accordance with IEC 60947-2.
-



■ Other regions

The disconnecting device must conform to the applicable local safety regulations.

Examining the compatibility of the motor and drive

Use asynchronous AC induction motors and permanent magnet 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. Refer [Requirements table \(page 56\)](#). For basics of protecting the motor insulation and bearings in drive systems, refer [Protecting the motor insulation and bearings \(page 56\)](#).

Note:

- Consult the motor manufacturer before using a motor whose nominal voltage 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 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.

du/dt 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 table

These tables show how to select the motor insulation system and when a drive du/dt 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.



This table shows the requirements when an ABB motor is in use.

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

¹⁾ manufactured before 1.1.1998

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

This table shows the requirements when a non-ABB motor is in use.

Motor type	Nominal AC line voltage	Requirement for			
		Motor insulation system	ABB du/dt and common mode filters, insulated N-end motor bearings		
			$P_n < 100 \text{ kW}$ and frame size $< \text{IEC 315}$	$100 \text{ kW} \leq P_n < 350 \text{ kW}$ or $\text{IEC 315} \leq \text{frame size} < \text{IEC 400}$	$P_n \geq 350 \text{ kW}$ or frame size $\geq \text{IEC 400}$
			$P_n < 134 \text{ hp}$	$134 \text{ hp} \leq P_n < 469 \text{ hp}$	$P_n \geq 469 \text{ hp}$
Random-wound and form-wound	$U_n \leq 420 \text{ V}$	Standard: $\hat{U}_{LL} = 1300 \text{ V}$	-	+ N or CMF	+ N + CMF
	$420 \text{ V} < U_n \leq 500 \text{ V}$	Standard: $\hat{U}_{LL} = 1300 \text{ V}$	+ du/dt	+ du/dt + (N or CMF)	+ N + du/dt + CMF
		or Reinforced: $\hat{U}_{LL} = 1600 \text{ V}$, 0.2 micro-second rise time	-	+ N or CMF	+ N + CMF

The abbreviations used in the tables are defined below.

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 du/dt filter and common mode filter by drive type

Refer chapter [du/dt filters](#) (page 224).

Additional requirements for explosion-safe (EX) motors

If you will use an explosion-safe (EX) motor, follow 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 braking applications

When the motor brakes the machinery, the intermediate circuit DC voltage of the drive increases, the effect being similar to increasing the motor supply voltage by up to 20 percent. Consider this voltage increase when specifying the motor insulation requirements if the motor will be braking a large part of its operation time.

Example: Motor insulation requirement for a 400 V AC line voltage application must be selected as if the drive were supplied with 480 V.

Additional requirements for the regenerative and low harmonics drives

It is possible to increase the intermediate circuit DC voltage from the nominal (standard) level with a parameter in the control program. If you choose to do this, select the motor insulation system which withstands the increased DC voltage level.

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 du/dt and common mode filters, insulated N-end motor bearings		
		$P_n < 100 \text{ kW}$	$100 \text{ kW} \leq P_n < 200 \text{ kW}$	$P_n \geq 200 \text{ kW}$
		$P_n < 140 \text{ hp}$	$140 \text{ hp} \leq P_n < 268 \text{ hp}$	$P_n \geq 268 \text{ hp}$
$U_n \leq 500 \text{ V}$	Standard	-	+ N	+ 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:

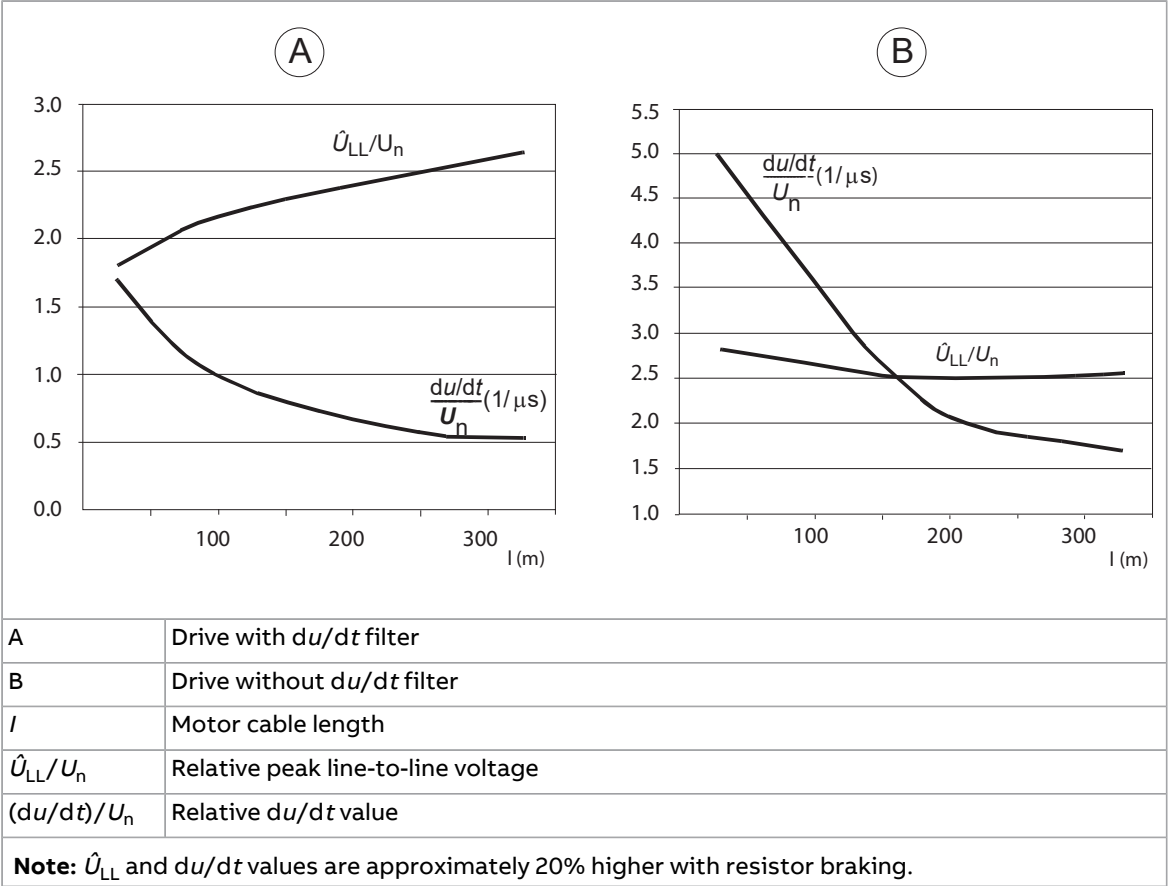
- If motor power is below 350 kW: Equip the drive and/or motor with the filters and/or bearings according to the table below.

Nominal AC supply voltage	Requirement for		
	Motor insulation system	ABB du/dt and common mode filters, insulated N-end motor bearings	
		$P_n < 100 \text{ kW or frame size} < \text{IEC 315}$	$100 \text{ kW} < P_n < 350 \text{ kW or IEC 315} < \text{frame size} < \text{IEC 400}$
		$P_n < 134 \text{ hp}$	$134 \text{ hp} < P_n < 469 \text{ hp}$
$U_n \leq 420 \text{ V}$	Standard: $\hat{U}_{LL} = 1300 \text{ V}$	+ N or CMF	+ N or CMF
$420 \text{ V} < U_n < 500 \text{ V}$	Standard: $\hat{U}_{LL} = 1300 \text{ V}$	+ du/dt + (N or CMF)	+ N + du/dt + CMF
	or Reinforced: $\hat{U}_{LL} = 1600 \text{ V}$, 0.2 microsecond rise time	+ N or CMF	+ N or CMF

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 $(du/dt)/U_n$ from the diagram below. Multiply the values by the nominal supply voltage (U_n) and substitute into equation $t = 0.8 \cdot \hat{U}_{LL}/(du/dt)$.



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 $1.5 \cdot U_n$.

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 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 maximum permissible temperature of conductor in continuous use.
Important: For certain product types or option configurations higher temperature rating may be required. Refer the [Technical data \(page 143\)](#) 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. Refer [Preferred power cable types \(page 61\)](#).

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.

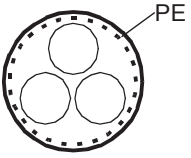
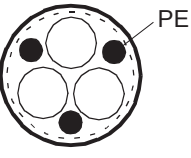
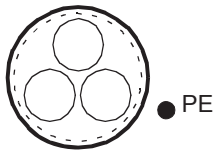
■ Typical power cable sizes

Refer the [Technical data \(page 143\)](#).

■ Power cable types

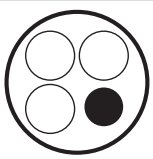
Preferred power cable types

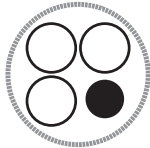
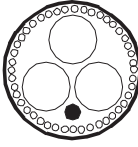
This section presents the preferred cable types. Make sure that the selected cable type also complies with local/state/country electrical codes.

Cable type	Use as input power cabling	Use as motor cabling
 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/cable¹⁾	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 mm ² (8 AWG) Cu.	Yes with phase conductor smaller than 10 mm ² (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.

Cable type	Use as input power cabling	Use as motor cabling and as brake resistor cabling
 Four-conductor armored cable (three phase conductors and PE)	Yes	Yes with phase conductor smaller than 10 mm ² (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.

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.

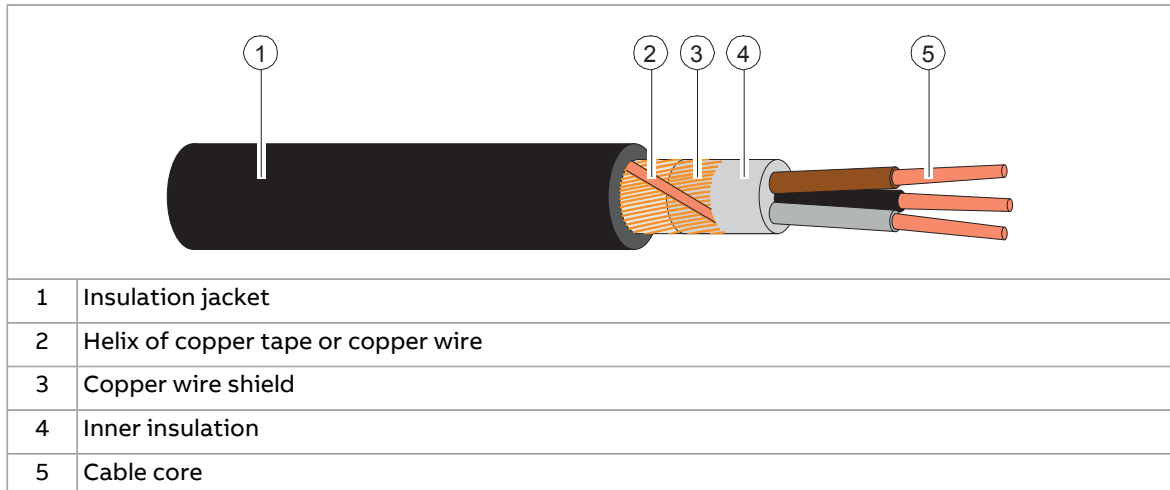
Not allowed power cable types

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

■ 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.



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.

This table shows the minimum cross-sectional area of the protective earth conductor related to the phase conductor size according to IEC 61800-5-1 when the phase conductor(s) and the protective earth conductor are made of the same metal. If this is not so, 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 (mm ²)	Minimum cross-sectional area of the corresponding protective earth conductor S_p (mm ²)
$S \leq 16$	$S^{1)}$
$16 < S \leq 35$	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 mm² Cu or 16 mm² 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 mm² 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 grounding conductors only when their conductivity is sufficient.



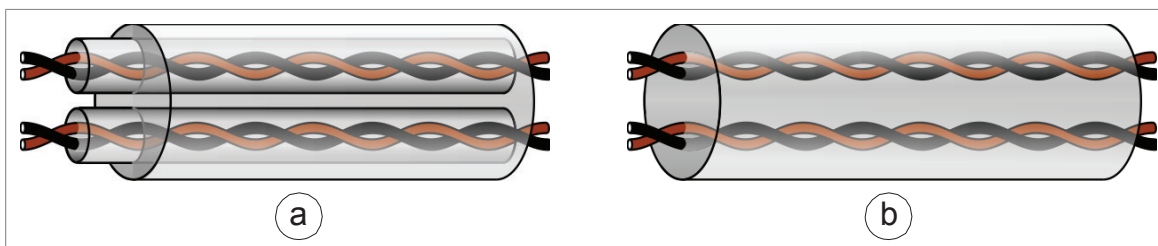
Selecting the control cables

■ 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.

Routing the cables

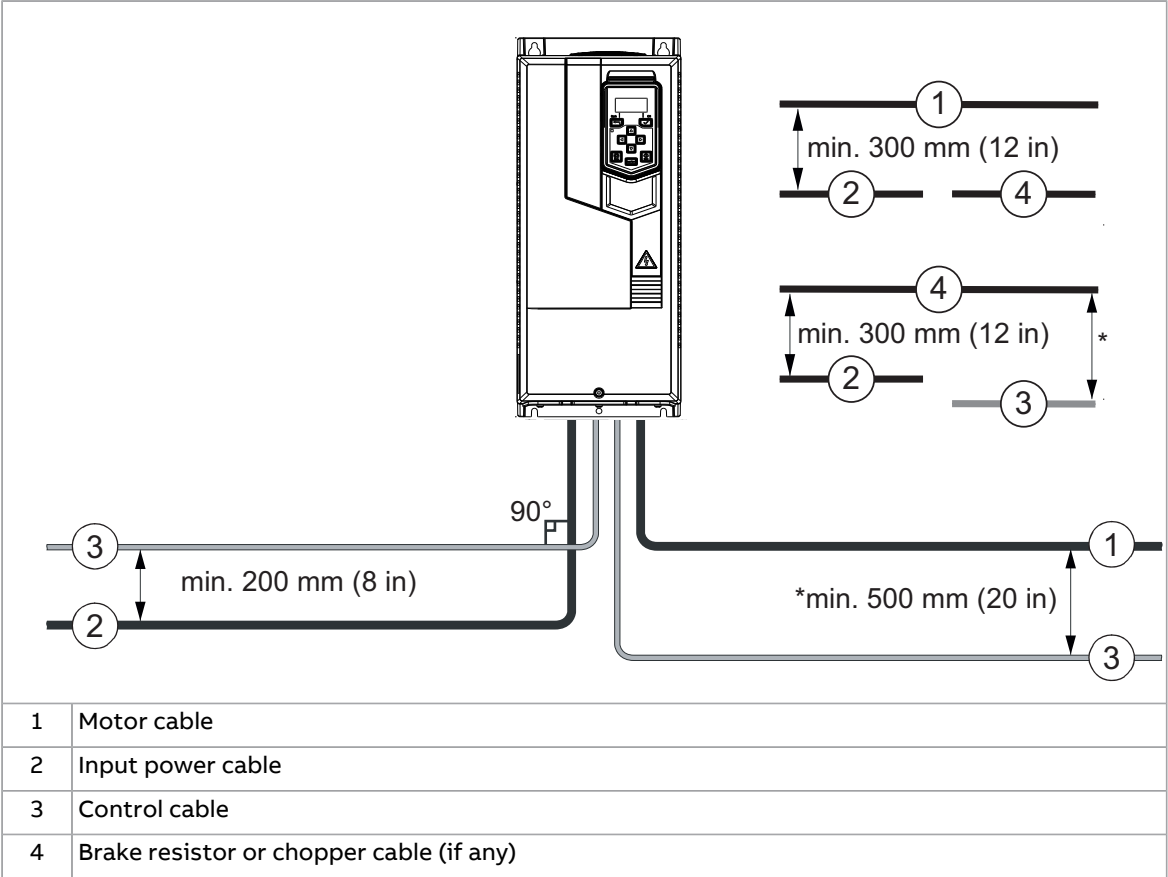
■ General guidelines – IEC

- 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.

Note: When motor cable is symmetrical and shielded and it has short parallel runs with other cables (< 1.5 m), distances between the motor cable and other cables can be reduced by half.





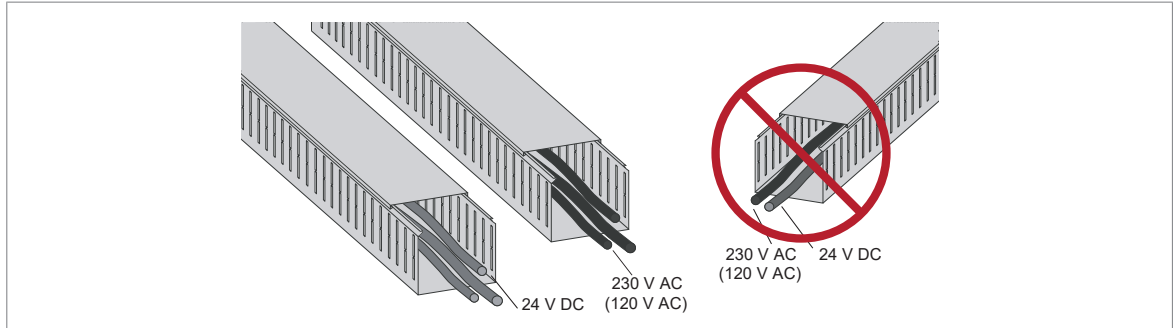
■ **Continuous motor cable shield/conduit or enclosure for equipment on the motor cable**

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

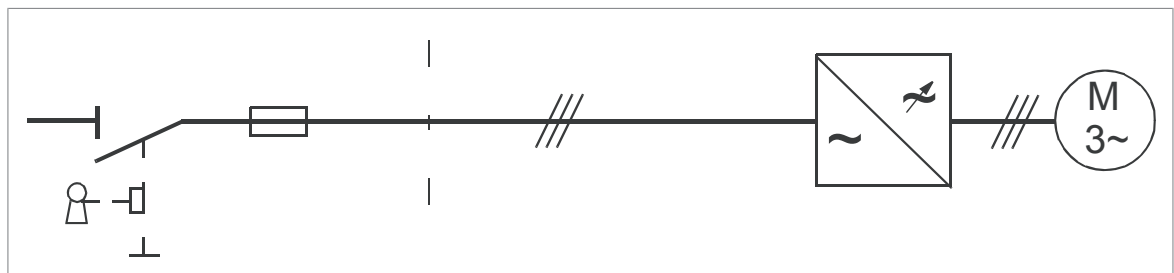
Put 24 V DC and 230 V AC (120 V AC) control cables in separate ducts, unless the 24 V DC cable is insulated for 230 V AC (120 V AC) or insulated with an insulation sleeving for 230 V AC (120 V AC).



Implementing short-circuit and thermal overload protection

■ Protecting the drive and the input power cable in short-circuits

Protect the drive and the input cable with fuses or a circuit breaker.



Select the fuses or circuit breakers according to local regulations for the input cable protection. Select the fuses or circuit breakers for the drive according to the instructions given in the technical data. The fuses or circuit breakers for the drive protection will restrict drive damage and prevent damage to adjoining equipment in case of a short-circuit inside the drive.

Note: If the fuses or circuit breakers for the drive protection are placed at the distribution board and the input cable is selected according to the nominal input current of the drive given in the technical data, the fuses or circuit breakers protect also the input cable in short-circuit situations, restrict drive damage and prevent damage to adjoining equipment in case of a short-circuit inside the drive. No separate fuses or circuit breakers for the input cable protection are required.



⚠ WARNING Due to the inherent operating principle and construction of circuit breakers, independent of the manufacturer, hot ionized gases can escape from the breaker enclosure in case of a short-circuit. To make sure of safe use, pay special attention to the installation and placement of the breakers. Obey the manufacturer's instructions.

■ 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
- 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 motor cables against thermal overload

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



⚠ WARNING If the drive is connected to multiple motors, use a separate overload protection for each motor cable and motor. The drive overload protection is tuned for the total motor load. It may not detect 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, refer to 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 the common IEC 61800-5-1 standard in conjunction with IEC 60947-4-1. The standards allow for motor overload protection without external temperature sensors.

The protection feature allows the user to specify the class of operation in the same manner as the overload relays are specified in standards IEC 60947-4-1.

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

For more information, refer 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. Refer the firmware manual for more information.

■ Residual current device compatibility



CAUTION This product can cause a DC current in the PE conductor. If you use a residual current-operated protective device (RCD) for protection against electric shock, use only an RCD of Type B on the supply side. All upstream RCD, up to the supply transformer, must be 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.

Implementing the emergency stop function

For safety reasons, install the emergency stop devices at each operator control station and at other operating stations where the emergency stop may be needed. Implement the emergency stop according to relevant standards.

Note: You can use the Safe torque off function of the drive to implement the Emergency stop function.

Implementing the Safe torque off function

Refer [The Safe torque off function \(page 191\)](#).



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.

NOTICE Do not connect power factor compensation capacitors or harmonic filters to the motor cables (between the drive and the motor). They are not designed for use 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 can trip or cause damage to 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.

Controlling a contactor between drive and motor

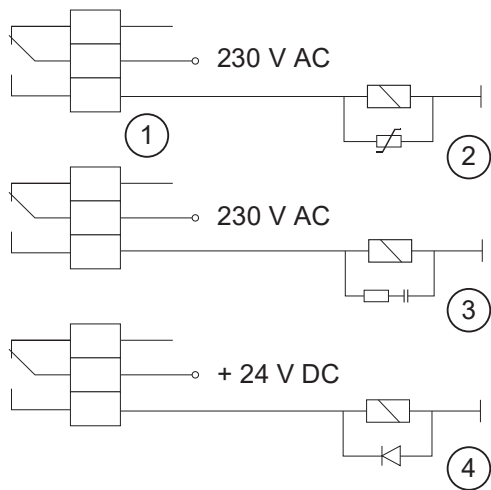
The control of the output contactor depends on how you use the drive, that is, which motor control mode and which motor stop mode you select.

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

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

Limiting relay output maximum voltages at high installation altitudes

Refer [Isolation areas \(page 120\)](#) and [Isolation areas \(page 123\)](#).

Implementing a motor temperature sensor connection



▲WARNING IEC 61800-5-1 requires double or reinforced insulation between the 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.

To connect a motor temperature sensor and other similar components to the drive, you have four 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. Refer 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 the sensor to the drive via an option module. The sensor and the module must form a double or reinforced insulation between the motor live parts and the drive control unit. Refer section [Connection of motor temperature sensor to the drive via an option module \(page 100\)](#). Make sure that the voltage does not exceed the maximum allowed voltage over the sensor.
3. 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.

■ Connecting a motor temperature sensor to the drive through an option module

This table shows:

- option module types that you can use for the motor temperature sensor connection
- insulation or isolation level that each option module forms between its temperature sensor connector and other connectors
- temperature sensor types that you can connect to each option module
- temperature sensor insulation requirement in order to form, together with the insulation of the option module, a reinforced insulation between the motor live parts and the drive control unit.

6

Electrical installation-IEC

Contents of this chapter

This chapter describes how to:

- measure the insulation
- do the grounding system compatibility check
- change the EMC filter or ground-to-phase varistor connection
- connect the power and control cables
- install optional modules
- connect a PC.



⚠ 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.

Make sure that the drive is disconnected from the input power during installation. If the drive is already connected to the input power, wait for 5 minutes after disconnecting the input power.



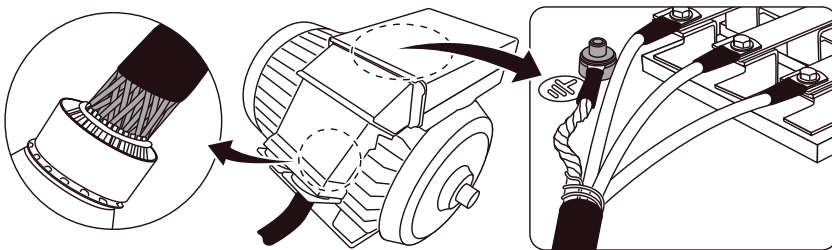
Necessary tools

To do the electrical installation, you need these tools:

- wire stripper
- screwdriver set (Torx, Phillips, flat and/or Pozidriv, as necessary)
- torque wrench.

Grounding the motor cable shield 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

NOTICE 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.

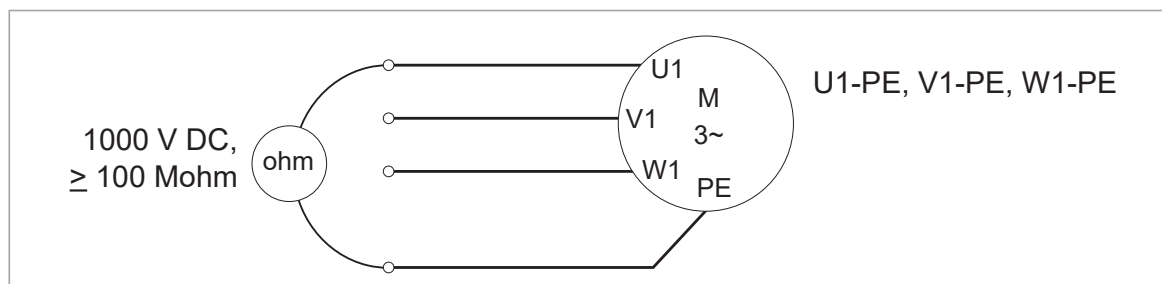
■ Measuring the insulation resistance of the motor and motor cable



⚠ 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 [Electrical safety precautions \(page 16\)](#) 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). 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.

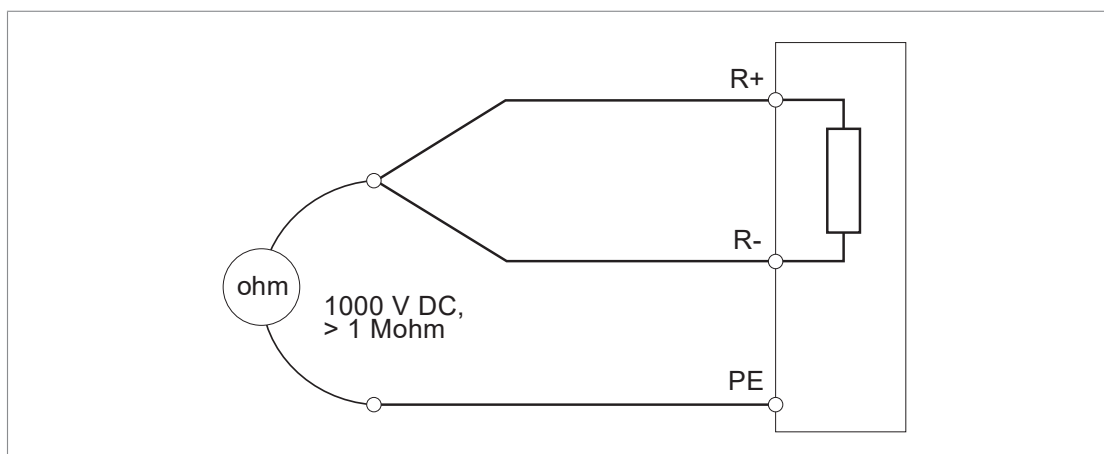


■ Brake resistor assembly for R1...R3



⚠ 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 electrical installation, commissioning or maintenance work.

1. Stop the drive and do the steps in [Electrical safety precautions \(page 16\)](#) before you start the work.
2. Make sure that the resistor cable is connected to the resistor and disconnected from the drive output terminals.
3. At the drive end, connect the R+ and R- conductors of the resistor cable together. Measure the insulation resistance between the conductors and the PE conductor with a measuring voltage of 1000 V DC. The insulation resistance must be more than 1 Mohm.



Grounding system compatibility check

The standard drive can be installed to a symmetrically grounded TN-S system. For other systems, refer sections [EMC filter](#) and [Ground-to-phase varistors \(page 76\)](#) below.

■ EMC filter

A drive with EMC filter connected 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. Refer sections [When to disconnect EMC filter or ground-to-phase varistor: TN-S, IT, corner-grounded delta and midpoint-grounded delta systems \(page 76\)](#), and [Guidelines for installing the drive to a TT system \(page 77\)](#).



⚠ 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.

Note: When the internal EMC filter is disconnected, the drive EMC compatibility is considerably reduced. Refer [EMC compatibility and motor cable length \(page 165\)](#).

■ **Ground-to-phase varistors**

A drive with the ground-to-phase varistor connected can be installed to a symmetrically grounded TN-S system. If you install the drive to another system, you may need to disconnect the varistor. Refer sections [When to disconnect EMC filter or ground-to-phase varistor: TN-S, IT, corner-grounded delta and midpoint-grounded delta systems \(page 76\)](#), and [Guidelines for installing the drive to a TT system \(page 77\)](#).



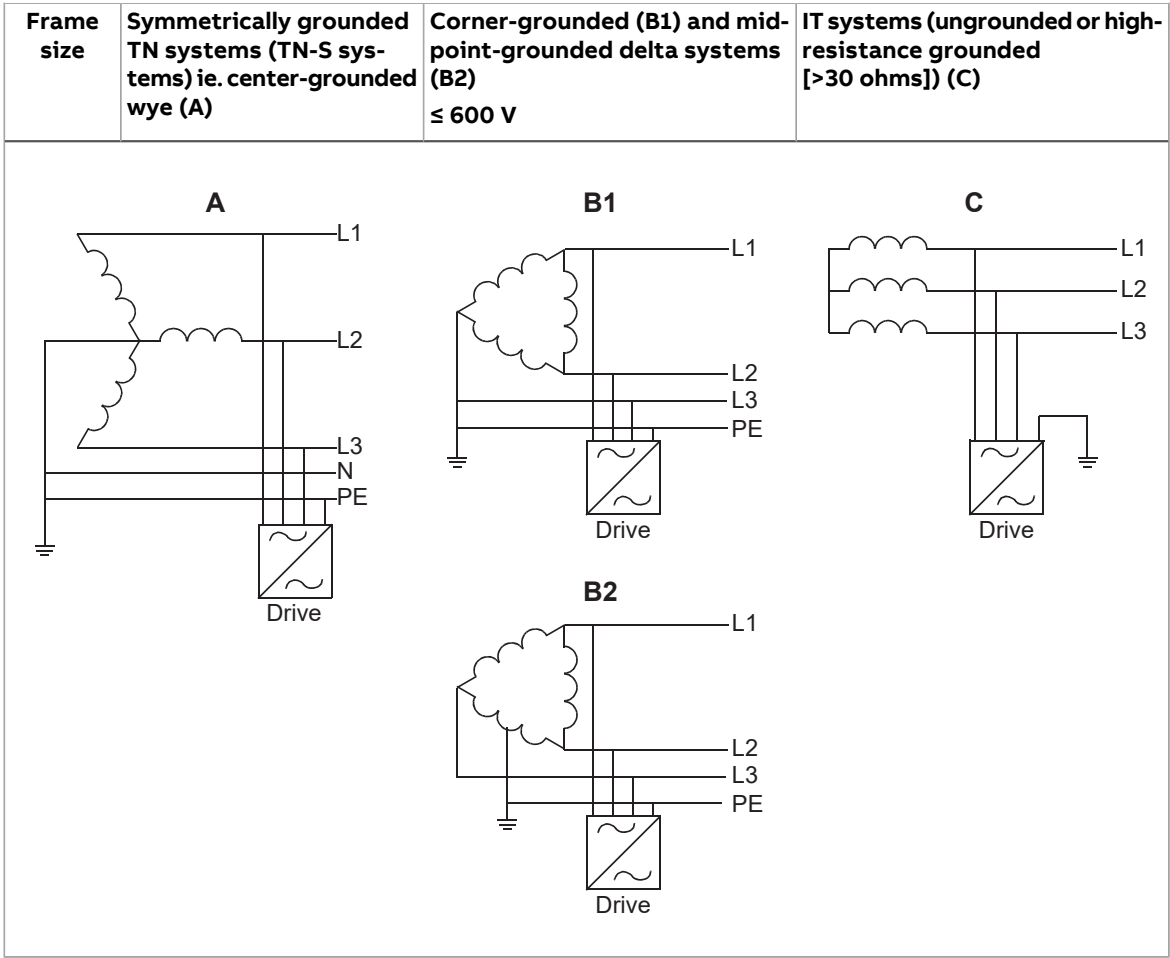
⚠ WARNING Do not install the drive with the ground-to-phase varistor connected to a system that the varistor is not suitable for. It can cause damage to the varistor circuit.

■ **When to disconnect EMC filter or ground-to-phase varistor: TN-S, IT, corner-grounded delta and midpoint-grounded delta systems**

Requirements for disconnecting EMC filter and varistor and additional requirements for different electrical power systems are given below.

Frame size	Symmetrically grounded TN systems (TN-S systems) ie. center-grounded wye (A)	Corner-grounded (B1) and midpoint-grounded delta systems (B2) ≤ 600 V	IT systems (ungrounded or high-resistance grounded [>30 ohms]) (C)
R1...R3 R4 v2	Do not disconnect EMC or VAR screws.	Not applicable	Disconnect EMC and VAR screws.
R4...R5	Do not disconnect EMC or VAR screws.	Not evaluated ¹⁾	Disconnect EMC screws (2 pcs) and VAR screw.
R6...R9	Do not disconnect EMC or VAR screws.	Do not disconnect EMC AC or VAR screws. Disconnect EMC DC screw.	Disconnect EMC screws (2 pcs) and VAR screw.





1) Frames R1 and R5 are not evaluated for use on corner-grounded systems or midpoint-grounded delta systems by IEC standards.

Note: These are the EMC filter and varistor screws of different drive frame sizes.

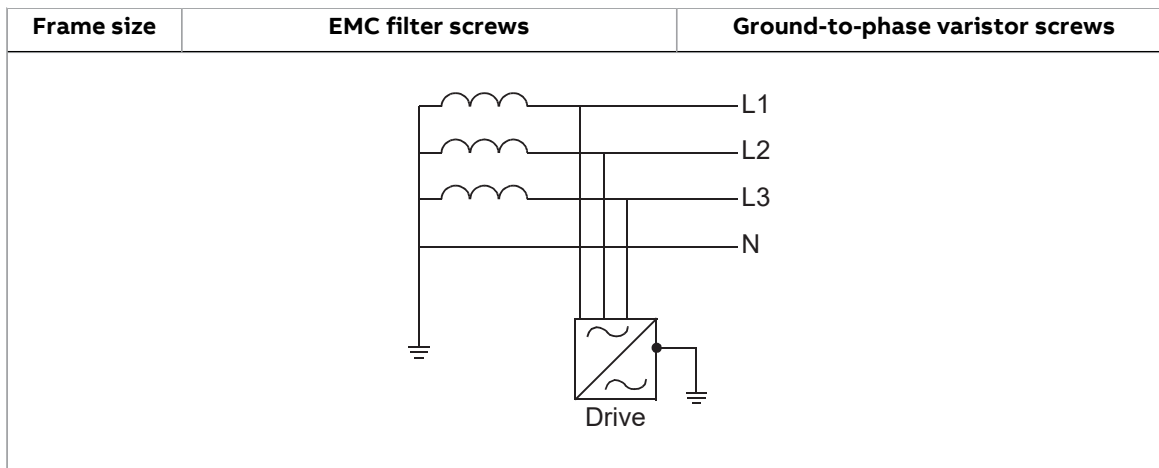
Frame size	EMC filter screws	Ground-to-phase varistor screws
R1...R3 R4 v2	EMC screw	VAR
R4...R5	Two EMC screws	VAR
R6...R9	Two EMC screws	VAR

■ Guidelines for installing the drive to a TT system

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

1. Residual current device has been installed in the supply system.
2. These screws have 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
R1...R3 R4 v2	EMC screw	VAR
R4...R5	Two EMC screws	VAR
R6...R9	Two EMC screws	VAR

**Note:**

- Because the EMC filter screws have 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 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.



⚠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 electrical installation, commissioning or maintenance work.

To identify the grounding system, examine the supply transformer connection. Refer to 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	$0.58 \cdot X$	$0.58 \cdot X$	$0.58 \cdot X$	TN-S system (symmetrically grounded)
X	$1.0 \cdot X$	$1.0 \cdot X$	0	Corner-grounded delta system (nonsymmetrical)
X	$0.866 \cdot X$	$0.5 \cdot X$	$0.5 \cdot X$	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)

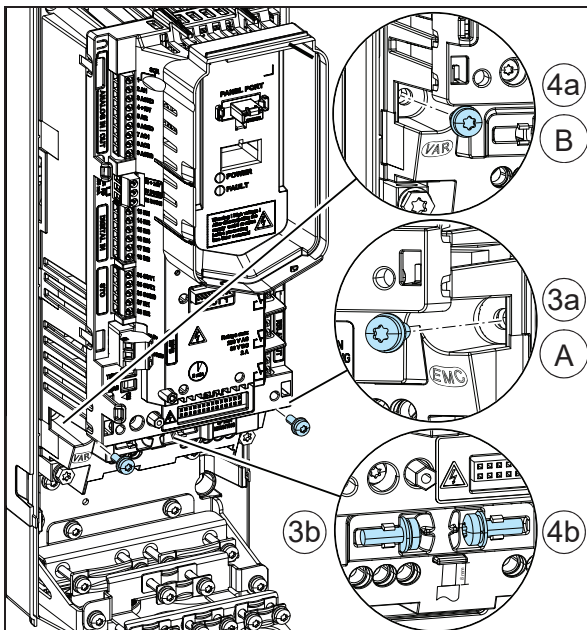


■ **Disconnecting internal EMC filter or ground-to-phase varistor - frames R1...R3**

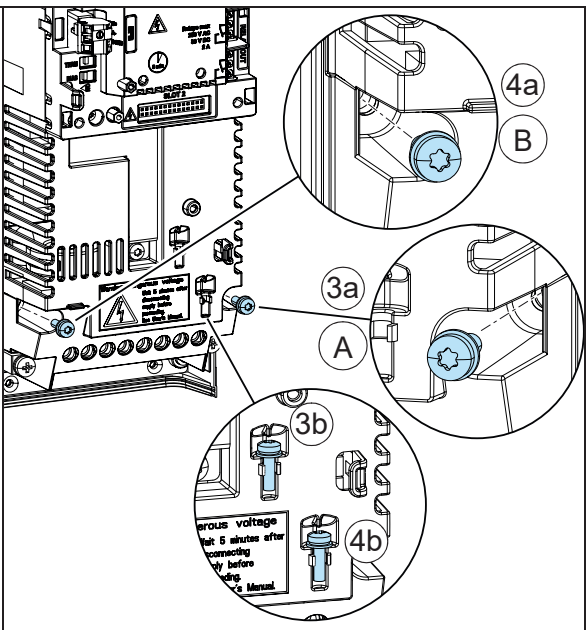
To disconnect the internal EMC filter or ground-to-phase varistor, if needed, do as follows:

- 1. Switch off the power from the drive.
- 2. Open the front cover, if not already opened, refer page 83.
- 3. To disconnect the internal EMC filter, remove the EMC screw (3a) and place it in the storage place (3b).
- 4. To disconnect the ground-to-phase varistor, remove the varistor screw (4a) and place it in the storage place (4b)

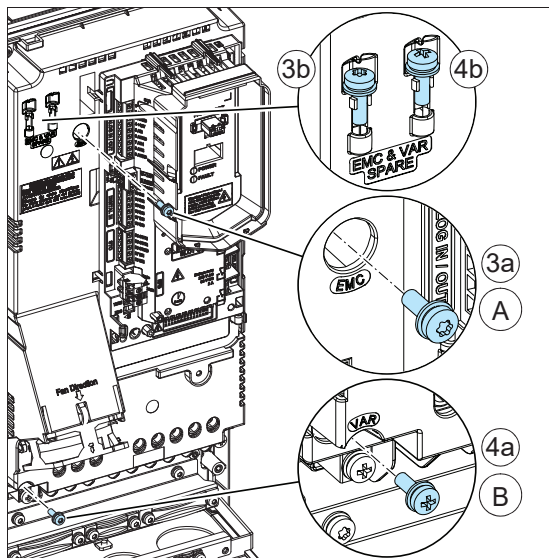
R1



R2



R3



	Screw
A	EMC (DC)
B	VAR

Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

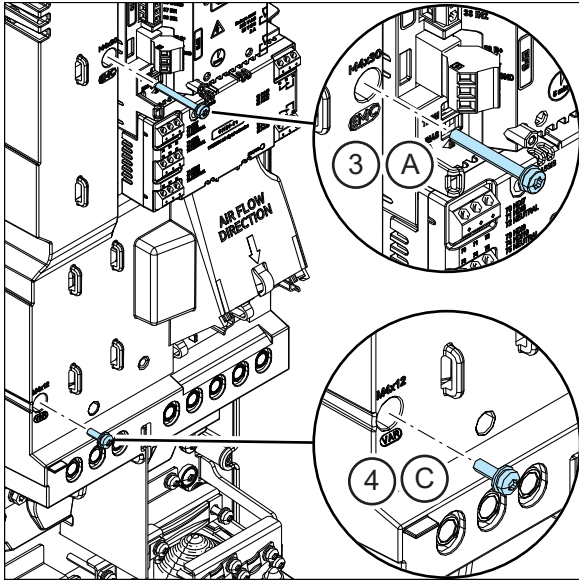
■ **Disconnecting internal EMC filter or ground-to-phase varistor - frames R4...R9**

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

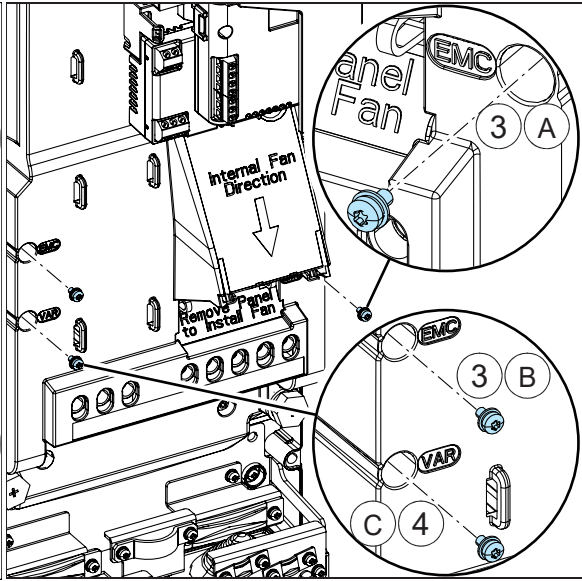
1. Switch off the power from the drive.
2. Open the cover, if not already opened.
3. To disconnect the internal EMC filter, remove the EMC screw(s).
4. To disconnect the ground-to-phase varistor, remove the varistor screw.



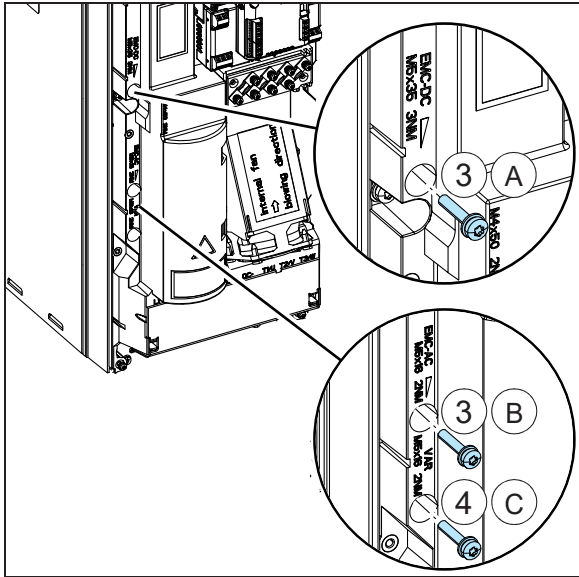
R4 v2



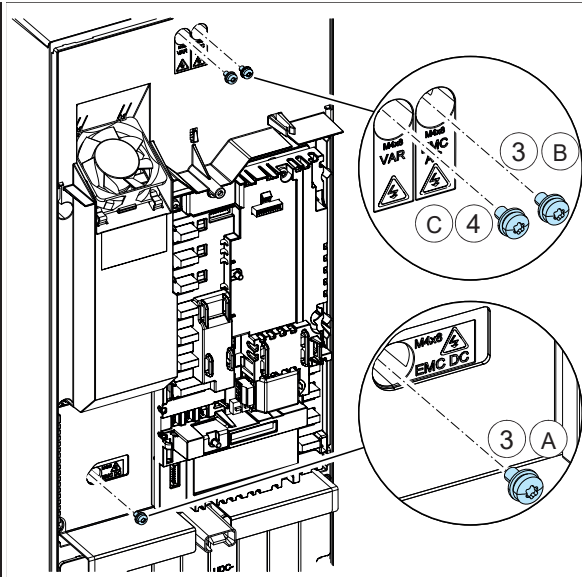
R4



R5



R6...R9



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

Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Connecting the power cables

■ Connection diagram

The diagram illustrates the electrical connection for a three-phase system. On the left, a three-phase supply is shown with lines L1, L2, and L3, and a PE (Protective Earth) line. Two options for the PE connection are shown: (2a) a separate PE cable and (2b) a cable with a separate PE conductor. The supply lines pass through a distribution board (1) and connect to the motor terminals T1/U, T2/V, and T3/W. A braking resistor (5) is connected to terminals R- and UDC+/R+. The motor is represented by a circle with terminals U1, V1, and W1, and a label '3 ~ M'. A common mode filter (7) is connected to the supply lines. The diagram also shows a 360-degree grounding requirement (4) for the motor and a separate grounding cable (6) for the motor shield. A note at the bottom provides additional information about the braking resistor and the motor cable.

1	For alternatives, refer section Selecting the main supply disconnecting device (page 55)
2	Use a separate grounding PE cable (2a) or a cable with a separate PE conductor (2b) if the conductivity of the shield does not meet the requirements for the PE conductor (refer Selecting the power cables (page 60))
3	360-degree grounding is recommended if shielded cable is used. Ground the other end of the input cable shield or PE conductor at the distribution board.
4	360-degree grounding is required
5	External brake resistor
6	Use a separate grounding cable if the shield does not meet the requirements of IEC 61439-1 (refer Selecting the power cables (page 60))
7	du/dt or common mode filter (optional), refer Common mode, du/dt and sine filters (page 223)

Note: Frames R1...R3 have a built-in brake chopper. If necessary, you can connect a brake resistor to terminals R-and UDC+/R+. The brake resistor is not included in the drive delivery. In frames R4...R9, you can connect an external brake chopper to terminals UDC+ and UDC- . The brake chopper is not included in the drive delivery.

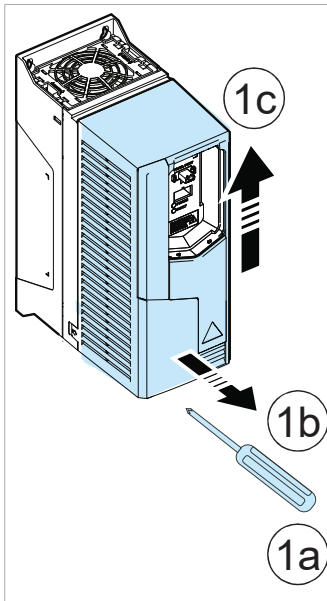
Do not use an asymmetrically constructed motor cable for motors above 30 kW (refer [General guidelines \(page 60\)](#)). Connecting its fourth conductor at the motor end increases bearing currents and causes extra wear.

For a single phase connection, use terminals L1 and L2.

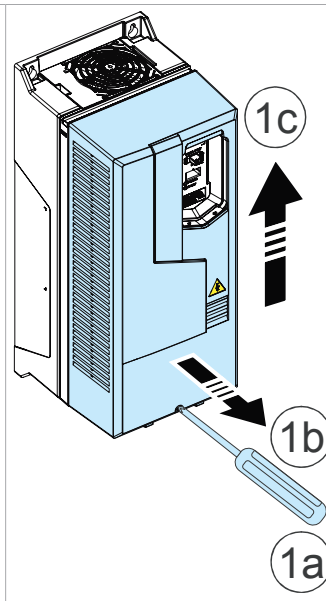
■ Connection procedure, frames R1...R4

1. Remove the front cover: Loosen the retaining screw with a T20 Torx screwdriver (1a) and lift the cover from the bottom outwards (1b) and then up (1c).

IP20,
R1...R2



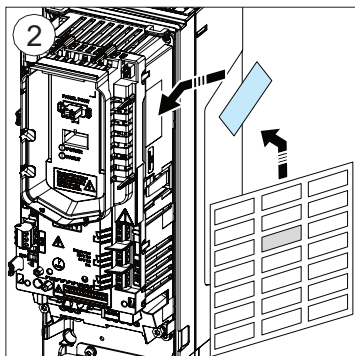
IP20,
R3...R4



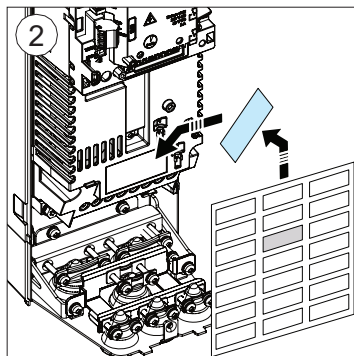
⚠WARNING If you install the drive on any other system than symmetrically grounded TN-S system, refer [Grounding system compatibility check \(page 75\)](#) if you have to disconnect the EMC filter and ground-to-phase varistor.

2. Attach the residual voltage warning sticker in the local language.

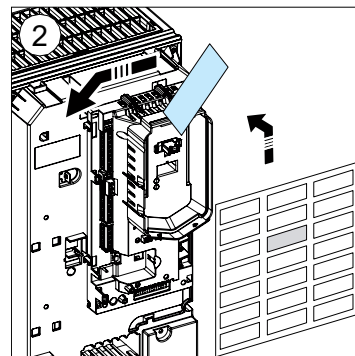
R1



R2



R3...R4



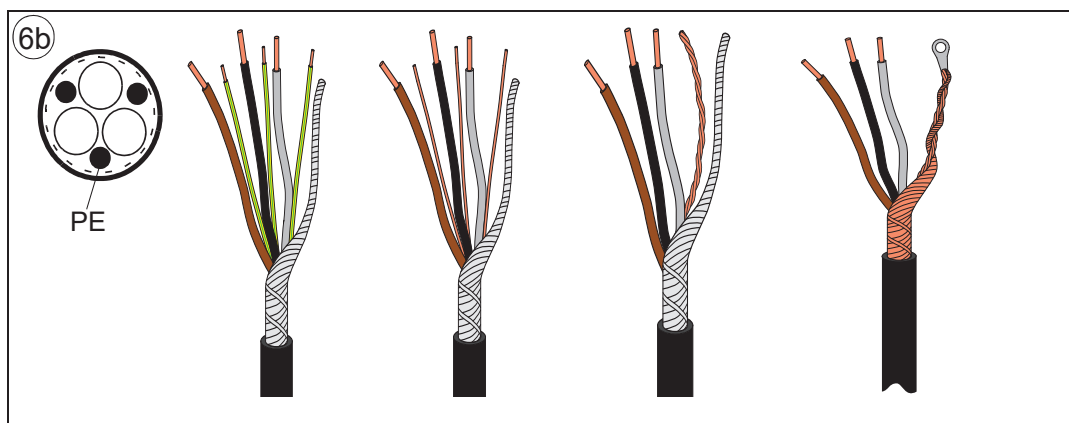
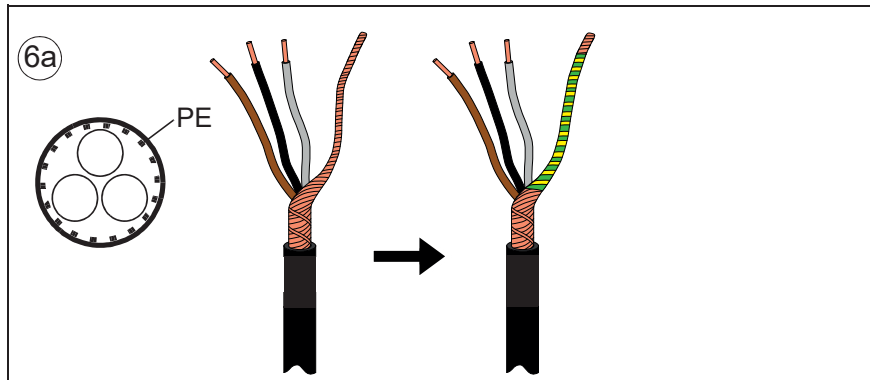
Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Motor cable

3. Prepare the ends of the cable as illustrated in the figures. In frames R1 and R2 there are markings on the drive frame near the power cable terminals helping you to strip the wires to the correct length of 8 mm.

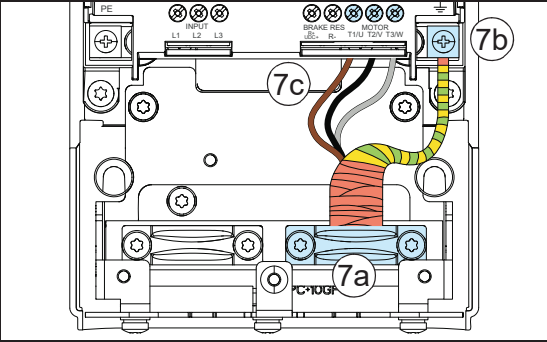
Two different motor cable types are shown (6a, 6b).

Note: The bare shield will be grounded 360 degrees. Mark the pigtail made from the shield as a PE conductor with yellow-and-green colour.

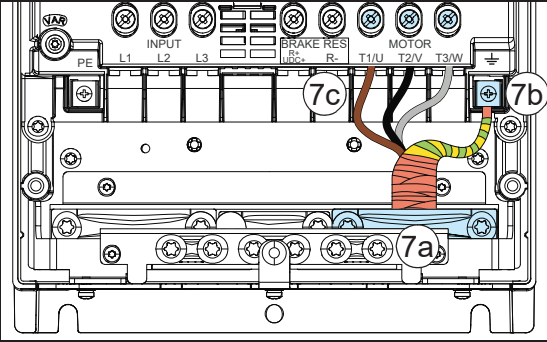


4. Connect the motor cable:
 - Ground the shield 360 degrees by tightening the clamp of the power cable grounding shelf onto the stripped part of the cable. (7a)
 - If you need more working space, open the screw (7d) and lift the EMC plate off. Remember to put it back after you have installed motor and input power cables.
 - Connect the twisted shield of the cable to the grounding terminal. (7b)
 - Connect the phase conductors of the cable to the T1/U, T2/V and T3/W terminals. Tighten the screws to the torque given in the table below (7c).

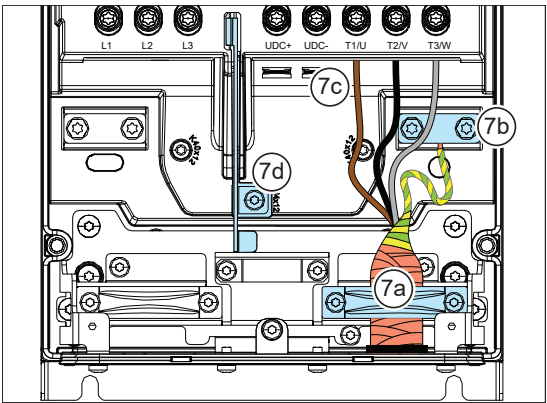
R1...R2



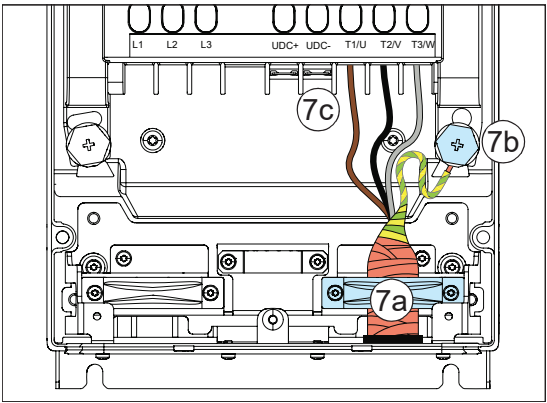
R3



R4 v2



R4



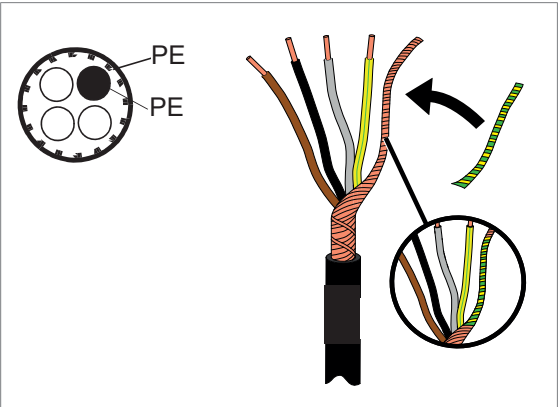
Frame size	R1	R2	R3	R4	R4 v2
	N·m	N·m	N·m	N·m	N·m
T1/U, T2/V, T3/W	1.0	1.5	3.5	4.0	5.5
PE, 	1.5	1.5	1.5	2.9	2.9
	1.2	1.2	1.2	1.2	1.2

Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Input power cable

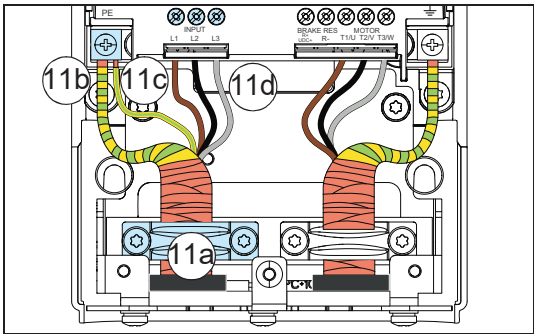
5. Prepare the ends of the cable as illustrated in the figure.

Note: The bare shield will be grounded 360 degrees. Mark the pigtail made from the shield as a PE conductor with yellow-and-green colour.

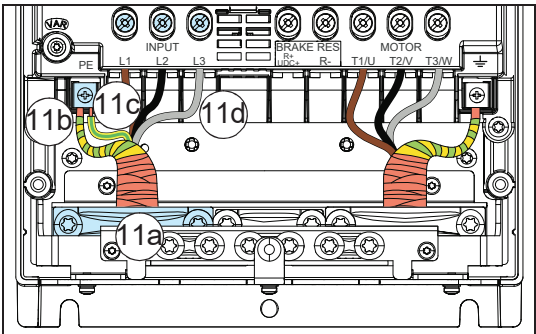


6. Connect the input power cable:
- Ground the shield 360 degrees by tightening the clamp of the power cable grounding shelf onto the stripped part of the cable (11a).
 - Connect the twisted shield of the cable to the grounding terminal (11b).
 - Connect the additional PE conductor of the cable (11c) (refer the note in section [Additional instructions and notes \(page 17\)](#)).
 - Connect the phase conductors of the cable to the L1, L2 and L3 terminals. Tighten the screws to the torque given below in the table (11d).

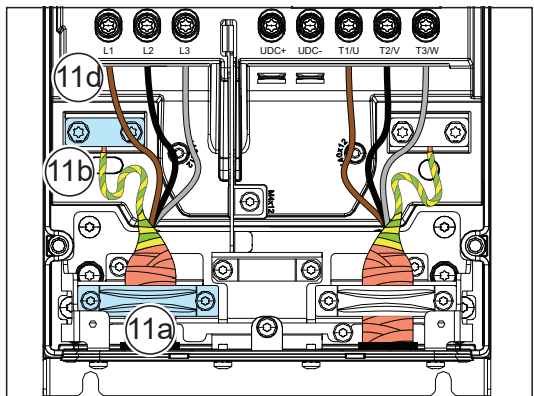
R1...R2



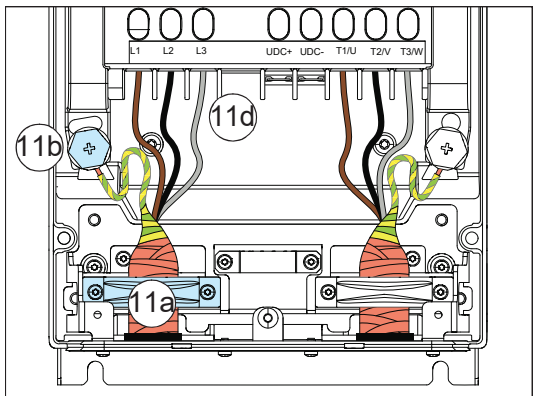
R3



R4 v2



R4



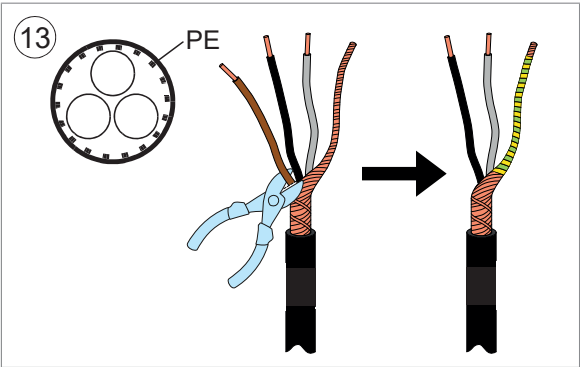
Frame size	R1	R2	R3	R4	R4 v2
	N·m	N·m	N·m	N·m	N·m
L1, L2, L3	1.0	1.5	3.5	4.0	5.5
PE, 	1.5	1.5	1.5	2.9	2.9
	1.2	1.2	1.2	1.2	1.2

Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Brake resistor cable (if used)

Frames R1...R3 only

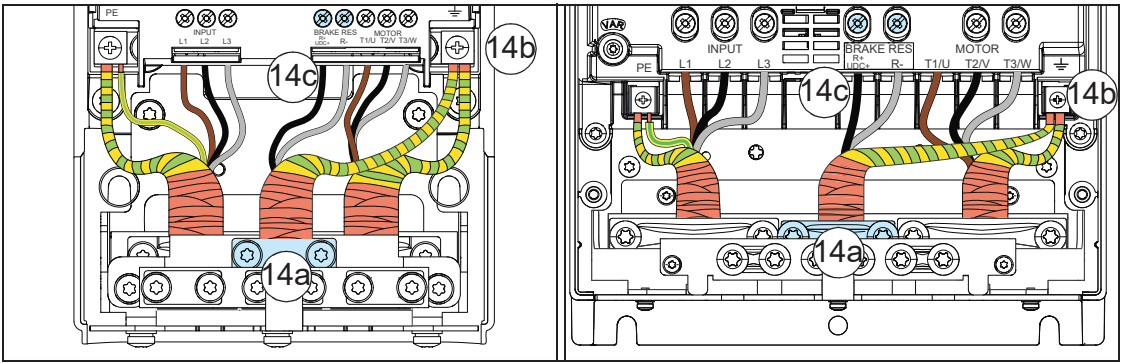
7. Repeat steps 4...6 for the brake resistor cable. Cut off one phase conductor.



8. Connect the cable as the motor cable in step 7. Ground the shield 360 degrees (14a). Connect the twisted shield to the grounding terminal (14b) and the conductors to the R+ and R- terminals (14c) and tighten to the torque given in the table.

R1...R2

R3



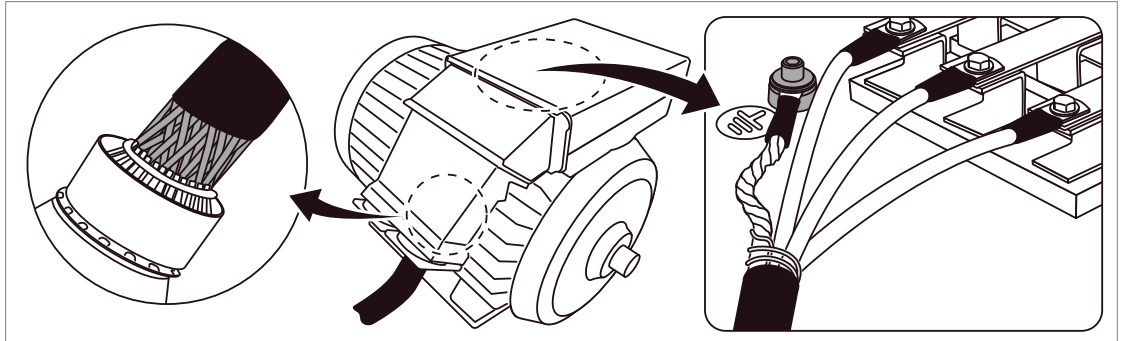
Frame size	R1	R2	R3
	N·m	N·m	N·m
R+, R-	1.0	1.5	3.5
PE,	1.5	1.5	1.5
	1.2	1.2	1.2

Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Finalization

Note: Frame R1: You have to install any optional I/O extension module, if used, in options slot 2 at this point. Refer section [Installing option modules \(page 103\)](#).

9. Secure the cables outside the unit mechanically.
10. Ground the motor cable shield at the motor end. For minimum radio frequency interference, ground the motor cable shield 360 degrees at the cable entry of the motor terminal box.

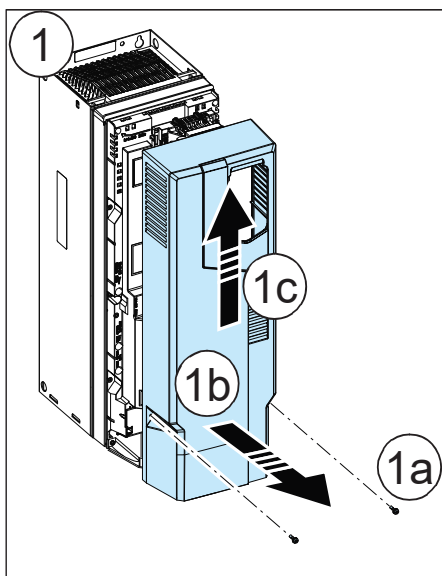


■ Connection procedure, frame R5

1. Remove the module cover: Loosen the retaining screws with a T20 Torx screwdriver (1a) and lift the cover from the bottom outwards (1b) and then up (1c).

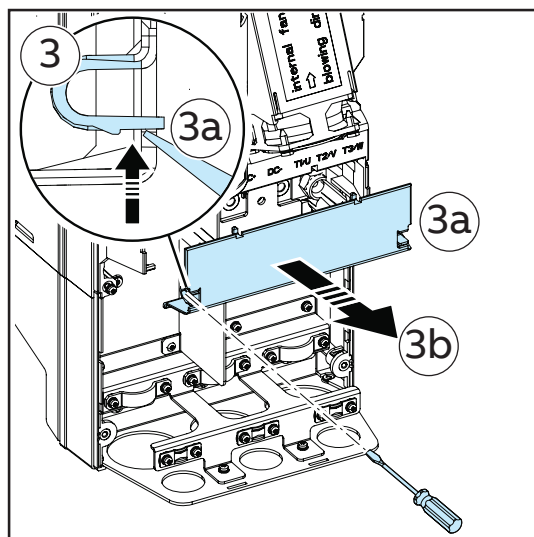
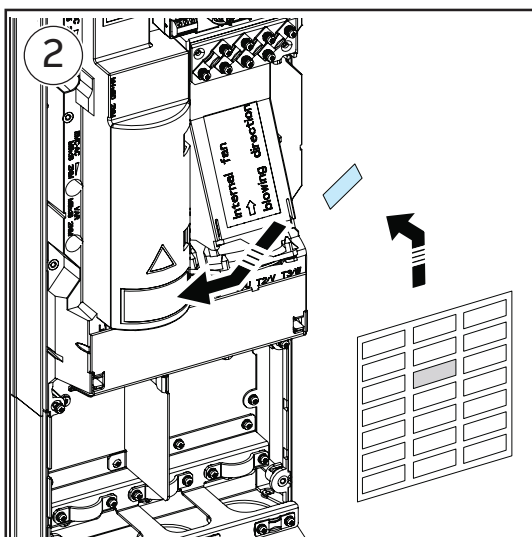


IP20



⚠WARNING If you install the drive on any other system than symmetrically grounded TN-S system, refer [Grounding system compatibility check \(page 75\)](#) if you have to disconnect the EMC filter and ground-to-phase varistor.

2. Attach the residual voltage warning sticker in the local language next to the control unit.
3. Remove the shroud on the power cable terminals by releasing the clips with a screwdriver (3a) and pulling the shroud out (3b).



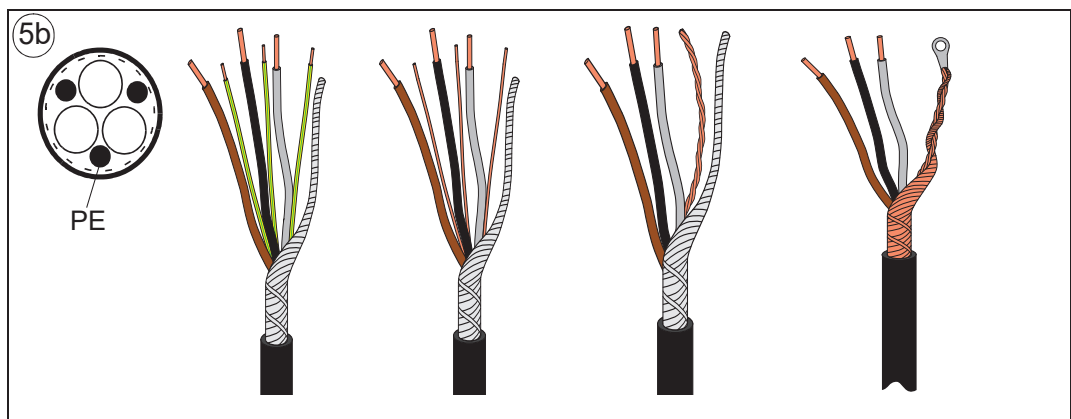
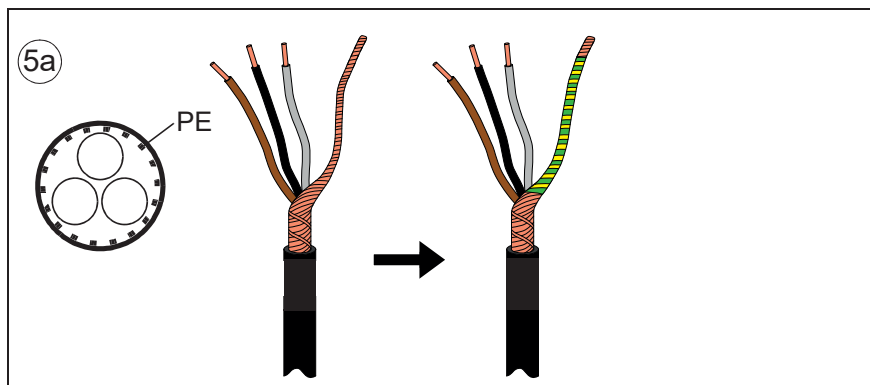
Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Motor cable

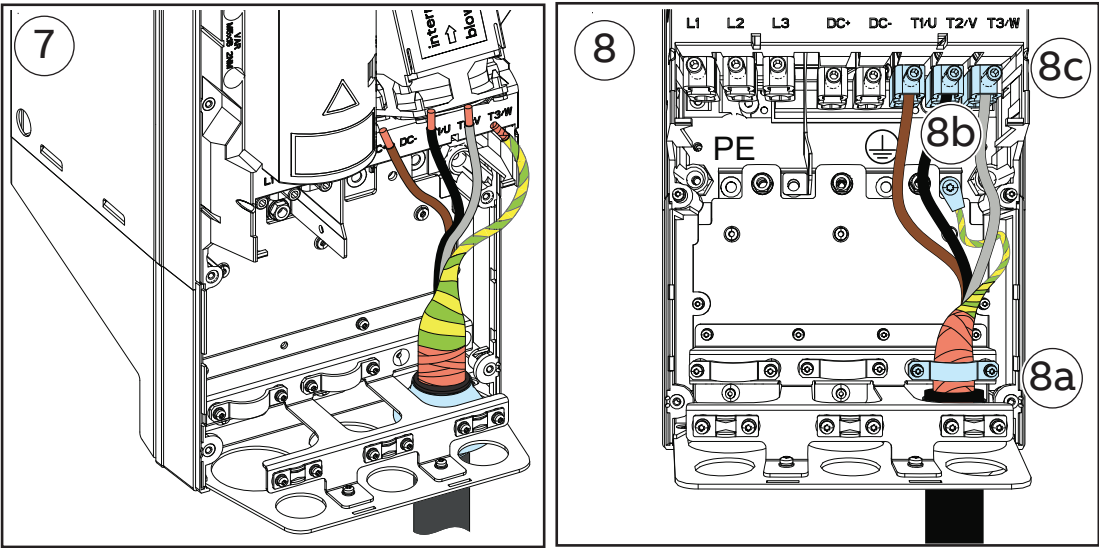
Use symmetrical shielded cable for motor cabling. If the cable shield is the sole PE conductor for drive or motor, make sure that it has sufficient conductivity for the PE.

4. Prepare the ends of the motor cable as illustrated in figures 5a and 5b (two different motor cable types are shown). If you use aluminum cables, put grease to the peeled aluminum cable before connecting it to the drive.

Note: The bare shield will be grounded 360 degrees. Mark the pigtail made from the shield as a PE conductor with yellow-and-green color.



5. Connect the motor cable:
 - Ground the shield 360 degrees by tightening the clamp of the power cable grounding shelf onto the stripped part of the cable (7a).
 - Connect the twisted shield of the cable to the grounding terminal (7b).
 - Connect the phase conductors of the cable to the T1/U, T2/V and T3/W terminals (7c). Tighten the screws to the torque given in the table.

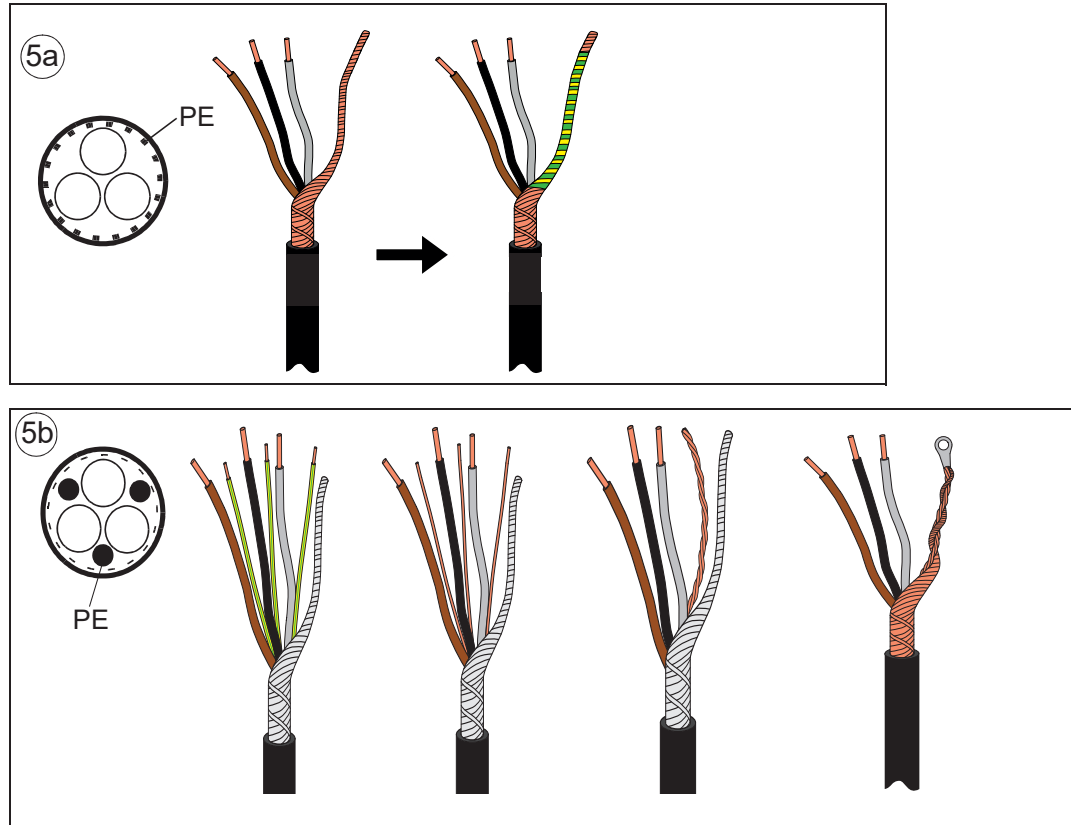


Frame size	T1/U, T2/V, T3/W	PE, $\oplus$		
	N·m	M	N·m	N·m
R5	5.6	M5	2.2	1.2

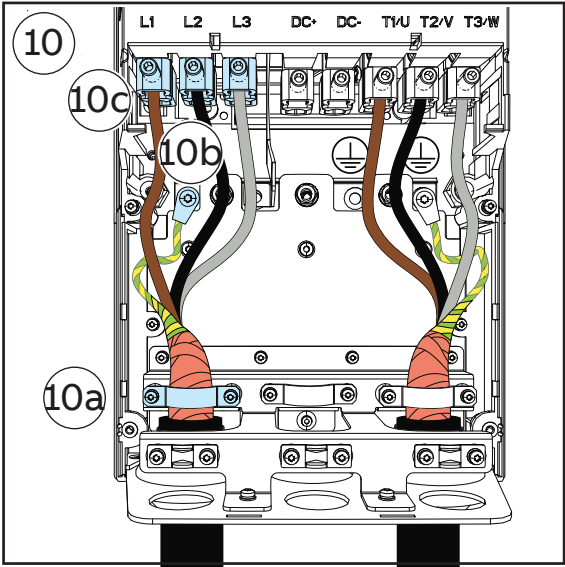
Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Input power cable

6. Repeat steps 4...6 for the input power cable.



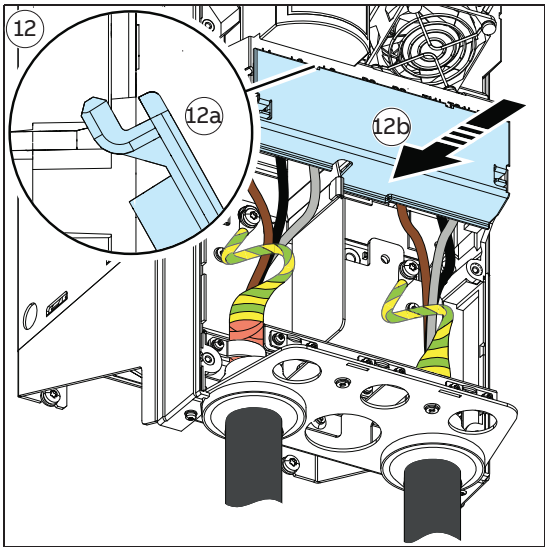
7. Connect the input power cable. Use terminals L1, L2 and L3. Tighten the screws to the torque given in the table.



Frame size	L1, L2, L3	PE, 		
	N·m	M	N·m	N·m
R5	5.6	M5	2.2	1.2

Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

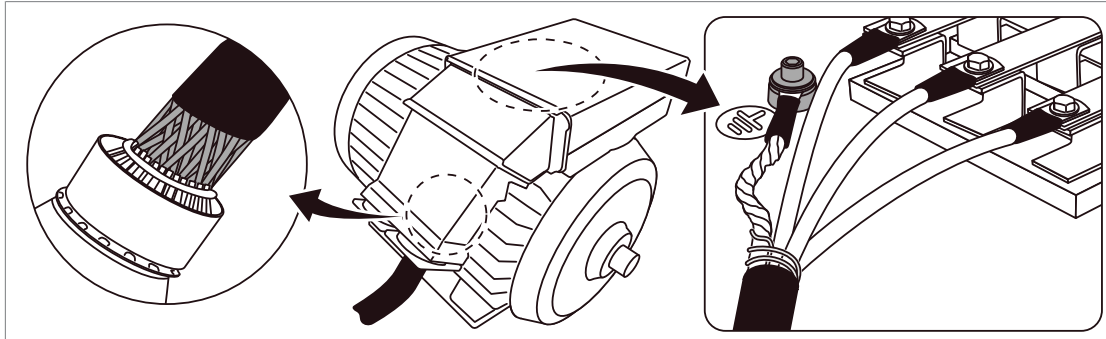
8. Reinstall the shroud on the power terminals by putting the tabs at the top of the shroud in their counterparts on the drive frame (11a) and then pressing the shroud in place (11b).



Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Finalization

9. Secure the cables outside the unit mechanically.
10. Ground the motor cable shield at the motor end. For minimum radio frequency interference, ground the motor cable shield 360 degrees at the cable entry of the motor terminal box.

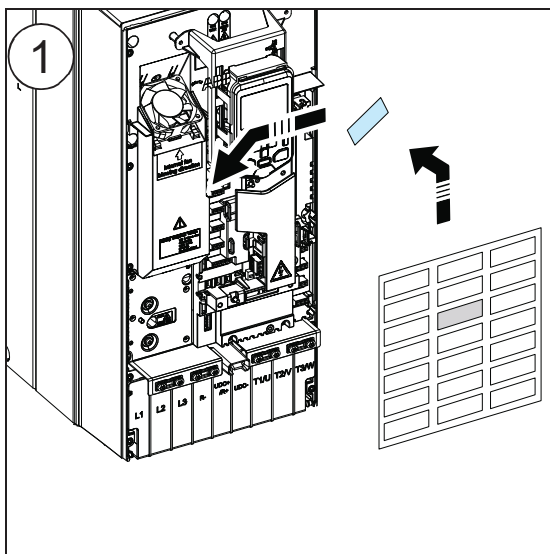


■ Connection procedure, frames R6...R9



▲WARNING If you install the drive on any other system than symmetrically grounded TN-S system, refer [Grounding system compatibility check \(page 75\)](#) if you have to disconnect the EMC filter and ground-to-phase varistor.

1. Attach the residual voltage warning sticker in the local language next to the control unit.



Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

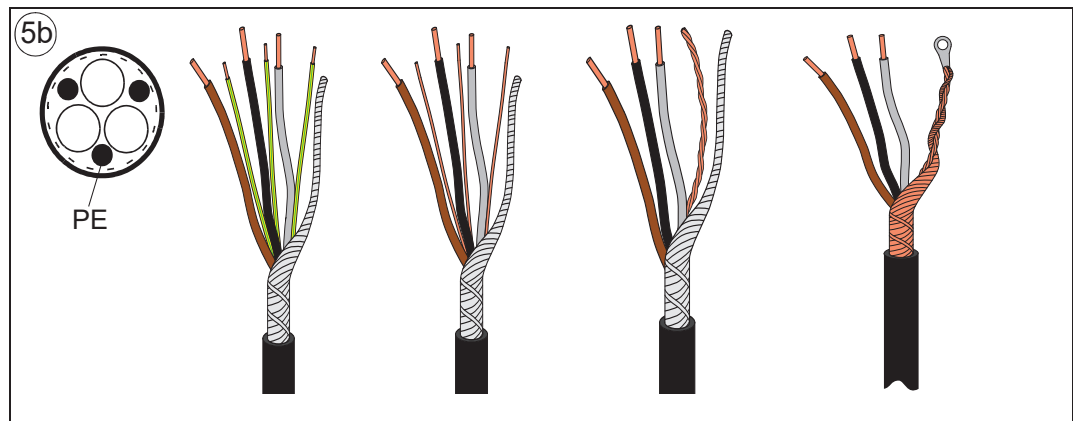
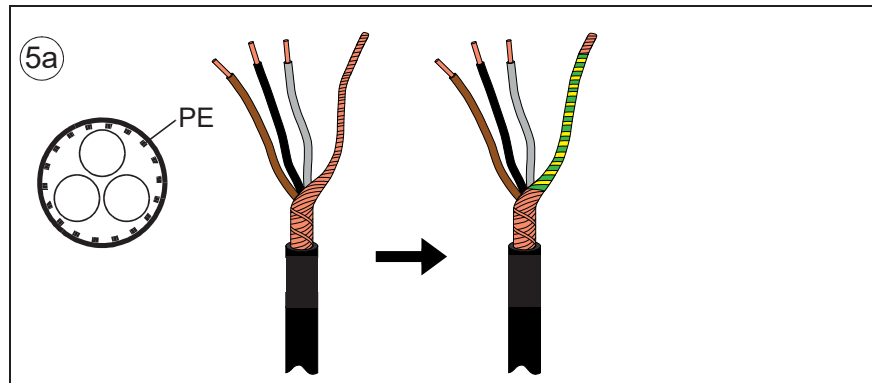
2. Remove the shroud on the power cable terminals by releasing the clips with a screwdriver (3a) and pulling the shroud out (3b).
3. Knock out holes in the shroud for the cables to be installed.

Motor cable

4. Prepare the ends of the input power cable and motor cable as illustrated in the figure. If you use aluminum cables, put grease to the peeled aluminum cable before

connecting it to the drive. Two different motor cable types are shown in the figures (7a, 7b).

Note: The bare shield will be grounded 360 degrees. Mark the pigtail made from the shield as a PE conductor with yellow-and-green color.

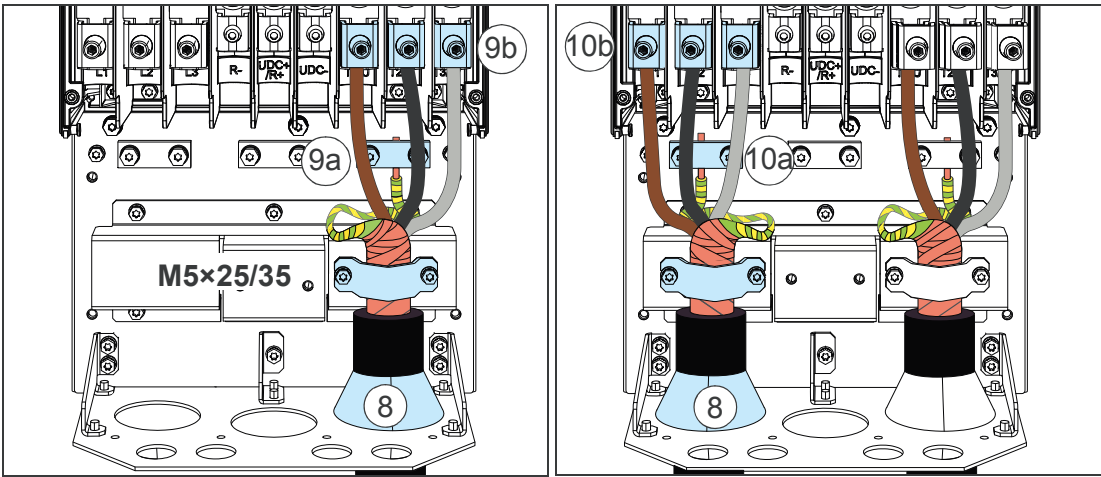


5. Connect the motor cable:
 - Ground the shield 360 degrees under the grounding clamps.
 - Connect the twisted shield of the cable to the grounding terminal (9a).
 - Connect the phase conductors of the cable to terminals T1/U, T2/V and T3/W. Tighten the screws to the torque given in the table (9b).

Input power cable

6. Connect the input power cable as in step 9. Use terminals L1, L2, L3.





Frame size	L1, L2, L3, T1/U, T2/V, T3/W	PE, 	
	N·m	N·m	N·m
R6	30	9.8	1.2
R7	40	9.8	1.2
R8	40	9.8	1.2
R9	70	9.8	1.2

Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

Detaching and reinstalling the connectors

This is possible but not recommended.

Terminals T1/U, T2/V and T3/W

- Remove the nut that attaches the connector to its busbar.
- Put the conductor under the connector pressure plate and pre-tighten the conductor.
- Put the connector back to its busbar. Start the nut, and turn it at least two rotations by hand.



⚠WARNING Before you use tools, make sure that the nut or screw is not cross-threading. Cross-threading can damage the drive and cause danger.

- Tighten the nut to a torque of 30 N·m .

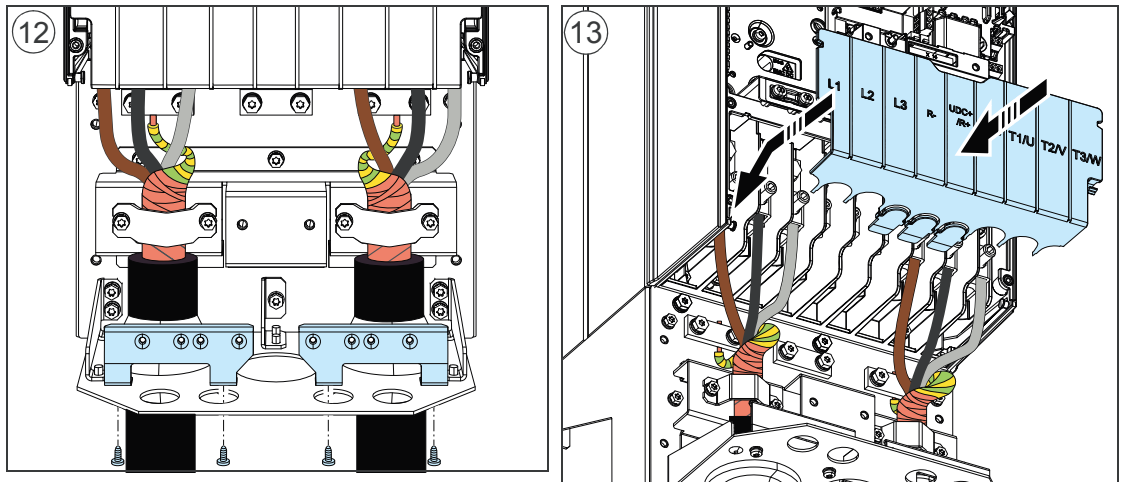
Terminals L1, L2 and L3

- Remove the combi screw that attaches the connector to its terminal post, and pull the connector off.
- Put the conductor under the connector pressure plate and pre-tighten the conductor.
- Put the connector back onto the terminal post. Start the combi screw, and turn it at least two rotations by hand.



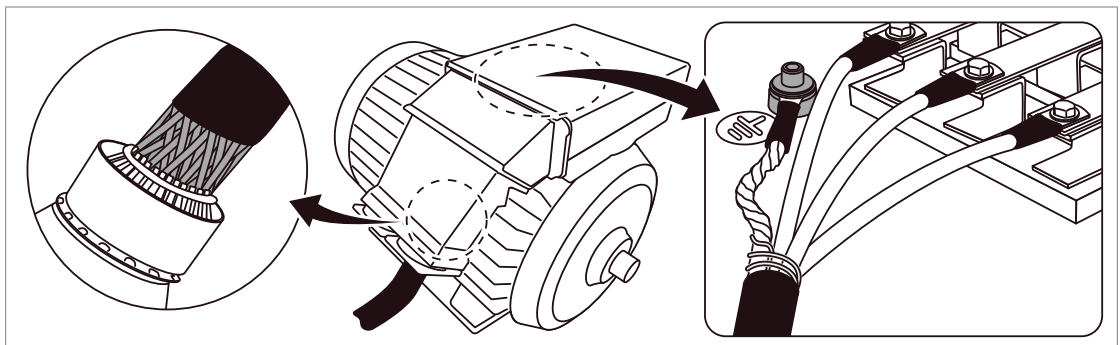
⚠WARNING Before you use tools, make sure that the nut or screw is not cross-threading. Cross-threading can damage the drive and cause danger.

- Tighten the combi screw to a torque of 30 N·m .
 - Tighten the conductor(s) to 40 N·m for frame R8 or to 70 N·m for frame R9.
7. Install the grounding shelf of the control cables.
 8. Reinstall the shroud on the power terminals.
 9. Secure the cables outside the unit mechanically.



Note: Drive with cable box is used as an example in the figure. Cable box is optional and need to be ordered separately.

10. Ground the motor cable shield at the motor end. For minimum radio frequency interference, ground the motor cable shield 360 degrees at the cable entry of the motor terminal box.



DC connection

The UDC+ and UDC- terminals (as standard in frames R4...R9) are for using external brake chopper units.

Connecting the control cables

■ Connection diagram

Refer [Default I/O connection diagram](#) for the default I/O connections of the drive.

■ Control cable connection procedure, frames R1...R9



▲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 [Electrical safety precautions \(page 16\)](#) before you start the work.
2. Remove the front cover(s) if not already removed. Refer to page [83](#) (R1...R4), page [89](#) (R5) or page [94](#) (R6...R9).

Analog signals

The figures for frames R1...R3 (page [99](#)), R4 (page [100](#)), R5 (page [101](#)) and R6...R9 (page [102](#)) show an example of connecting a cable. Make the connections according to the default configuration.

3. If you have ordered an optional conduit box, cut an adequate hole into the rubber grommet and slide the grommet onto the cable. Slide the cable through a hole in the cable entry and attach the grommet to the hole.
4. Ground the outer shield of the cable 360 degrees under the grounding clamp. Keep the cable unstripped as close to the terminals of the control unit as possible.
Frames R5...R9: Secure the cables mechanically at the clamps below the control unit.
Ground also the pair-cable shields and grounding wire at the SCR terminal.

5. Route the cable as shown in the figures for frames R1...R3 (page [99](#)), R4 (page [100](#)), R5 (page [101](#)) and R6...R9 (page [102](#)).

6. Connect the conductors to the appropriate terminals of the control unit and tighten to 0.5...0.6 N·m .

Digital signals

The figures for frames R1...R3 (page [99](#)), R4 (page [100](#)), R5 (page [101](#)) and R6...R9 (page [102](#)) show an example of connecting a cable. Make the connections according to the macro in use.

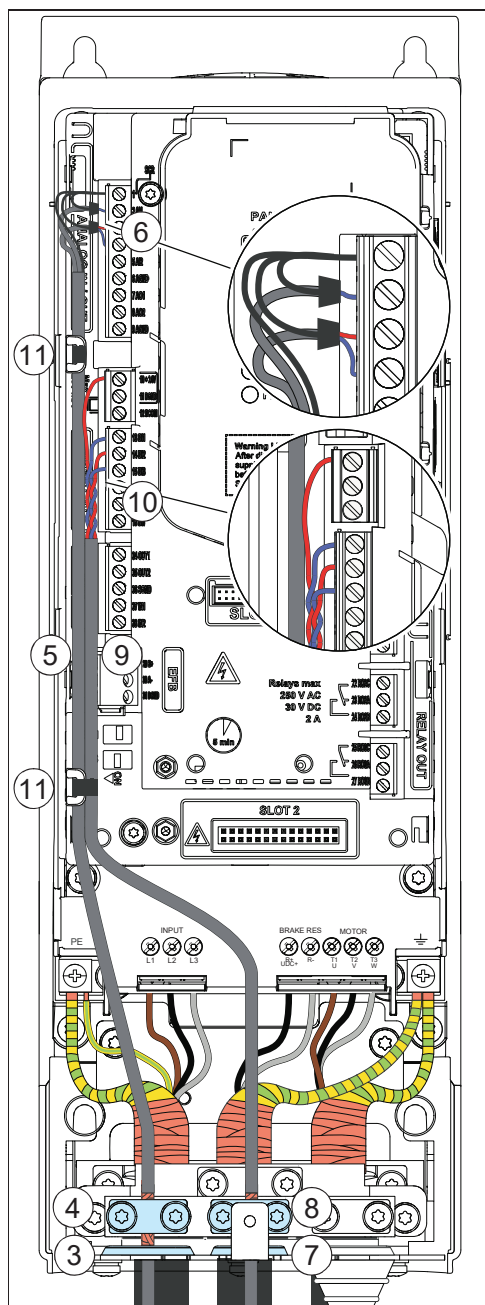
7. Cut an adequate hole into the rubber grommet and slide the grommet onto the cable. Slide the cable through the hole in the cable entry and attach the grommet to the hole.
8. Ground the outer shield of the cable 360 degrees under the grounding clamp. Keep the cable unstripped as close to the terminals of the control unit as possible.
Frames R5...R9: Secure the cables mechanically at the clamps below the control unit.
If you use double-shielded cables, ground also the pair-cable shields and grounding wire at the SCR terminal.
9. Route the cable as shown in the figures for frames R1...R3 (page [99](#)), R4 (page [100](#)), R5 (page [101](#)) and R6...R9 (page [102](#)).



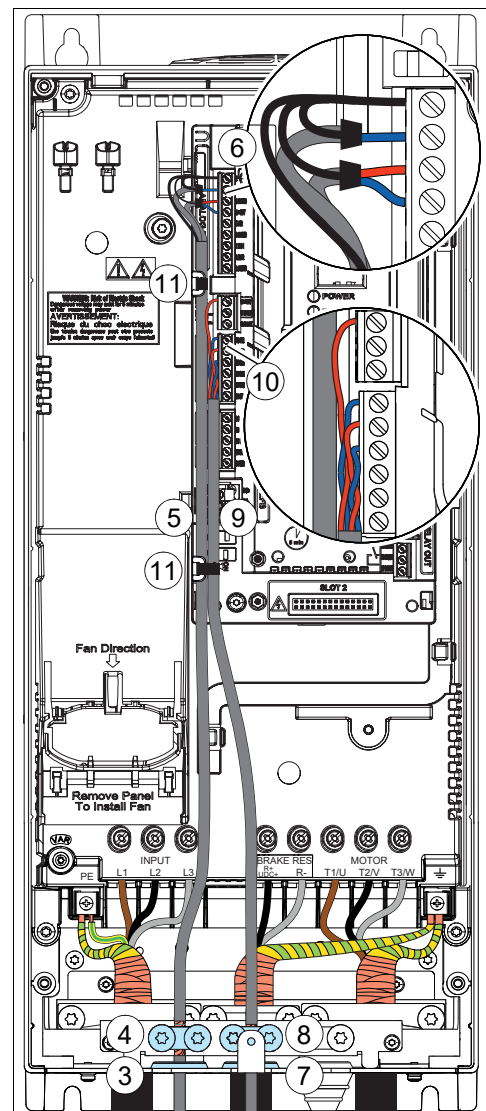
10. Connect the conductors to the appropriate terminals of the control unit and tighten to 0.5...0.6 N·m.
11. Tie all control cables to the provided cable tie mounts.

Note:

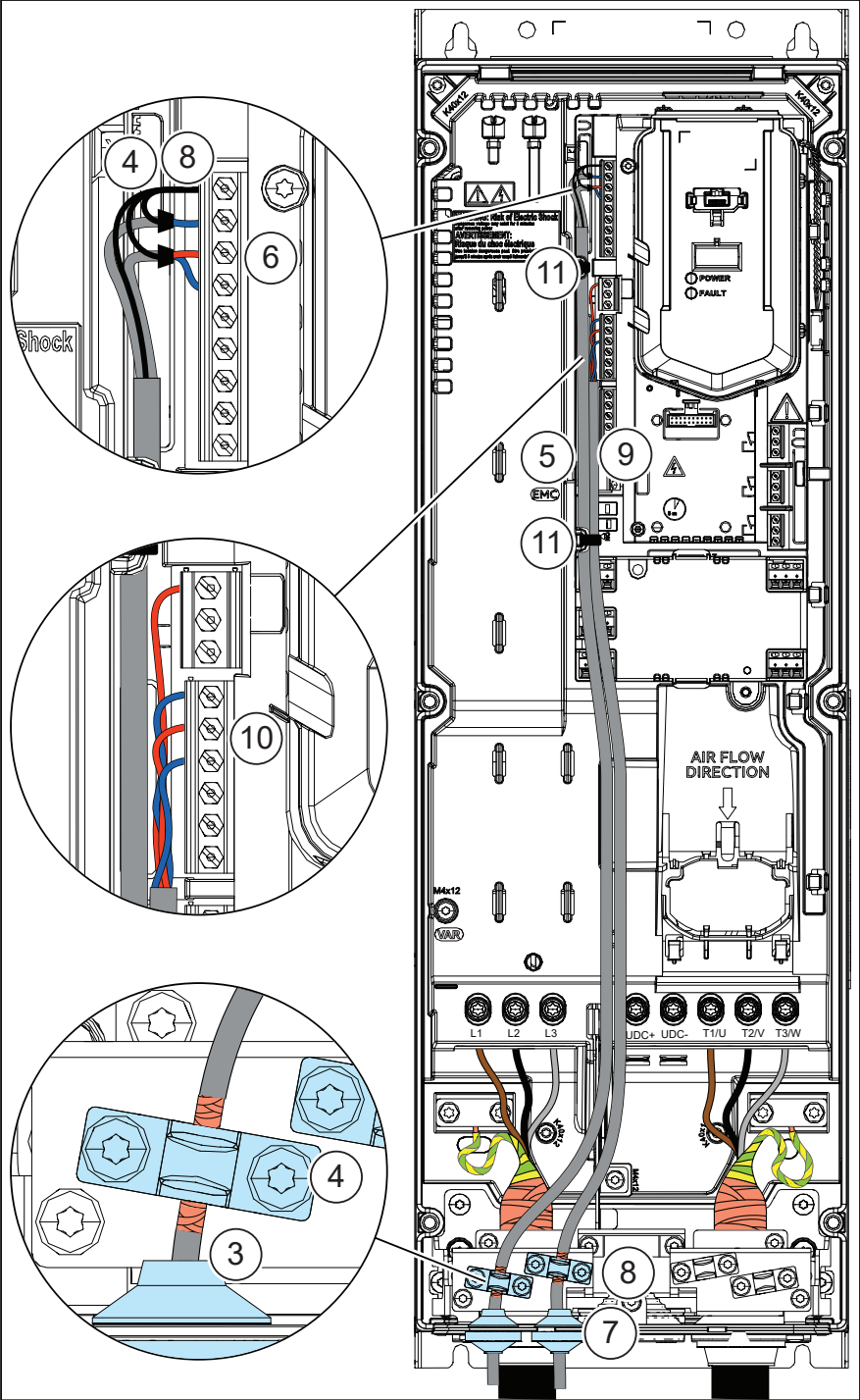
- Leave the other ends of the control cable shields unconnected or ground them indirectly via a high-frequency capacitor with a few nanofarads, eg, 3.3 nF / 630 V. The shield can also be grounded directly at both ends if they are in the same ground line with no significant voltage drop between the end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



R1...R2: 0.5...0.6 N·m



R3: 0.5...0.6 N·m



R4

Installing option modules

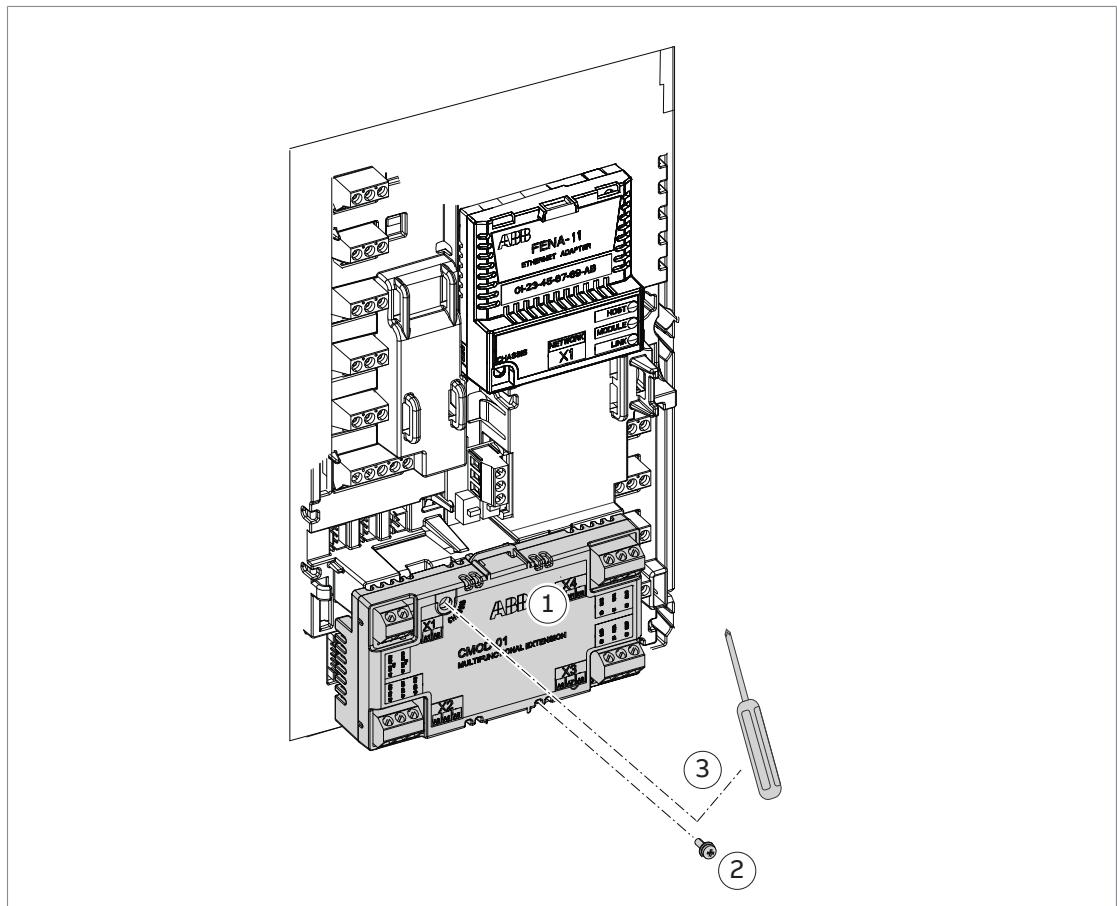


⚠ WARNING Obey the safety instructions of the drive. If you ignore them, injury or death, or damage to the equipment can occur.

1. Stop the drive and do the steps in section [Electrical safety precautions \(page 16\)](#) before you start the work.

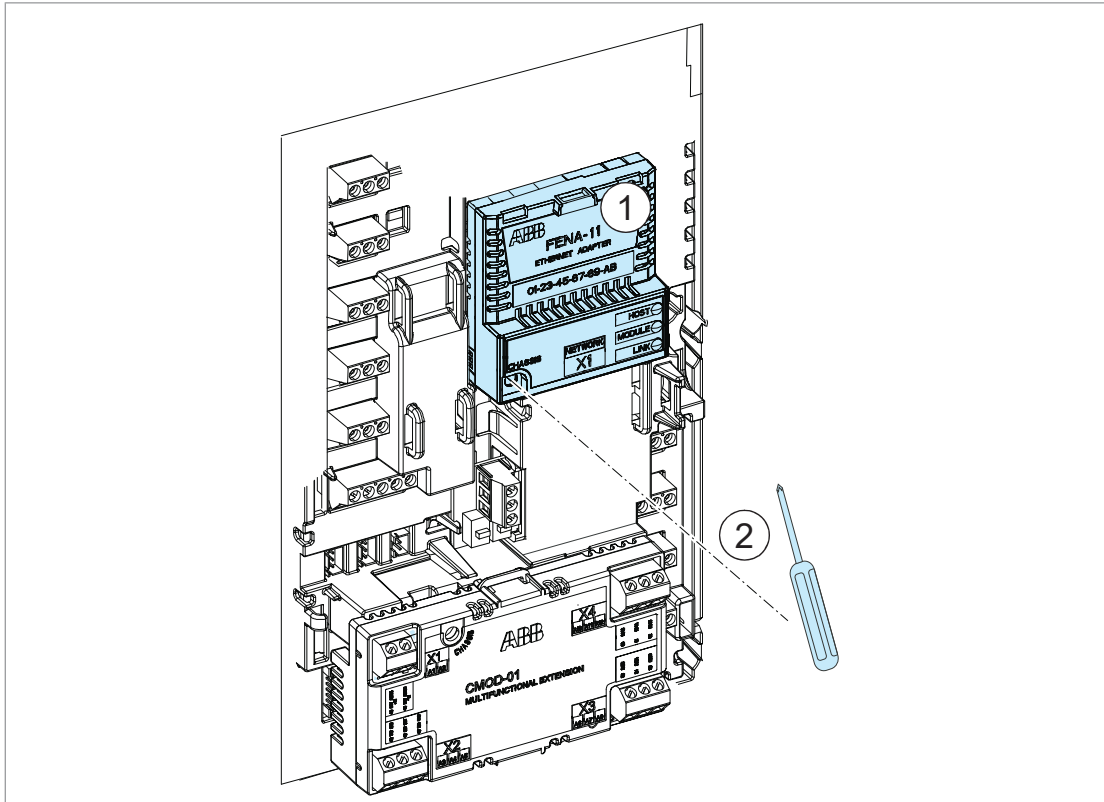
■ Option slot 2 (I/O extension modules)

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. The screw grounds the module. It is necessary for fulfilling the EMC requirements and for correct operation of the module.



■ Option slot 1 (fieldbus adapter modules)

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



■ Wiring the optional modules

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



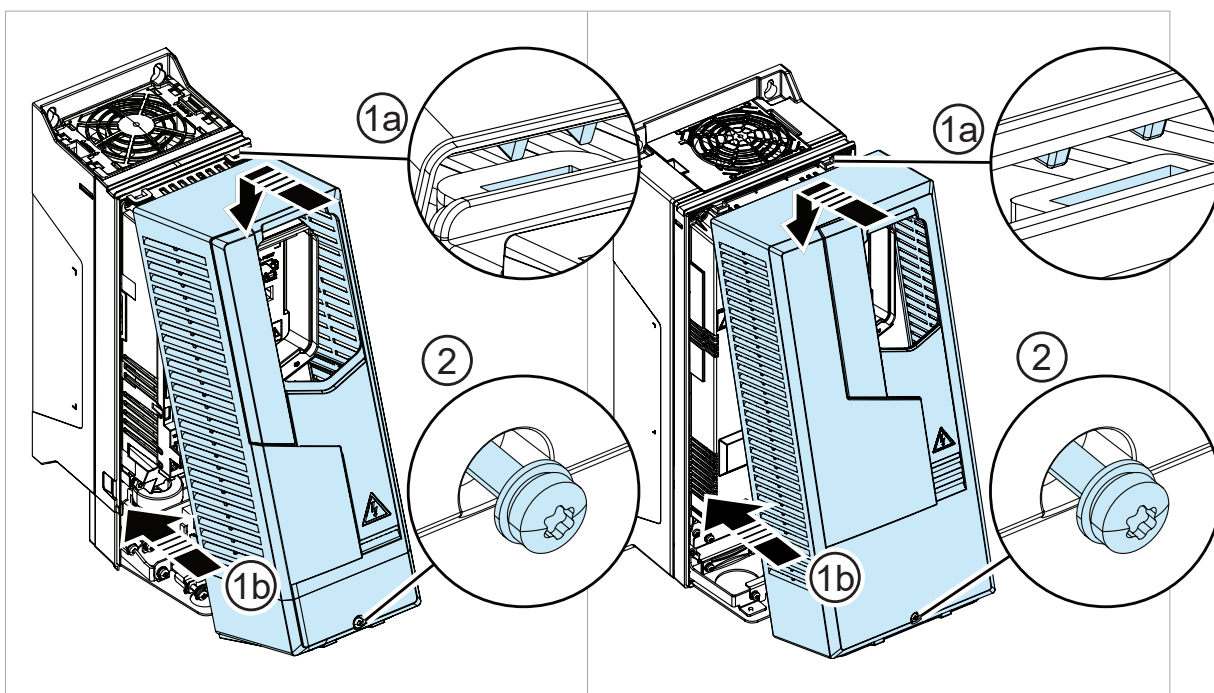
Reinstalling covers

■ Reinstalling cover, frames R1...R4

1. Reinstall the cover: Put the tabs on the cover top in their counterparts on the housing (1a) and then press the cover (1b).
2. Tighten the retaining screw at the bottom with a T20 Torx screwdriver.

IP20 R1...R2

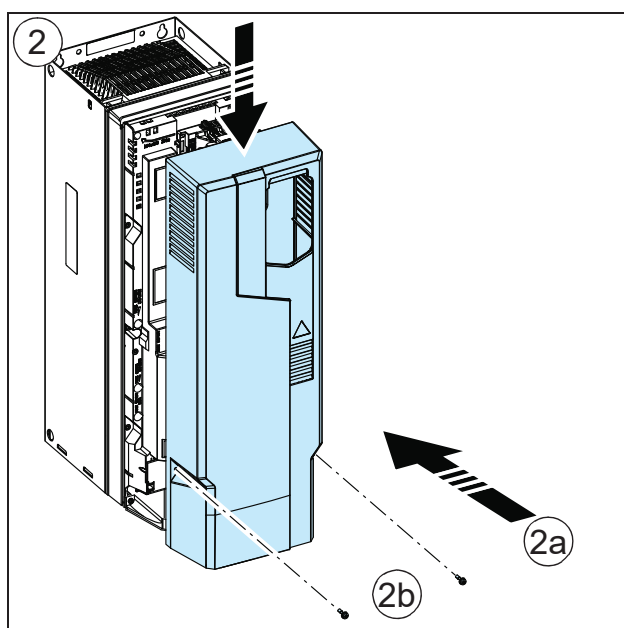
IP20 R3...R4



■ Reinstalling covers, frames R5...R9

Reinstall the module cover: Press the cover at the bottom (2a) and tighten the retaining screws (2b).

IP20



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-23 and CCU-24).

Layout

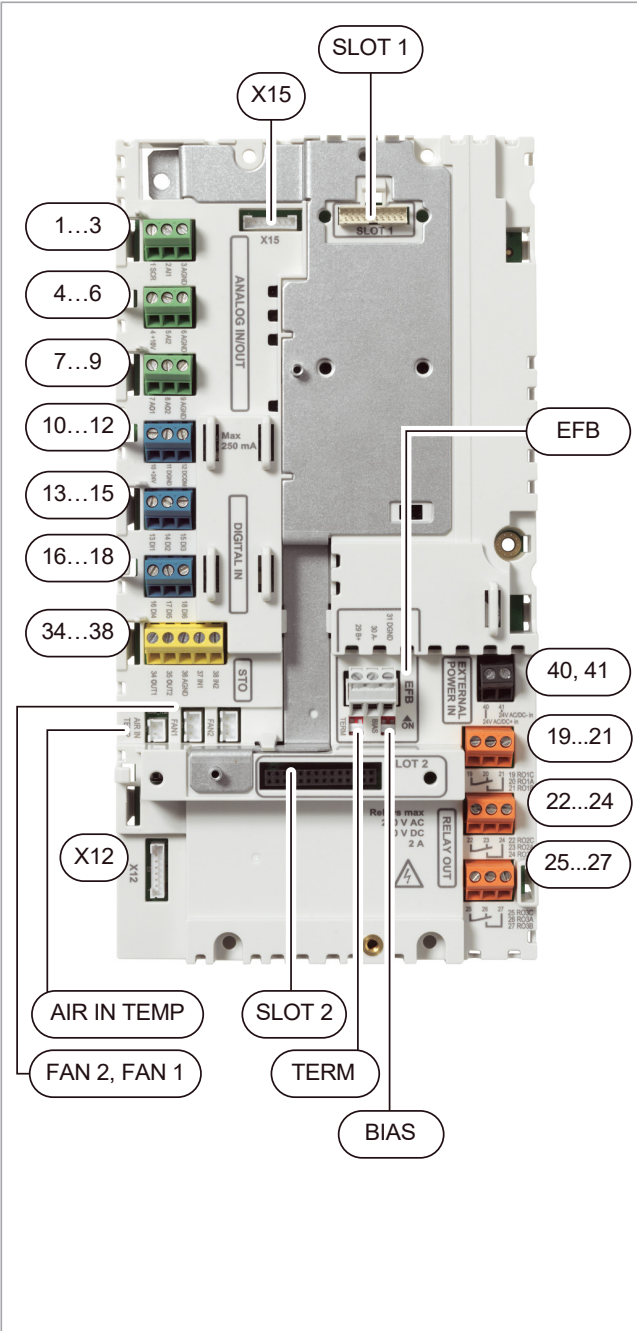
The layout of the external control connection terminals on the drive module control unit is shown below.

■ CCU-23 (frames R1...R5)

The diagram shows the front panel of the CCU-23 control unit. On the left, there are several terminal blocks labeled with ranges: 1...3 (Analog IN/OUT), 4...6 (Analog IN/OUT), 7...9 (Analog IN/OUT), 10...12 (Analog IN/OUT), 13...18 (DIGITAL IN), 34...38 (STO), and 29...31 (TERM). On the right, there are labels for X12 (Panel port), SLOT 1 (EIA/RS-485 fieldbus connector), and SLOT 2 (Relay output). At the bottom, there are labels for BIAS, EFB, TERM, and SLOT 2. The unit also features a POWER button, a FAULT indicator, and a warning label: 'Warning! High voltage! After disconnecting the supply, wait 5 minutes before proceeding. See User's manual.'

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.
X12	Panel port (control panel connection, wired at the factory to the control panel)
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)	
RO1 ... RO3	
19...21	Relay output 1 (RO1)
22...24	Relay output 2 (RO2)
25...27	Relay output 3 (RO3)

■ CCU-24 (frames R6...R9)



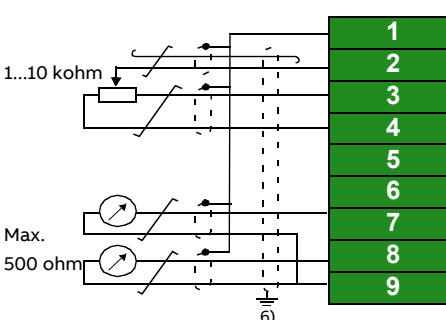
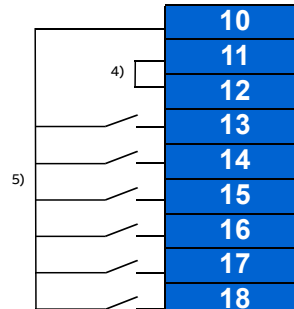
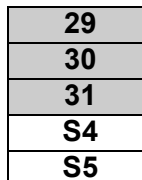
SLOT 1	
Option slot 1 (fieldbus adapter modules)	
ANALOG IN/OUT	
1...3	Analog input 1
4...6	Analog input 2
7...9	Analog outputs
10...12	Auxiliary voltage output
DIGITAL IN	
13...18	Digital inputs
STO	
34...38	Safe torque off connection.
AIR IN TEMP	Internal air temperature NTC sensor connection
FAN2	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)

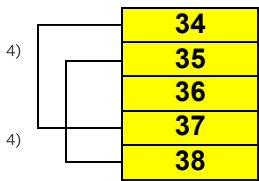
Default I/O connection diagram

■ Default I/O connection diagram

The default control connections for the HVAC default are shown below.

CCU-23 (frames R1...R5)

Connection	Term	Description	
X1 Reference voltage and analog inputs and outputs			
	1	SCR	Signal cable shield (screen)
	2	AI1	Output frequency/speed reference: 0...10 V ¹⁾
	3	AGND	Analog input circuit common
	4	+10V	Reference voltage 10 V DC
	5	AI2	Actual feedback: 0...20 mA ¹⁾
	6	AGND	Analog input circuit common
	7	AO1	Output frequency: 0...10 V
	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	Not configured
	15	DI3	Constant frequency/speed selection ³⁾
	16	DI4	Start interlock 1 (1 = allow start)
	17	DI5	Not configured
	18	DI6	Not configured
X5 Embedded fieldbus			
	29	B+	Embedded fieldbus, EFB (EIA-485)
	30	A-	
	31	DGND	
	S4	TERM	Termination switch
	S5	BIAS	Termination switch
X6, X7, X8 Relay outputs			

Connection		Term	Description
Damper actuator	19	RO1C	Damper control
	20	RO1A	250 V AC / 30 V DC
	21	RO1B	2 A
Run status	22	RO2C	Running
	23	RO2A	250 V AC / 30 V DC
	24	RO2B	2 A
Fault status	25	RO3C	Fault (-1)
	26	RO3A	250 V AC / 30 V DC
	27	RO3B	2 A
X4 Safe Torque Off			
	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 191) . X4 Safe Torque Off
	35	OUT2	
	36	SGND	
	37	IN1	
	38	IN2	

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.

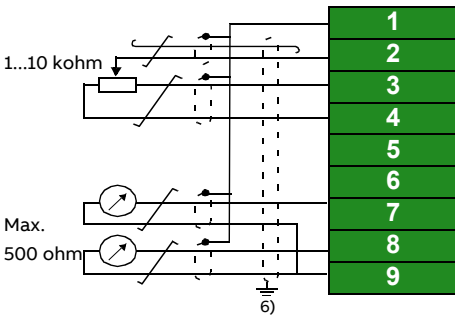
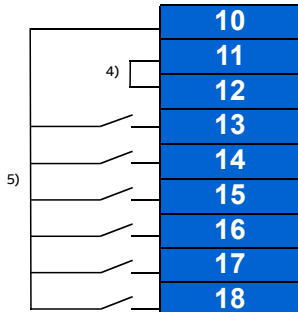
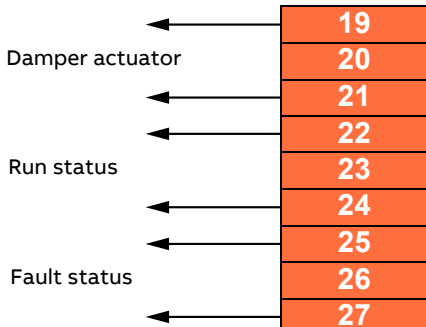
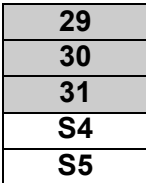
Terminal sizes: 0.2 ... 2.5 mm² (24...14 AWG) (Terminals +24V, DGND, DCOM, B+, A-, DGND, Ext. 24V)

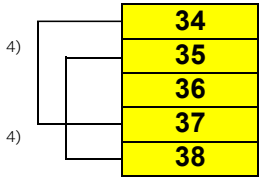
Terminal sizes: 0.14 ... 1.5 mm² (26...16 AWG) (Terminals DI, AI, AO, AGND, RO, STO)

Tightening torques: 0.5 ... 0.6 N·m

Wire strip length 7...8 mm

CCU-24 (frames R6...R9)

Connection	Term	Description	
X1 Reference voltage and analog inputs and outputs			
	1	SCR	Signal cable shield (screen)
	2	AI1	Output frequency/speed reference: 0...10 V ¹⁾
	3	AGND	Analog input circuit common
	4	+10V	Reference voltage 10 V DC
	5	AI2	Actual feedback: 0...20 mA ¹⁾
	6	AGND	Analog input circuit common
	7	AO1	Output frequency: 0...10 V
	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	Not configured
	15	DI3	Constant frequency/speed selection ³⁾
	16	DI4	Start interlock 1 (1 = allow start)
	17	DI5	Not configured
	18	DI6	Not configured
X6, X7, X8 Relay outputs			
	19	RO1C	Damper control
	20	RO1A	250 V AC / 30 V DC
	21	RO1B	2 A
	22	RO2C	Running
	23	RO2A	250 V AC / 30 V DC
	24	RO2B	2 A
	25	RO3C	Fault (-1)
	26	RO3A	250 V AC / 30 V DC
	27	RO3B	2 A
X5 Embedded fieldbus			
	29	B+	Embedded fieldbus, EFB (EIA-485)
	30	A-	
	31	DGND	
	S4	TERM	Termination switch
	S5	BIAS	Bias resistors switch
X4 Safe Torque Off			

Connection	Term	Description
	34	OUT1
	35	OUT2
	36	SGND
	37	IN1
	38	IN2
X10 24 V AC/DC		
	40	24 V AC/DC+ in
	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 mm² (26...14 AWG)

Tightening torques: 0.5 ... 0.6 N·m

Wire strip length 7...8 mm

Notes:

- 1) Current [0(4)...20 mA, $R_{in} = 100 \text{ ohm}$] or voltage [0(2)...10 V, $R_{in} > 200 \text{ kohm}$]. 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) In scalar control: See **Menu > Primary settings > Start, stop, reference > Constant speeds / constant frequencies** or parameter group 28 Frequency reference chain.

DI3	Operation/Parameter
0	Set frequency through AI1
1	28.26 Constant frequency 1

- 4) Connected with jumpers at the factory.
- 5) Use shielded twisted-pair cables for digital signals.
- 6) Ground the outer shield of the cable 360° under the grounding clamp on the grounding shelf, and the pair-cable shields and grounding wire at the grounding terminal (SCR) of the control unit.
- 7)  **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 I/O connections

■ Embedded EIA-485 fieldbus connection

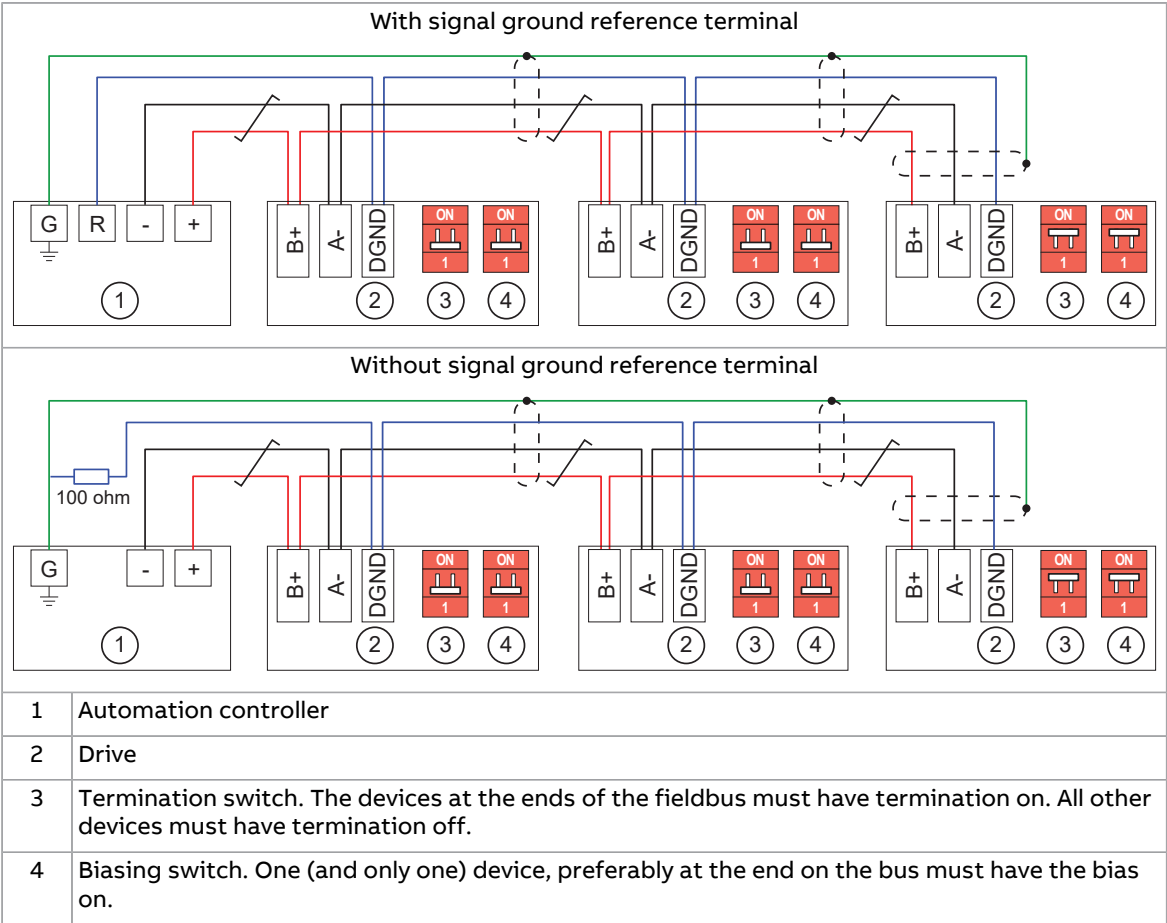
The EIA-485 network uses shielded, twisted-pair cable with a characteristic impedance of 100...130 ohm for data signaling. The distributed capacitance between conductors

is less than 100 pF per meter. Distributed capacitance between conductors and shield is less than 200 pF per meter. Foil or braided shields are acceptable.

Connect the cable to the EIA-485 terminal on the control unit. 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.

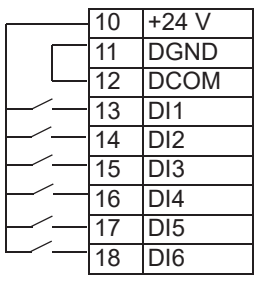
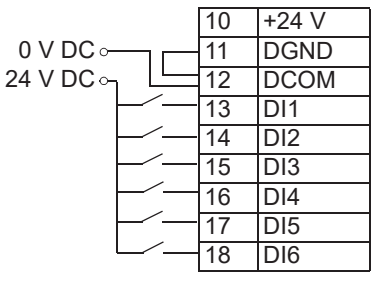
Connection examples are shown below.

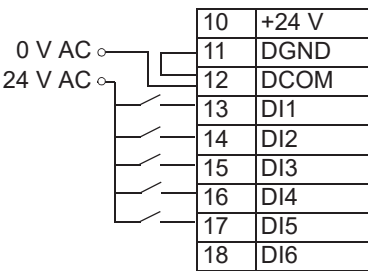


■ Connecting motor temperature sensors to the drive

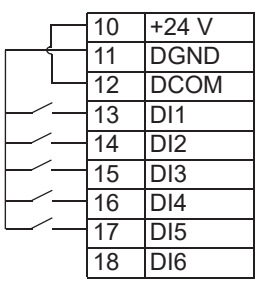
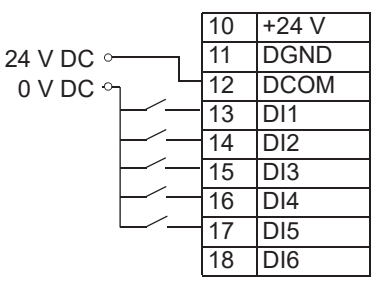
IEC/EN 60664 requires double or reinforced insulation between the control unit and the live parts of the motor. To achieve this, use an CMOD-02 I/O extension module. Refer [Implementing a motor temperature sensor connection](#) and chapter [CMOD-02 multifunction extension module \(external 24 V AC/DC and isolated PTC interface\)](#).

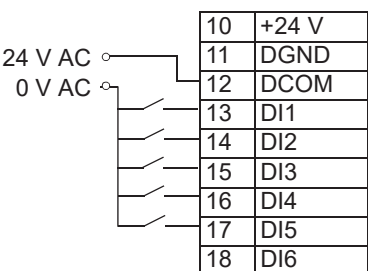
■ PNP configuration for digital inputs (DIGITAL IN)

Internal 24 V voltage source	External 24 V DC voltage source
	

External 24 V AC voltage source	▲WARNING CCU-23: If you connect external 24 V AC voltage source via CMOD-01 or CMOD-02 to control unit, do not connect 24 V AC to terminal block DIGITAL IN. It can cause damage to the control unit. CCU-24: If you connect external 24 V AC voltage source to terminal block EXTERNAL POWER IN (terminals 40 and 41), do not connect 24 V AC to terminal block DIGITAL IN. It can cause damage to the control unit.
 Note: DI6 is not supported with external 24 V AC voltage source.	

■ NPN configuration for digital inputs (DIGITAL IN)

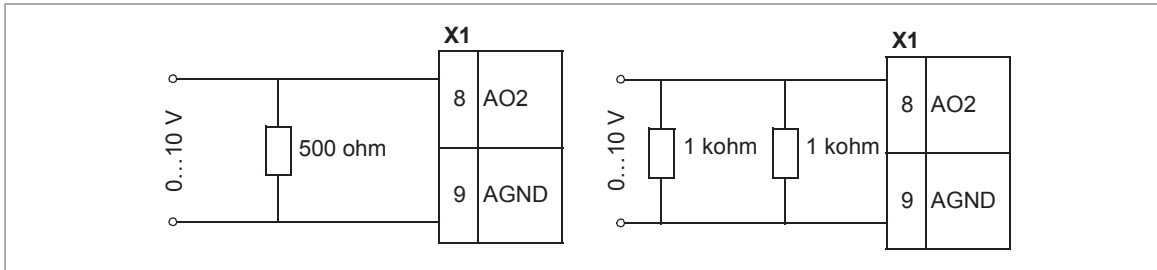
Internal 24 V voltage source	External 24 V DC voltage source
	

External 24 V AC voltage source	▲WARNING CCU-23: If you connect external 24 V AC voltage source via CMOD-01 or CMOD-02 to control unit, do not connect 24 V AC to terminal block DIGITAL IN. It can cause damage to the control unit. CCU-24: If you connect external 24 V AC voltage source to terminal block EXTERNAL POWER IN (terminals 40 and 41), do not connect 24 V AC to terminal block DIGITAL IN. It can cause damage to the control unit.
	

Note: DI6 is not supported in the NPN configuration.

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

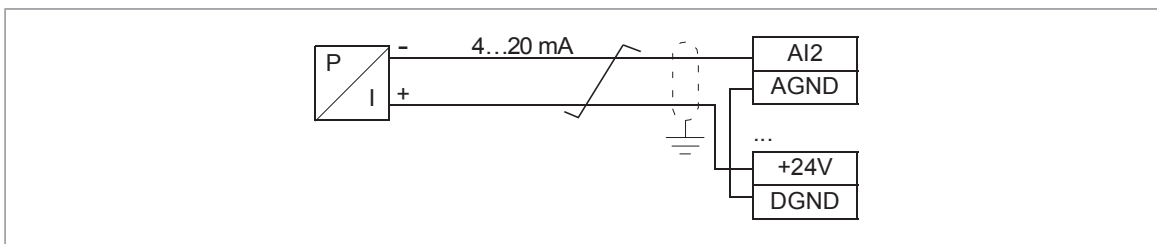
To obtain 0...10 V from analog output AO2, connect a 500 ohm resistor (or two 1 kohm resistors in parallel) between analog output AO2 and analog common ground AGND.



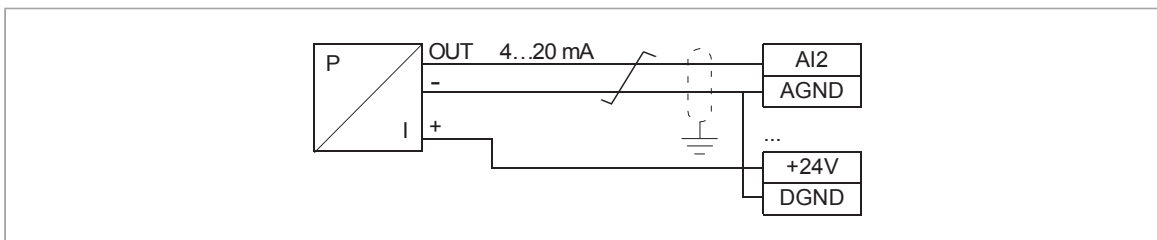
■ Connection examples of two-wire and three-wire sensors to analog input (AI2)

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, refer 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. Refer also chapter [The Safe torque off function \(page 191\)](#).

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

Technical data

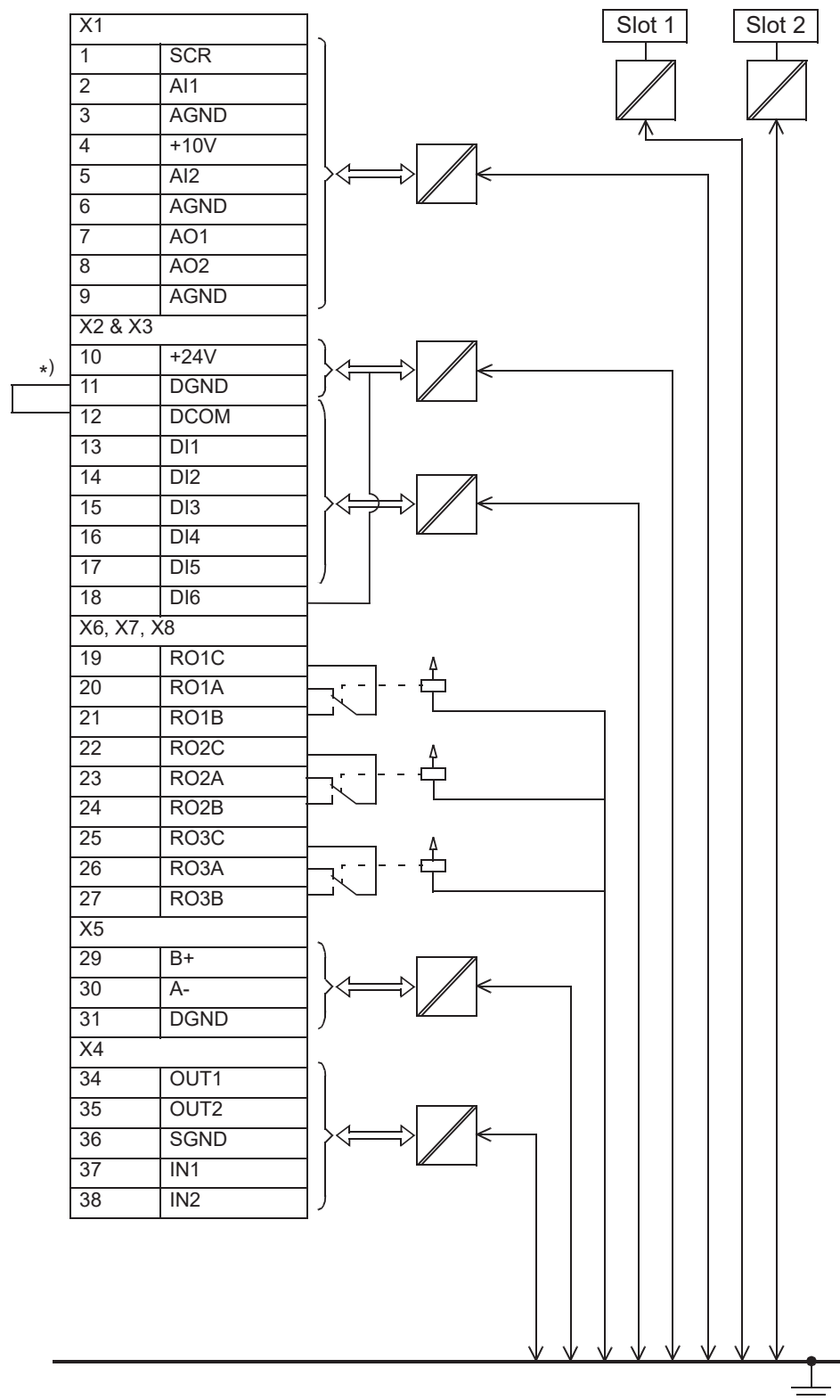
■ CCU-23 (frames R1...R5)

External power supply through option module CMOD-01 or CMOD-02	Maximum power: 25 W, 1.04 A at 24 V AC/DC $\pm 10\%$ as standard Terminal size: 0.2 ... 2.5 mm ² (24 ... 14 AWG)
+24 V DC output (Term. 10)	Total load capacity of the outputs is 6.0 W (250 mA / 24 V) minus the power taken by the option modules installed on board. Terminal size: 0.2 ... 2.5 mm ² (24 ... 14 AWG)
Digital inputs DI1...DI6 (Term. 13...18)	Input type: NPN/PNP Terminal size: 0.14 ... 1.5 mm² (26 ... 16 AWG) <u>DI1...DI4 (Term. 13...16)</u> 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 <u>DI5 (Term.17)</u> 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) <u>DI6 (Term.18)</u> 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 ... 1.5 mm ² (26 ... 16 AWG) Refer section Isolation areas (page 120) .
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 114). Current input: 0(4)...20 mA, R_{in}: 100 ohm Voltage input: 0(2)...10 V, R_{in}: > 200 kohm Terminal size: 0.14 ... 1.5 mm² (26 ... 16 AWG) Inaccuracy: typical $\pm 1\%$, max. $\pm 1.5\%$ 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, refer Connection for obtaining 0...10 V from analog output 2 (AO2) (page 116). Current output: 0...20 mA, R_{load}: < 500 ohm Voltage input: 0...10 V, R_{load}: > 100 kohm (AO1 only) Terminal size: 0.14 ... 1.5 mm² (26 ... 16 AWG) Inaccuracy: $\pm 1\%$ of full scale (in voltage and current modes)
Reference voltage output for analog inputs +10V DC (Term. 4)	Max. 20 mA output Inaccuracy: $\pm 1\%$

Embedded fieldbus (X5)	Connector pitch 5 mm, maximum wire size 2.5 mm² (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
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 ... 1.5 mm² (26 ... 16 AWG)
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	Fieldbus extension
	3	I/O extension
		Reinforced insulation (IEC/EN 61800-5-1:2007)
		Functional insulation (IEC/EN 61800-5-1:2007)
	<u>Below altitudes 4000 m (13123 ft):</u> 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).	

Ground isolation diagram



*) Jumper installed at factory

■ CCU-24 (frames R6...R9)

External power supply
Term. 40, 41

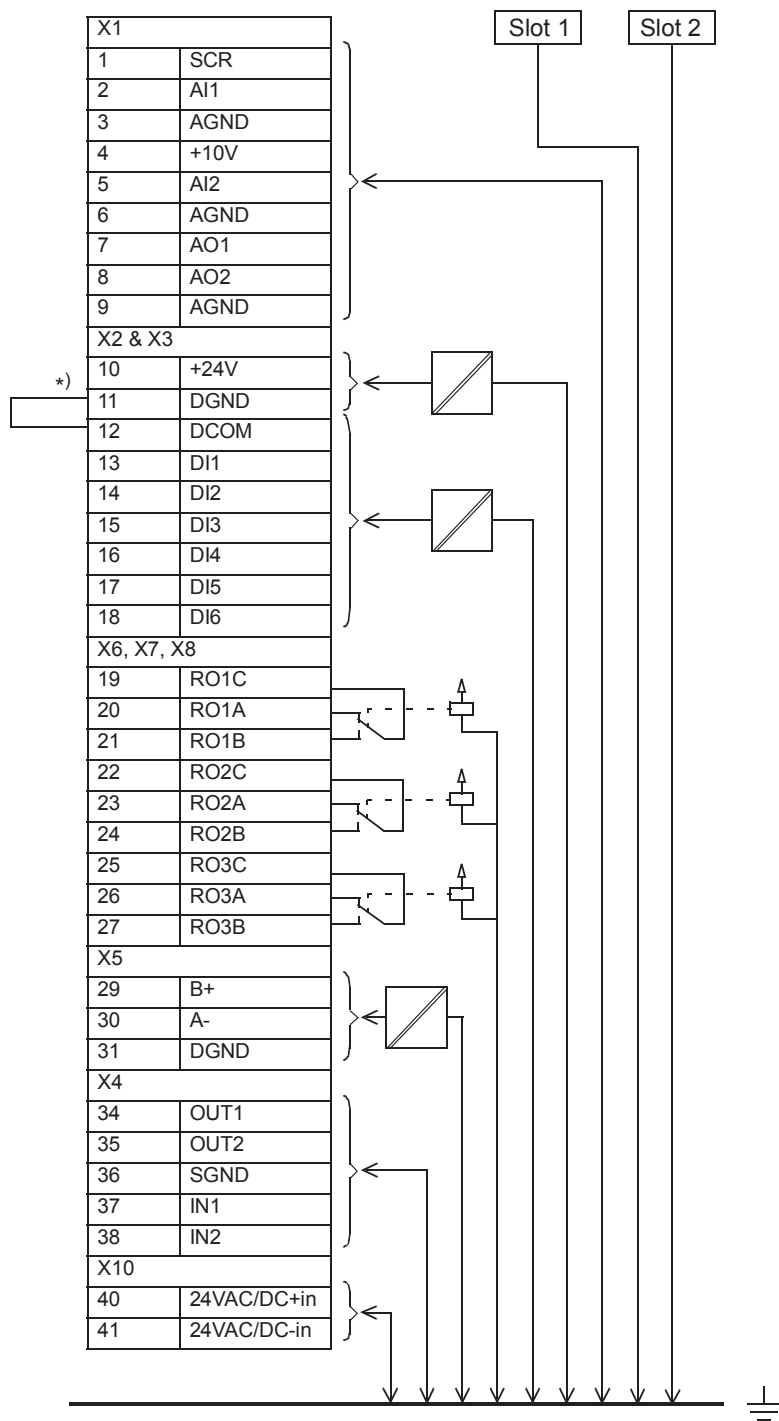
Maximum power: 36 W, 1.50 A at 24 V AC/DC $\pm 10\%$ as standard
Terminal size: 0.14 ... 2.5 mm² (26 ... 14 AWG)

+24 V DC output (Term. 10)	Total load capacity of this output 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 mm ² (26 ... 14 AWG)
Digital inputs DI1...DI6 (Term. 13...18)	Input type: NPN/PNP Terminal size: 0.14 ... 2.5 mm² (26 ... 14 AWG) <u>DI1...DI4 (Term. 13...16)</u> 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 <u>DI5 (Term.17)</u> 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) <u>DI6 (Term.18)</u> 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 mm ² (26 ... 14 AWG) Refer section Isolation areas (page 123) .
Analog inputs AI1 and AI2 (Term. 2 and 5)	Current/voltage input mode selected with a parameter, refer Connecting motor temperature sensors to the drive (page 114). 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 $\pm 1\%$, max. $\pm 1.5\%$ of full scale Inaccuracy for Pt100 sensors: 10 °C
Analog outputs AO1 and AO2 (Term. 7 and 8)	Current/voltage output mode for AO1 selected with a parameter, refer Connection for obtaining 0...10 V from analog output 2 (AO2) (page 116). 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: $\pm 1\%$ of full scale (in voltage and current modes)
Reference voltage output for analog inputs +10V DC (Term. 4)	Max. 20 mA output Inaccuracy: $\pm 1\%$
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 mm² (26 ... 14 AWG)

Embedded fieldbus (X5)	Connector pitch 5 mm, maximum wire size 2.5 mm² (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
Control panel - PC connection	USB Type Mini-B, max. cable length 2 m
Isolation areas	SLOT 1 1...3 AI1 4...6 AI2 7...8 AO 10...12 24 V GND 13...15 DI 16...18 DI 34...38 STO SLOT 2 19...21 RO1 22...24 RO2 25...27 RO3 EFB EIA/R5-485 40, 41 Ext. 24 V 1 Panel port 2 Power unit connection at the bottom of the control unit Reinforced insulation (IEC/EN 61800-5-1:2007) Functional insulation (IEC/EN 61800-5-1:2007) 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.

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Ground isolation diagram



8

Installation checklist

Contents of this chapter

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

Checklist



⚠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 electrical installation, commissioning or maintenance work.



⚠WARNING Do the steps in [Electrical safety precautions \(page 16\)](#) before you start the work.

Examine the mechanical and electrical installation of the drive before start-up. Do the tasks in the checklist together with a second person.

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. Refer to 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 attached securely to an even, vertical, and non-flammable surface.	☐
The cooling air can flow freely in and out of the drive.	☐

126 Installation checklist

Make sure that ...	☒
<u>If the drive is connected to a network other than a symmetrically grounded TN-S system:</u> You have done all the required modifications (for example, you may need to disconnect the EMC filter or ground-to-phase varistor). Refer to the electrical installation instructions.	☐
Appropriate AC fuses and main disconnecting device are installed.	☐
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 is measured according to the regulations.	☐
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.	☐
<u>If an external brake resistor is connected to the drive:</u> There is an adequately sized protective earth (ground) conductor between the brake resistor and the drive, and the conductor is connected to the correct terminal, and the terminals are tightened to the correct torque. Grounding has also been measured according to the regulations.	☐
<u>If an external brake resistor is connected to the drive:</u> The brake resistor cable is connected to the correct terminals, and the terminals are tightened to the correct torque.	☐
<u>If an external brake resistor is connected to the drive:</u> The brake resistor cable is routed away from other cables.	☐
The control cables are connected to the correct terminals, and the terminals are tightened to the correct torque.	☐
<u>If a drive bypass connection will be used:</u> 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.	☐
Drive covers and the terminal box cover of the motor are in place.	☐
The motor and the driven equipment are ready for power-up.	☐

9

Start-up

Contents of this chapter

This chapter describes the start-up procedure of the drive.

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 \[English\]\)](#).

Start-up procedure

1. Run setup of the drive control program according to the start-up instructions given in or in the firmware manual.
 - For drives with resistor braking: Refer chapter [Resistor braking \(page 185\)](#).
 - For SynRM motor drives: Set bit 2 of parameter 95.21 HW options word 2 to SynRM.
 - For sine filters: Refer [Sine filter hardware manual \(3AXD50000016814 \[English\]\)](#).
 2. Validate the Safe torque off function according to the instructions given in chapter [The Safe torque off function \(page 191\)](#).
-

10

Maintenance

Contents of this chapter

This chapter contains maintenance instructions.

Maintenance intervals

The tables below show the maintenance tasks which can be done by the end user. The complete maintenance schedule is available on the Internet (new.abb.com/drives/services/maintenance/preventive-maintenance). For more information, consult your local ABB Service representative (www.abb.com/searchchannels).

■ 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

Action	Description
P	Quality of supply voltage
I	Spare parts
P	Capacitor reforming for spare modules and spare capacitors, refer Capacitors (page 138)
I	Tightness of terminals
I	Dustiness, corrosion or temperature
P	Heatsink cleaning, see Cleaning the heatsink (page 131)

Component	Years from start-up						
	3	6	9	12	15	18	21
Cooling							
Fans, IP20 frames R1 to R9							
Main cooling fan R1...R4, R5 v2: page 133 , R5: page 135		R		R		R	
Main cooling fan (LONGLIFE) R6...R8: page 135 , R9: page 136			R			R	
Auxiliary cooling fan for circuit boards R4 v2, R5 v2 IP20 drive types 077A-4 and 089A-4, R5 v2: page 138		R		R		R	
Auxiliary cooling fan (LONGLIFE) for circuit boards, R5: page 138 , R6...R9: page 137			R			R	
Aging							
Control panel battery: page 139			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:

- Maintenance and component replacement intervals are based on the assumption that the equipment is operated 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. For additional maintenance recommendations, contact ABB.

Cleaning the exterior



⚠ 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 electrical installation, commissioning or maintenance work.

1. Stop the drive and do the steps in [Electrical safety precautions \(page 16\)](#) before you start the work.
2. Clean the exterior. 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).

NOTICE Do not use too much water, a hose, or steam to clean the drive. Moisture can go into the drive and cause damage.

Cleaning the heatsink

The heatsink of the power module (drive, supply, inverter, converter, and so on) collects dust from the cooling air. This can cause overtemperature warnings and faults. When it is necessary, clean the heatsink as follows.



⚠ 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 electrical installation, commissioning or maintenance work.



⚠ CAUTION Use the required personal protective equipment. Wear protective gloves and long sleeves. Some parts have sharp edges.

1. Stop the drive and do the steps in [Electrical safety precautions \(page 16\)](#) before you start the work.
2. Remove the module cooling fan(s). Refer to the separate instructions.
3. Protect the adjacent equipment from dust.
4. Blow dry, clean, and oil-free compressed air from the bottom to the top, and simultaneously use a vacuum cleaner at the air outlet to collect the dust.

NOTICE Use an antistatic wrist strap and a vacuum cleaner with an antistatic hose and nozzle. A normal vacuum cleaner creates static discharges which can cause damage to circuit boards.

5. Install the cooling fan.

Fans

Refer [Maintenance intervals \(page 129\)](#) for the fan replacement interval in average operation conditions.

Parameter 05.04 Fan on-time counter indicates the running time of the cooling fan. Reset the counter after a fan replacement. Refer the firmware manual.

In a speed-controlled fan, the speed of the fan matches the cooling needs. This increases the life span of the fan.

Main fans are speed controlled. When the drive is stopped, the main fan runs at low speed until the drive cools down. IP20 frames R5...R9 have auxiliary fans that are not speed controlled and run all the time when the control unit is powered.

Replacement fans are available from the manufacturer. Do not use other than specified spare parts.

■ Replacing the main cooling fan, IP20 frames R1...R4



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

1. Stop the drive and disconnect it from the power line. Wait for five minutes and then make sure by measuring that there is no voltage. Refer section [Electrical safety precautions \(page 16\)](#) before you start the work.

Frames R1...R3

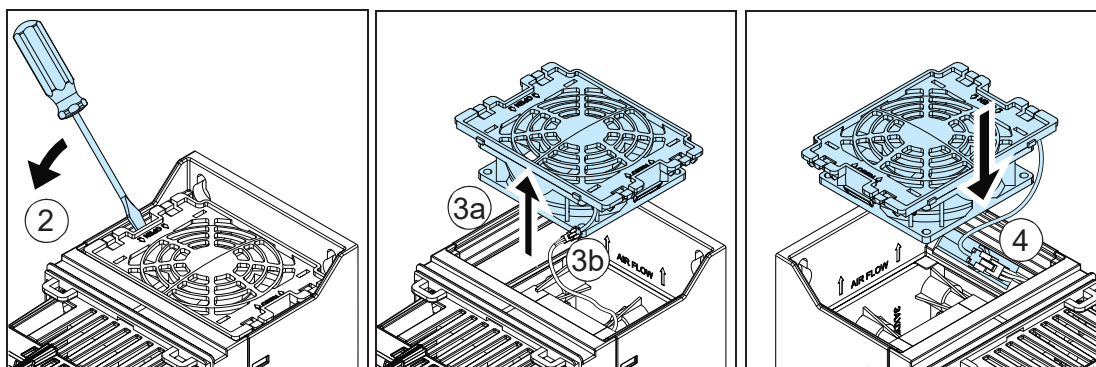
2. Lever the fan assembly off the drive frame with for example a screwdriver (2a) and pull out the fan assembly (2b) until you can unplug the fan power supply wires from the fan assembly (2c).

3. Install the fan assembly in reverse order.

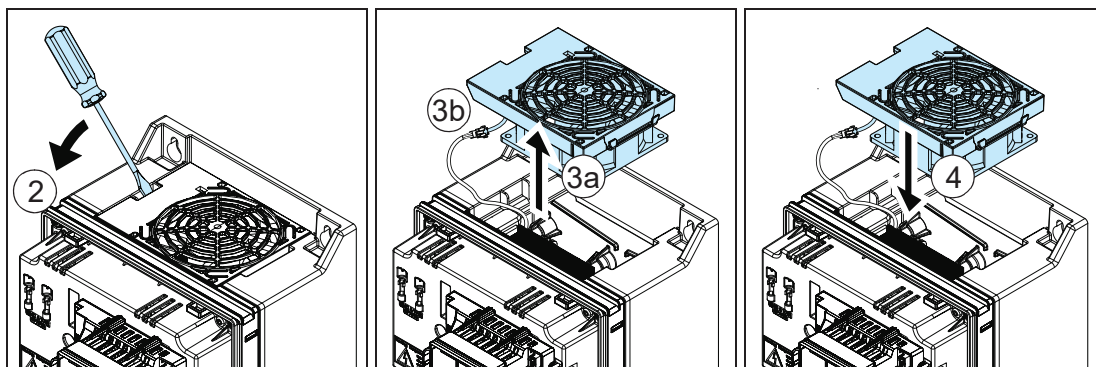
Frames R1 and R2: Put the connector and extra length of wires in the groove so that the wires do not get caught in the revolving fan.

Frame R3: Put the extra length of wires under the fan assembly so that the wires do not get caught in the revolving fan.

Frames R1 and R2



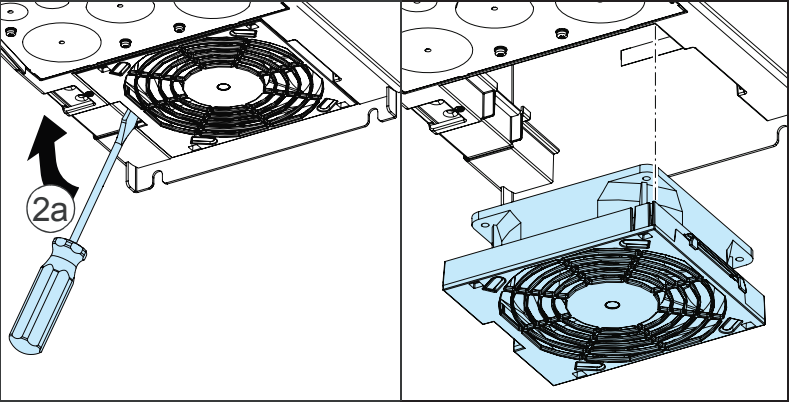
Frame R3



R4

1. Lever the fan assembly off the drive frame with for example a screwdriver (2a) and pull out the fan assembly (2b).
2. Install the fan assembly in reverse order.

R4

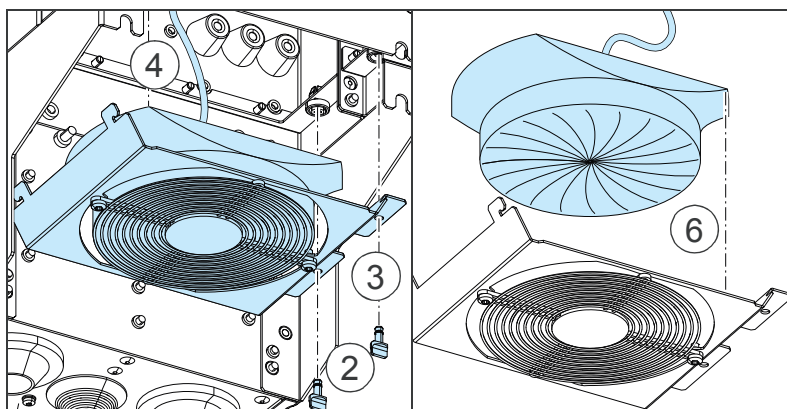


■ Replacing the main cooling fan, IP20 frames R5...R8

**⚠ WARNING**

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

1. Stop the drive and disconnect it from the power line. Wait for five minutes and then make sure by measuring that there is no voltage. Refer section [Electrical safety precautions \(page 16\)](#) before you start the work.
2. Remove the two mounting screws of the fan mounting plate at the bottom of the drive.
3. Pull the fan mounting plate down from the side edge.
4. Unplug the fan power supply wires from the drive.
5. Lift the fan mounting plate off.
6. Remove the fan from the mounting plate.
7. Install the new fan in reverse order.

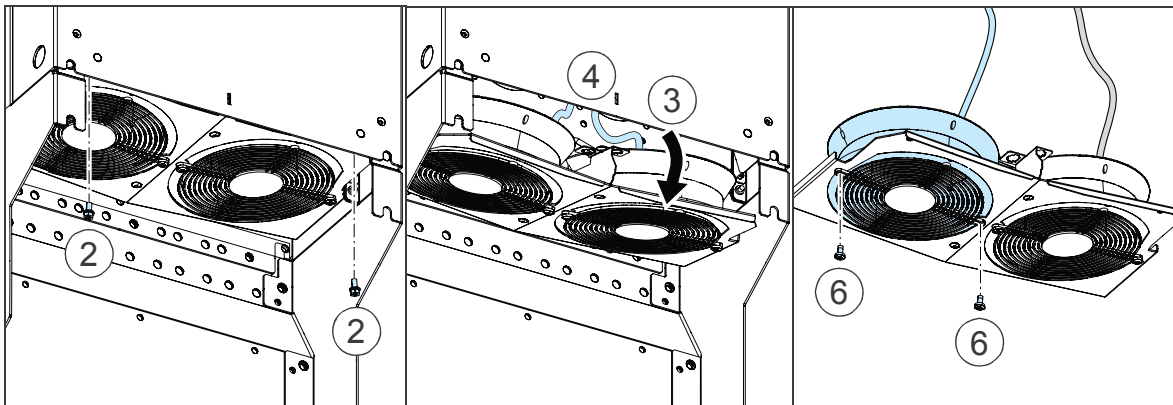


■ Replacing the main cooling fans, IP20 frame R9



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

1. Stop the drive and disconnect it from the power line. Wait for five minutes and then make sure by measuring that there is no voltage. Refer section [Electrical safety precautions \(page 16\)](#) before you start the work.
2. Remove the two mounting screws of the fan mounting plate.
3. Turn the mounting plate downwards.
4. Unplug the fan power supply wires from the drive.
5. Remove the fan mounting plate.
6. Remove the fans by removing the two mounting screws.
7. Install the new fans in reverse order.



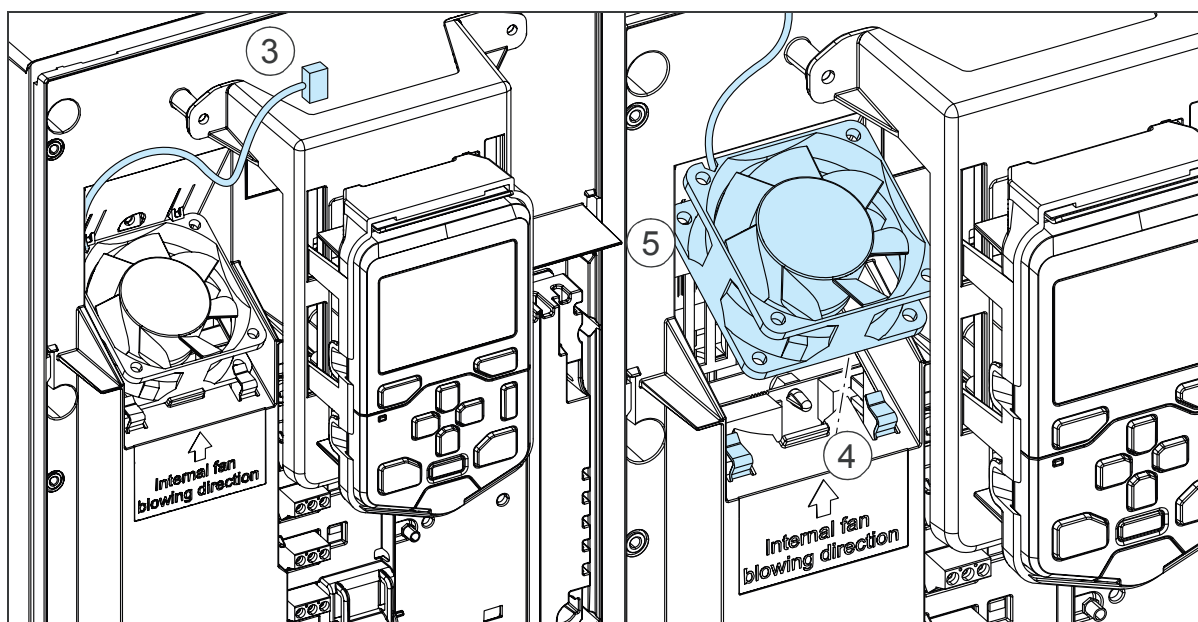
■ Replacing the auxiliary cooling fan, IP20 frames R6...R9



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

1. Stop the drive and disconnect it from the power line. Wait for five minutes and then make sure by measuring that there is no voltage. Refer section [Electrical safety precautions \(page 16\)](#) before you start the work.
2. Remove the front cover. Refer section [Installing the drive vertically, frames R6...R9 \(page 53\)](#).
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.



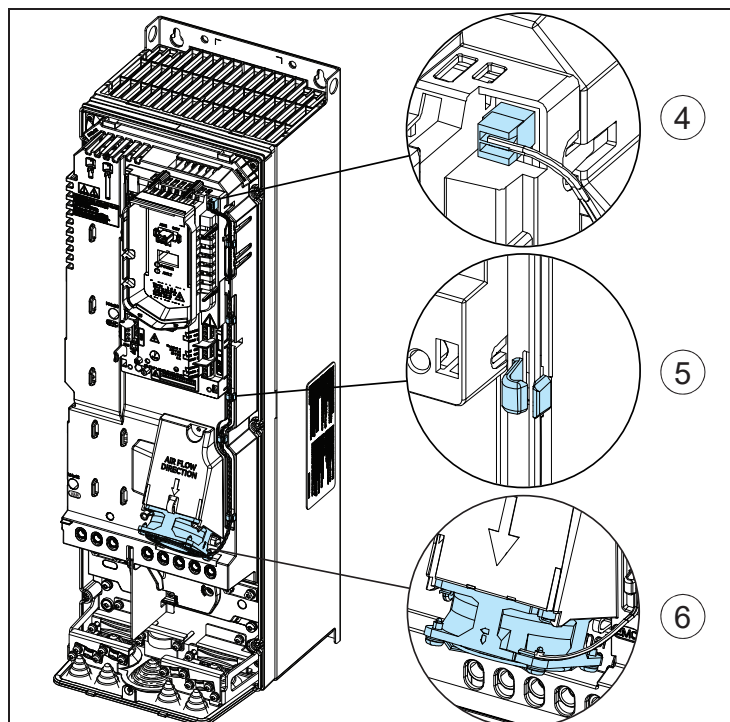
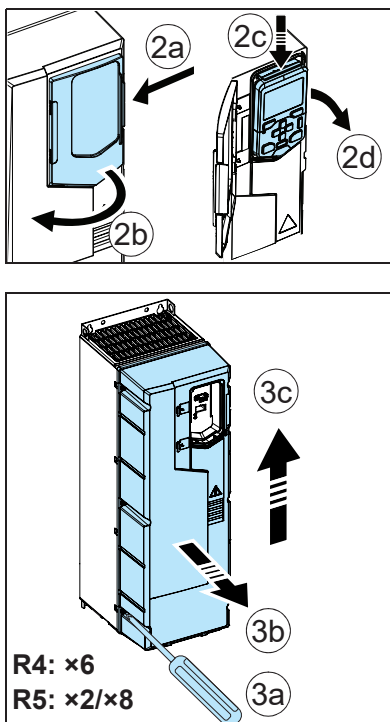
■ Replacing the auxiliary cooling fan, IP20 frame R5



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

1. Stop the drive and disconnect it from the power line. Wait for five minutes and then make sure by measuring that there is no voltage. Refer section [Electrical safety precautions \(page 16\)](#) before you start the work.
2. Remove the control panel: Press the retaining clip of the IP20 panel cover (2a) and open the cover (2b). Press the retaining clip of the control panel at the top (2c) and pull it forward from the top edge (2d).
3. Remove the front cover: Loosen the retaining screws (frame R4: 6 pieces, and frame R5: IP20 2 pieces) with a screwdriver (3a) and lift the cover from the bottom outwards (3b) and then up (3c).
4. Unplug the fan power supply wires from the drive.
5. Detach the fan cable from the clips.
6. Pull the fan off.
7. Install the new fan in reverse order.

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



Capacitors

The intermediate DC circuit of the drive contains several electrolytic capacitors. The operating time, load, and surrounding air temperature have an effect on the operating life of these capacitors. A lower ambient temperature can increase the operating life of capacitors.

Capacitor failure can cause damage to the unit, 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

Reform the capacitors if the drive was not powered for a year or more (is in storage or is unused). Read the manufacturing date from the type designation label. For the instructions, refer to [Capacitor reforming instructions \(3BFE64059629 \[English\]\)](#).

Control panel

Refer to:

- [ACS-AP-I, -S, -W Assistant control panels user's manual \(3AUA0000085685 \[English\]\)](#)
 - [ACS-BP-S basic control panels user's manual \(3AXD50000032527 \[English\]\)](#).
-

LEDs

■ Drive LEDs

There is a green POWER and a red FAULT LED on the front of the drive. They are visible through the panel cover but invisible if a control panel is attached to the drive. The table below describes the drive LED indications.

Drive LEDs POWER and FAULT, on the front of the drive, under the control panel / panel cover If a control panel is attached to the drive, switch to remote control (otherwise a fault will be generated), and then remove the panel to be able to see the LEDs				
LEDs off	LED lit and steady		LED blinking	
No power	Green (POWER)	Power supply on the board OK	Green (POWER)	<u>Blinking:</u> Drive in an alarm state <u>Blinking for one second:</u> Drive selected on the control panel when multiple drives are connected to the same panel bus.
	Red (FAULT)	Active fault in the drive. To reset the fault, press RESET from the control panel or switch off the drive power.	Red (FAULT)	Active fault in the drive. To reset the fault, switch off the drive power.

■ Control panel LEDs

The control panel has one LED. The table below describes the control panel LED indications. For more information refer *ACS-AP-I, -S, -W and ACH-AP-H, -W Assistant control panels user's manual* (3AUA0000085685 [English]).

Control panel LED, at the left edge of the control panel				
LED off	LED lit and steady		LED blinking/flickering	
Panel has no power	Green	Drive functioning normally. Connection between the drive and control panel may be faulty or lost, or the panel and drive may be incompatible. Check the control panel display.	Green	<u>Blinking:</u> Active warning in the drive <u>Flickering:</u> Data transferred between the PC tool and drive through the USB connection of the control panel
	Red	Check the display to see where the fault is. - Active fault in the drive. Reset the fault. - Active fault in another drive in the panel bus. Switch to the drive in question and check and reset the fault.	Red	Active fault in the drive. To reset the fault, cycle the drive power.
			Blue	Panels with a Bluetooth interface only. <u>Blinking:</u> Bluetooth interface is enabled. It is in discoverable mode and ready for pairing. <u>Flickering:</u> Data is transferred through the Bluetooth interface of the control panel.

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.

For more information, contact ABB.

11

Technical data

Contents of this chapter

This chapter contains the technical specifications of the drive including the ratings, sizes and technical requirements, provisions for fulfilling the requirements for CE and other approval marks.

Ratings

■ IEC

Type ACH531- 01-	Frame size	Input rat- ing	Output ratings						
			Max. cur- rent	Nominal use		Light-duty use		Heavy-duty use	
		I_1	$I_{\max}$	I_2	P_n	I_{Ld}	P_{Ld}	I_{Hd}	P_{Hd}
		A	A	A	kW	A	kW	A	kW
3-phase $U_n = 400\text{ V}$ (380...415 V)									
02A7-4	R1	2.6	3.2	2.6	0.75	2.5	0.75	1.8	0.55
03A4-4	R1	3.3	4.7	3.3	1.1	3.1	1.1	2.6	0.75
04A1-4	R1	4.0	5.9	4.0	1.5	3.8	1.5	3.3	1.1
05A7-4	R1	5.6	7.2	5.6	2.2	5.3	2.2	4.0	1.5
07A3-4	R1	7.2	10.1	7.2	3.0	6.8	3.0	5.6	2.2
09A5-4	R1	9.4	13.0	9.4	4.0	8.9	4.0	7.2	3.0
12A7-4	R1	12.6	15.3	12.6	5.5	12.0	5.5	9.4	4.0
018A-4	R2	17.0	22.7	17.0	7.5	16.2	7.5	12.6	5.5
026A-4	R2	25.0	30.6	25.0	11.0	23.8	11.0	17.0	7.5
033A-4	R3	32.0	44.3	32.0	15.0	30.4	15.0	24.6	11.0
039A-4	R3	38.0	56.9	38.0	18.5	36.1	18.5	31.6	15.0

Type ACH531- 01-	Frame size	Input rat- ing	Output ratings						
			Max. cur- rent	Nominal use		Light-duty use		Heavy-duty use	
		I_1	$I_{\max}$	I_2	P_n	I_{Ld}	P_{Ld}	I_{Hd}	P_{Hd}
		A	A	A	kW	A	kW	A	kW
046A-4	R3	45.0	67.9	45.0	22.0	42.8	22.0	37.7	18.5
062A-4	R4	62	81	62	30	58	30	45	22
073A-4	R4 v2	73	110	73	37	68	37	61	30
089A-4	R4 v2	89	130	89	45	83	45	72	37
106A-4	R5	106	157	106	55	100	55	72	37
145A-4	R6	145	178	145	75	138	75	87	45
169A-4	R7	169	247	169	90	161	90	145	75
206A-4	R7	206	287	206	110	196	110	169	90
246A-4	R8	246	350	246	132	234	132	206	110
293A-4	R8	293	418	293	160	278	160	246 ¹⁾	132
363A-4	R9	363	498	363	200	345	200	293	160
430A-4	R9	430	545	430	250	400	200	363 ²⁾	200
490A-4	R9	450	600	490	250	480 ^{*)}	250	385 ³⁾	200

¹⁾ Continuous current, no overloadability

Refer definitions and notes in section [Definitions \(page 144\)](#)

Definitions

U_n	Nominal output voltage of the drive. For input voltage range [U_1 , refer section Electrical power network specification (page 162) . 50 Hz for IEC ratings.
I_1	Nominal input current. Continuous rms input current (for dimensioning cables and fuses).
$I_{\max}$	Maximum output current. Available for two seconds at start.
I_2	Nominal output current. Maximum continuous rms output current allowed (no overload).
P_n	Nominal power of the drive. Typical motor power (no overload). The kilowatt ratings apply to most IEC 4-pole motors.
I_{Ld}	Continuous rms output current. Allows 10% overload for 1 minute every 10 minutes.
P_{Ld}	Typical motor power in light-duty use (10% overload).

■ 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 for I_2 . Above theses temperatures derating is required.

Note: The DriveSize dimensioning PC tool available from ABB (<http://new.abb.com/drives/software-tools/drivesize>) is recommended for selecting the drive, motor and gear combination.

■ Derating

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) = (I_2 or I_{Ld}) 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 1, IEC: How to calculate the derated current

The IP21 / UL Type 1 drive type is ACH531-01-062A-4, which has drive output current of 62 A. Calculate the derated drive output current (I_2) at 4 kHz switching frequency, at 1500 m altitude and at 50 °C ambient temperature as follows:

1. [Switching frequency derating by derating factor \(page 149\)](#):
No derating needed for 4 kHz.
2. [Altitude derating \(page 148\)](#):
The derating factor for 1500 m is $1 - 1/10\,000\text{ m} \cdot (1500 - 1000)\text{ m} = 0.95$.
The derated drive output current becomes $I_2 = 0.95 \cdot 62\text{ A} = 58.9\text{ A}$.
3. [Surrounding air temperature derating, IP21 \(UL Type 1\) \(page 146\)](#):
The derating factor for 50 °C ambient temperature = 0.90.
The derated drive output current becomes then $I_2 = 0.90 \cdot 58.9\text{ A} = 53.01\text{ A}$.

Example 1, UL (NEC): How to calculate the derated current

The IP21 / UL Type 1 drive type is ACH531-01-052A-4, which has drive output current of 52 A. Calculate the derated drive output current (I_{Ld}) at 4kHz switching frequency, at 4921 ft (1500 m) altitude and at 50 °C ambient temperature as follows:

1. [Switching frequency derating by derating factor \(page 149\)](#):
No derating needed for 4 kHz.
2. [Altitude derating \(page 148\)](#):
The derating factor for 4921 ft (1500 m) is $1 - 1/10\,000\text{ m} \cdot (1500 - 1000)\text{ m} = 0.95$.
The derated drive output current becomes $I_{Ld} = 0.95 \cdot 52\text{ A} = 49.4\text{ A}$.
3. [Surrounding air temperature derating, IP21 \(UL Type 1\) \(page 146\)](#):
The derating factor for 50 °C ambient temperature = 0.90.
The derated drive output current becomes then $I_{Ld} = 0.90 \cdot 49.4\text{ A} = 44.46\text{ A}$.

Example 2, IEC: How to calculate the required drive

If your application requires continuous 12.0 A of motor current (I_2) at 8 kHz switching frequency, the supply voltage is 400 V and the drive is situated at 1500 m altitude and

at 35 °C ambient temperature, calculate the appropriate IP21 / (UL Type 1) drive size requirement as follows:

1. [Switching frequency derating by derating factor \(page 149\)](#):
The minimum size required is $I_2 = 12.0 \text{ A} / 0.65 = 18.46 \text{ A}$,
where 0.65 is the derating for 8 kHz switching frequency (frames R2...R3).
2. [Altitude derating \(page 148\)](#):
The derating factor for 1500 m is $1 - 1/10\,000 \text{ m} \cdot (1500 - 1000) \text{ m} = 0.95$.
The minimum size required becomes then $I_2 = 18.46 \text{ A} / 0.95 = 19.43 \text{ A}$.
3. [Surrounding air temperature derating, IP21 \(UL Type 1\) \(page 146\)](#):
No derating needed for 35 °C ambient temperature.

Referring to I_2 in the ratings tables (starting from page 143), drive type ACH531-01-026A-4 exceeds the I_2 requirement of 19.43 A.

Example 2, UL (NEC): How to calculate the required drive

If your application requires continuous maximum current with 10% overload 12.0 A of motor current (I_{Ld}) at 8 kHz switching frequency, the supply voltage is 480 V and the drive is situated at 4921 ft (1500 m) altitude and at 35 °C ambient temperature, calculate the appropriate IP21 / UL Type 1 drive size requirement as follows:

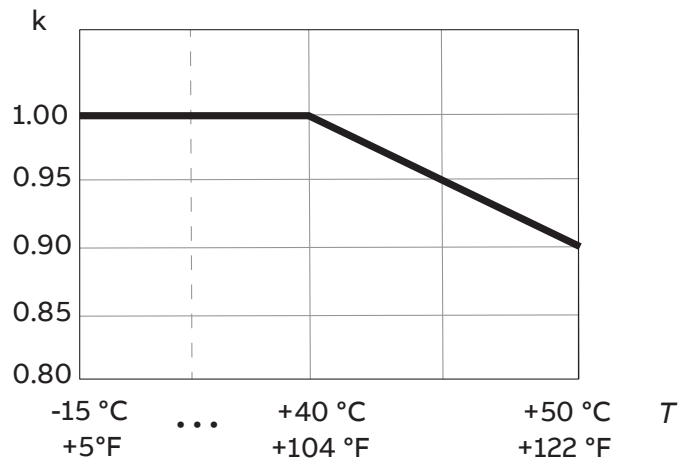
1. [Switching frequency derating by derating factor \(page 149\)](#):
The minimum size required is $I_{Ld} = 12.0 \text{ A} / 0.65 = 18.46 \text{ A}$,
where 0.65 is the derating for 8 kHz switching frequency (frames R2...R3).
2. [Altitude derating \(page 148\)](#):
The derating factor for 4921 ft (1500 m) is $1 - 1/10\,000 \text{ m} \cdot (1500 - 1000) \text{ m} = 0.95$.
The minimum size required becomes then $I_{Ld} = 18.46 \text{ A} / 0.95 = 19.43 \text{ A}$.
3. [Surrounding air temperature derating, IP21 \(UL Type 1\) \(page 146\)](#):
No derating needed for 35 °C ambient temperature.

Referring to I_{LD} in the ratings tables (starting from page 143), drive type ACH531-01-026A-4 exceeds the I_{Ld} requirement of 19.43 A.

Surrounding air temperature derating, IP21 (UL Type 1)

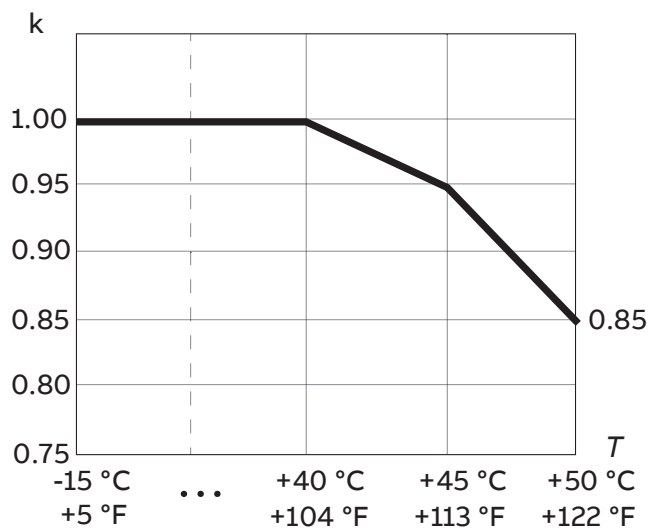
IP21 (UL Type 1) drive types, other than the exceptions below

In the temperature range +40...50 °C (+104...122 °F), the rated output current is derated by 1% for every added 1 °C (1.8 °F). The output current can be calculated by multiplying the current given in the rating table by the derating factor (k, in the diagram below).

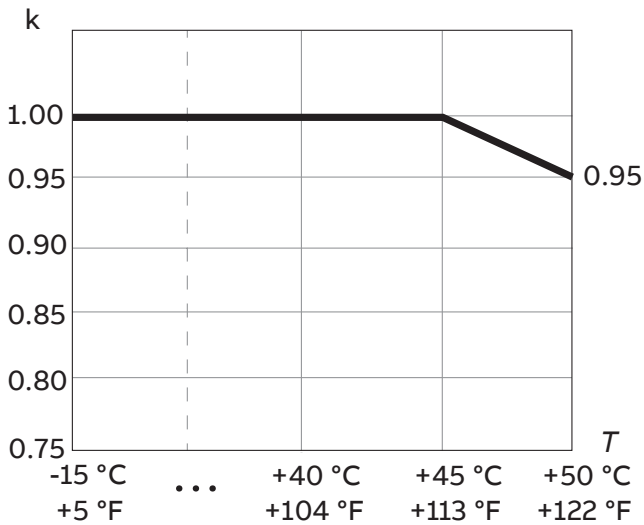


IP21 (UL Type 1) drive type -078A-4; -099A-6, -125A-6, -144A-6

-078A-4: In the temperature range +40...45 °C (+104...113 °F), the rated output current is derated by 1% for every added 1 °C (1.8 °F). In the temperature range +45...50 °C (+113...122 °F), the rated output current is derated by 2% for every added 1 °C (1.8 °F). The output current can be calculated by multiplying the current given in the rating table by the derating factor (k):



-099A-6, -125A-6, -144A-6: In the temperature range +40...45 °C (+104...113 °F), the rated output current is not derated at all. In the temperature range +45...50 °C (+113...122 °F), the rated output current is derated by 1% for every added 1 °C (1.8 °F). The output current can be calculated by multiplying the current given in the rating table by the derating factor (k):



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 ($1000 \text{ m} \leq x \leq 4000 \text{ m}$) is:

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

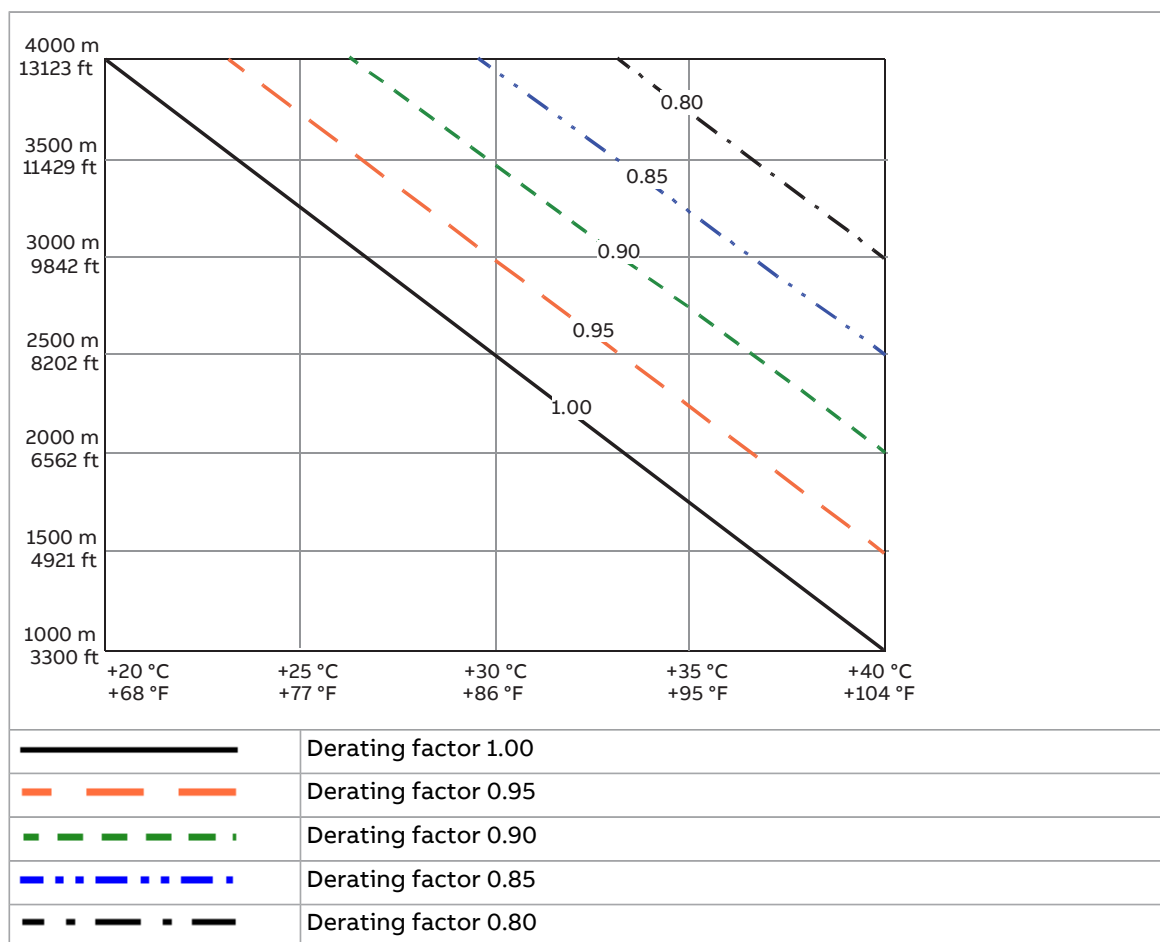
Altitude and surrounding air temperature

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 $1 - 1.5\% \cdot 10 = 0.85$.

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



Note: Check the supply network compatibility restrictions above 2000 m (6562 ft), see [Installation site altitude \(page 168\)](#). Check also PELV limitation on relay output terminals above 2000 m (6562 ft), see sections [Isolation areas \(page 120\)](#) for frames R1...R5 and [Isolation areas \(page 123\)](#) 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	ACH531-01-...	Derating factor (k) for the switching frequencies at 40 °C (+104 °F)											
		1.5 kHz	2 kHz	3 kHz	4 kHz	5 kHz	6 kHz	7 kHz	8 kHz	9 kHz	10 kHz	11 kHz	12 kHz
3-phase U_n = 400 V													
R1	02A7-4...12A7-4	N/A	1	1	1	0.90	0.83	0.74	0.67	0.62	0.58	0.53	0.50
R2	018A-4...026A-4	N/A	1	1	1	0.90	0.82	0.73	0.65	0.60	0.56	0.51	0.48
R3	033A-4...046A-4	N/A	1	1	1	0.90	0.82	0.73	0.65	0.60	0.56	0.51	0.48
R4	062A-4	N/A	1	1	1	0.94	0.90	0.85	0.82	0.76	0.72	0.67	0.64
R4 v2	062A-4	N/A	1	1	1	0.90	0.82	0.73	0.65	0.60	0.56	0.51	0.48
R4	073A-4	N/A	1	1	1	0.92	0.86	0.79	0.73	0.67	0.63	0.59	0.55
R4 v2	073A-4...089A-4	N/A	1	1	1	0.90	0.82	0.73	0.65	0.60	0.55	0.51	0.47

Frame size	ACH531-01-...	Derating factor (k) for the switching frequencies at 40 °C (+104 °F)											
		1.5 kHz	2 kHz	3 kHz	4 kHz	5 kHz	6 kHz	7 kHz	8 kHz	9 kHz	10 kHz	11 kHz	12 kHz
R5	106A-4	N/A	1	1	1	0.91	0.85	0.77	0.69	0.67	0.63	0.60	0.53
R6	145A-4	1	0.97	0.91	0.84	0.78	0.74	0.69	0.66	0.62	0.58	0.55	0.52
R7	169A-4...206A-4	1	0.98	0.94	0.89	0.83	0.79	0.74	0.71	0.66	0.61	0.57	0.53
R8	246A-4...293A-4	1	0.96	0.89	0.82	0.76	0.71	0.65	0.61	0.56	0.52	0.48	0.45
R9	363A-4...430A-4	1	0.95	0.87	0.79	0.73	0.68	0.62	0.58	0.53	0.50	0.46	0.43
R9	490A-4	1	0.97	0.92	0.87	0.83	0.80	0.75	0.71	0.66	0.61	0.58	0.54

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	ACH531-01-....	Nominalout-put	Nominal output current (I_2) for the minimum switching frequencies at 40 °C				
		I_2	1 kHz	2kHz	4kHz	8 kHz	12 kHz
3-phase U_n = 400 V							
R1	02A7-4	2.6	2.6	2.6	2.6	1.7	1.3
R1	03A4-4	3.3	3.3	3.3	3.3	2.2	1.7
R1	04A1-4	4.0	4.0	4.0	4.0	2.7	2.0
R1	05A7-4	5.6	5.6	5.6	5.6	3.8	2.8
R1	07A3-4	7.2	7.2	7.2	7.2	4.8	3.6
R1	09A5-4	9.4	9.4	9.4	9.4	6.3	4.7
R1	12A7-4	12.6	12.6	12.6	12.6	8.4	6.3
R2	018A-4	17.0	17.0	17.0	17.0	11.1	8.2
R2	026A-4	25.0	25.0	25.0	25.0	16.3	12.0
R3	033A-4	32.0	32.0	32.0	32.0	20.8	15.4
R3	039A-4	38.0	38.0	38.0	38.0	24.7	18.2
R3	046A-4	45.0	45.0	45.0	45.0	29.3	21.6
R4	062A-4	62	62	62	62	51	39.7
R4 v2	062A-4	62	62	62	62	40.1	29.7
R4	073A-4	73	73	73	73	53	40.2
R4 v2	073A-4	73	73	73	73	47.2	34.6
R4 v2	089A-4	89	89	89	89	58	41.9
R5	106A-4	106	106	106	106	75	60
R6	145A-4	145	145	141	122	96	75
R7	169A-4	169	169	166	150	120	90
R7	206A-4	206	206	202	183	146	109
R8	246A-4	246	246	236	202	150	111
R8	293A-4	293	293	281	240	179	132
R9	363A-4	363	363	345	287	211	156
R9	430A-4	430	430	409	340	249	185
R9	490A-4	490	450	409	340	249	185

Output frequency derating

Output frequency derating applies for ratings up to ACH531-01-106A-4 (R5). Inverter output current is limited by the following factor k below 5 Hz absolute inverter output frequency f_{abs} .

$$k = 2/3 + 1/3 \cdot (f_{abs} / 5 \text{ Hz})$$

Fuses (IEC)

gG as well as uR or aR fuses for protection against short-circuit in the input power cable or drive are listed below. Either fuse type can be used for frames R1...R6 if it operates rapidly enough. The operating time depends on the supply network impedance and the cross-sectional area and length of the supply cable.

Note 1: Refer also [Implementing short-circuit and thermal overload protection \(page 67\)](#).

Note 2: Fuses with higher current rating than the recommended ones must not be used.

Note 3: 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.

■ gG fuses

Check on the fuse time-current curve to ensure the operating time of the fuse is below 0.5 seconds. Obey the local regulations.

Type ACH531- 01-	Frame size	Min. short-circuit current ¹⁾	Input current	gG (IEC 60269)				
				Nominal current	<i>I</i> ² <i>t</i>	Voltage rating	ABB type	IEC 60269 size
		A	A	A	A ² s	V		
3-phase <i>U</i> _n = 400 V								
02A7-4	R1	32	2.6	4	55	500	OFAF000H4	000
03A4-4	R1	48	3.3	6	110	500	OFAF000H6	000
04A1-4	R1	48	4.0	6	110	500	OFAF000H6	000
05A7-4	R1	80	5.6	10	360	500	OFAF000H10	000
07A3-4	R1	80	7.2	10	360	500	OFAF000H10	000
09A5-4	R1	128	9.4	16	740	500	OFAF000H16	000
12A7-4	R1	128	12.6	16	740	500	OFAF000H16	000
018A-4	R2	200	17.0	25	2500	500	OFAF000H25	000
026A-4	R2	256	25.0	32	4000	500	OFAF000H32	000
033A-4	R3	320	32.0	40	7700	500	OFAF000H40	000
039A-4	R3	400	38.0	50	16000	500	OFAF000H50	000
046A-4	R3	500	45.0	63	20100	500	OFAF000H63	000
062A-4	R4	800	62	80	37500	500	OFAF000H80	000
073A-4	R4 v2	1000	73	100	65000	500	OFAF000H100	000
089A-4	R4 v2	1000	89	100	65000	500	OFAF000H100	000
106A-4	R5	1300	106	125	103000	500	OFAF00H125	00
145A-4	R6	1700	145	160	185000	500	OFAF00H160	00
169A-4	R7	3300	169	250	600000	500	OFAF0H250	0
206A-4	R7	5500	206	315	710000	500	OFAF1H315	1
246A-4	R8	6400	246	355	920000	500	OFAF1H355	1
293A-4	R8	7800	293	425	1300000	500	OFAF2H425	2
363A-4	R9	9400	363	500	2000000	500	OFAF2H500	2

Type ACH531- 01-	Frame size	Min. short- circuit current ¹⁾	Input current	gG (IEC 60269)				
				Nominal current	I_t	Voltage rating	ABB type	IEC 60269 size
				A	A ² s	V		
430A-4	R9	10200	430	630	2800000	500	OFAF3H630	3
490A-4	R9	10200	450	630	2800000	500	OFAF3H630	3

¹⁾ Minimum short-circuit current of the installation

■ uR and aR fuses

Type ACH531- 01-	Frame size	Min. short- circuit current ¹⁾	Input current	uR or aR (DIN 43620 blade style)				
				Nominal current	I²t	Voltage rating	Bussmann type	IEC 60269 size
		A	A	A	A²s	V		
3-phase U _n = 400 V								
02A7-4	R1	65	2.6	25	130	690	170M1561	000
03A4-4	R1	65	3.3	25	130	690	170M1561	000
04A1-4	R1	65	4.0	25	130	690	170M1561	000
05A7-4	R1	65	5.6	25	130	690	170M1561	000
07A3-4	R1	65	7.2	25	130	690	170M1561	000
09A5-4	R1	65	9.4	25	130	690	170M1561	000
12A7-4	R1	65	12.6	25	130	690	170M1561	000
018A-4	R2	120	17.0	40	460	690	170M1563	000
026A-4	R2	120	25.0	40	460	690	170M1563	000
033A-4	R3	170	32.0	63	1450	690	170M1565	000
039A-4	R3	170	38.0	63	1450	690	170M1565	000
046A-4	R3	280	45.0	80	2550	690	170M1566	000
062A-4	R4	380	62	100	4650	690	170M1567	000
073A-4	R4 v2	480	73	125	8500	690	170M1568	000
089A-4	R4 v2	700	89	160	16000	690	170M1569	000
106A-4	R5	1280	106	315	46500	690	170M3817	1
145A-4	R6	1280	145	315	46500	690	170M3817	1
169A-4	R7	1800	169	450	105000	690	170M5809	2
206A-4	R7	2210	206	500	145000	690	170M5810	2
246A-4	R8	3010	246	630	275000	690	170M5812	2
293A-4	R8	4000	293	800	490000	690	170M6812D	3
363A-4	R9	5550	363	1000	985000	690	170M6814D	3
430A-4	R9	7800	430	1250	2150000	690	170M8554D	3
490A-4	R9	7800	450	1250	2150000	690	170M8554D	3

¹⁾ Minimum short-circuit current of the installation

Type ACH531- 01-	Frame size	Min. short- circuit current ¹⁾	Input current	uR or aR (DIN 43653 bolted tags)				
				Nominal current	<i>I</i> ² t	Voltage rating	Bussmann type	IEC 60269 size
		A	A	A	A ² s	V		
3-phase <i>U</i> _n = 400 V								
02A7-4	R1	65	2.6	25	130	690	170M1311	000
03A4-4	R1	65	3.3	25	130	690	170M1311	000
04A1-4	R1	65	4.0	25	130	690	170M1311	000
05A7-4	R1	65	5.6	25	130	690	170M1311	000
07A3-4	R1	65	7.2	25	130	690	170M1311	000
09A5-4	R1	65	9.4	25	130	690	170M1311	000
12A7-4	R1	65	12.6	25	130	690	170M1311	000
018A-4	R2	120	17.0	40	460	690	170M1313	000
026A-4	R2	120	25.0	40	460	690	170M1313	000
033A-4	R3	170	32.0	63	1450	690	170M1315	000
039A-4	R3	170	38.0	63	1450	690	170M1315	000
046A-4	R3	280	45.0	80	2550	690	170M1316	000
062A-4	R4	380	62	100	4650	690	170M1417	000
073A-4	R4 v2	480	73	125	8500	690	170M1318	000
089A-4	R4 v2	700	88	160	16000	690	170M1319	000
106A-4	R5	700	106	200	15000	690	170M3015	1
145A-4	R6	1000	145	250	28500	690	170M3016	1
169A-4	R7	1280	169	315	46500	690	170M3017	1
206A-4	R7	1520	206	350	68500	690	170M3018	1
246A-4	R8	3010	246	450	105000	690	170M5009	2
293A-4	R8	4000	293	500	145000	690	170M5010	2
363A-4	R9	5550	363	630	275000	690	170M5012	2
430A-4	R9	7800	430	700	405000	690	170M5013	2
490A-4	R9	7800	450	700	405000	690	170M5013	2

¹⁾ Minimum short-circuit current of the installation

Circuit breakers (IEC)

The protective characteristics of circuit breakers depend on the type, construction and settings of the breakers. There are also limitations pertaining to the short-circuit capacity of the supply network.



⚠ WARNING Pay special attention to the installation and placement of the breakers. Obey the instructions of the manufacturer. Hot ionized gases can escape from the breaker enclosure if there is a short circuit.

You can use the circuit breakers listed below. Other circuit breakers can be used with drive if they provide the same electrical characteristics. ABB does not assume any liability whatsoever for the correct function and protection with circuit breakers not

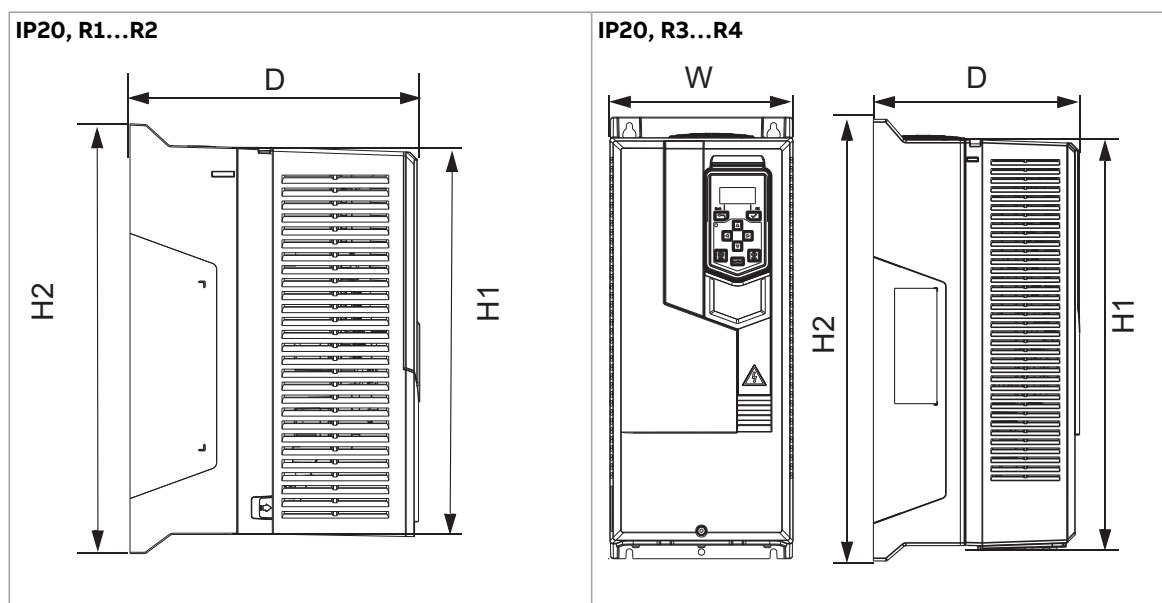
listed below. Furthermore, if the recommendations given by ABB are not obeyed, the drive can experience problems that the warranty does not cover.

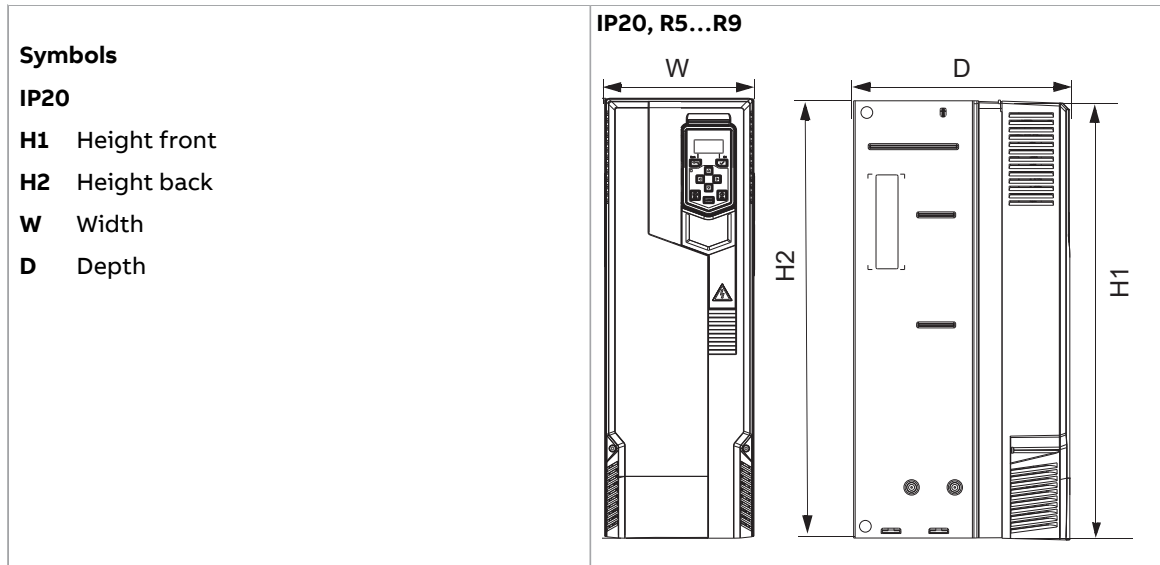
Type ACH531- 01-	Frame size	MCBs and MCCBs					
		ABB type	Max. short- circuit	Tmax frame XT / T class	Tmaxrat- ing	Electron- ic release	SACE ordering code for breaker and re- lease unit
			I_{sc}				
			kA				
3-phase $U_n = 400\text{ V}$							
02A7-4	R1	S 303P-B/C/Z 10	20	N/A	N/A	N/A	N/A
03A4-4	R1	S 303P-B/C/Z 10	20	N/A	N/A	N/A	N/A
04A1-4	R1	S 303P-B/C/Z 10	20	N/A	N/A	N/A	N/A
05A7-4	R1	S 303P-B/C/Z 10	20	N/A	N/A	N/A	N/A
07A3-4	R1	S 303P-B/C/Z 10	20	N/A	N/A	N/A	N/A
09A5-4	R1	S 303P-B/C/Z 10	20	N/A	N/A	N/A	N/A
12A7-4	R1	S 303P-B/C/Z 16	20	N/A	N/A	N/A	N/A
018A-4	R2	S 303P-B/C/Z 20	20	N/A	N/A	N/A	N/A
026A-4	R2	S 303P-B/C/Z 25	20	N/A	N/A	N/A	N/A
033A-4	R3	S 303P-B/C/Z 32	12	N/A	N/A	N/A	N/A
039A-4	R3	S 303P-B/C/Z 40	12	N/A	N/A	N/A	N/A
046A-4	R3	S 303P-B/C/Z 50	12	N/A	N/A	N/A	N/A
062A-4	R4	S 803S-B/C 80	50	N/A	N/A	N/A	N/A
073A-4	R4 v2	S 803S-B/C 80	50	N/A	N/A	N/A	N/A
089A-4	R4 v2	S 803S-B/C 100	50	N/A	N/A	N/A	N/A
106A-4	R5	S 803S-B/C 125	50	N/A	N/A	N/A	N/A
145A-4	R6	XT4 L 250 Ekip LS/I In=250 3p F F	65	XT4	250	250	1SDA068555R1
169A-4	R7	XT4 L 250 Ekip LS/I In=250 3p F F	65	XT4	250	250	1SDA068555R1
206A-4	R7	T4 L 320 PR221DS- LS/I In=320 3p F F	65	T4	320	320	1SDA054141R1
246A-4	R8	T5 L 400 PR221DS- LS/I In=400 3p F F	65	T5	400	400	1SDA054365R1
293A-4	R8	T5 L 630 PR221DS- LS/I In=630 3p F F	65	T5	630	630	1SDA054420R1
363A-4	R9	T5 L 630 PR221DS- LS/I In=630 3p F F	65	T5	630	630	1SDA054420R1
430A-4	R9	T5 L 630 PR221DS- LS/I In=630 3p F F	65	T5	630	630	1SDA054420R1
490A-4	R9	-	-	-	-	-	-

Dimensions, weights and free space requirements

Frame size	Dimensions and weights				
	IP20				
	H1*	H2*	W	D	Weight
	mm	mm	mm	mm	kg
R1	300	331	125	223	4
R2	393	432	125	229	6
R3	454	490	203	229	14.5
R4, R4 v2	600	636	203	257	18.5
R5	596	596	203	295	26.5
R6	549	548	252	369	42.6
R7	601	600	284	370	49.6
R8	677	680	300	393	62.8
R9	680	680	380	418	84.8

*Height without cable box.





Losses, cooling data and noise

The air flow direction is from bottom to top.

■ Cooling air flow, heat dissipation and noise for stand-alone drives

The table below specifies the heat dissipation in the main circuit at nominal load and in the control circuit with minimum load (I/O, options and panel not in use) and maximum load (all digital inputs and relays in the ON state, and the panel, fieldbus and fan in use). The total heat dissipation is the sum of the heat dissipation in the main and control circuits. Use the maximum heat dissipation when designing cabinet or electrical room cooling needs.

IEC

Type ACH531-01-	Frame size	Typical heat dissipation ¹⁾	Air flow	Noise
		W	m³/h	dB(A)
3-phase $U_n = 400\text{ V}$				
02A7-4	R1	44	43	59
03A4-4	R1	51	43	59
04A1-4	R1	60	43	59
05A7-4	R1	85	43	59
07A3-4	R1	98	43	59
09A5-4	R1	136	43	59
12A7-4	R1	213	43	59
018A-4	R2	240	101	64
026A-4	R2	383	101	64
033A-4	R3	492	179	76
039A-4	R3	523	179	76
046A-4	R3	672	179	76
062A-4	R4	873	134	69
062A-4	R4 v2	776	150	70

Type ACH531-01-	Frame size	Typical heat dissipation ¹⁾	Air flow	Noise
		W	m ³ /h	dB(A)
073A-4	R4	1120	134	69
073A-4	R4 v2	858	150	70
089A-4	R4 v2	1028	159	70
106A-4	R5	1290	139	63
145A-4	R6	1960	435	67
169A-4	R7	2021	450	67
206A-4	R7	2785	450	67
246A-4	R8	3131	550	65
293A-4	R8	4071	550	65
363A-4	R9	4834	1150	68
430A-4	R9	6072	1150	68
490A-4	R9	5831	1150	68

1) Typical drive losses when it operates at 90% of the motor nominal frequency and 100% of the drive nominal output current.

Terminal and lead-through data for the power cables

■ IEC

Input, motor, resistor and DC cable lead-throughs, maximum wire sizes (per phase) and terminal screw sizes and tightening torques (T) are given below.

Frame size	Cable lead-throughs		L1, L2, L3, T1/U, T2/V, T3/W terminals			Grounding terminals	
	Per cable type	Ø ¹⁾	Min wire size (solid/stranded) ²⁾	Max wire size (solid/stranded)	T	Max wire size	T
	pcs	mm	mm ²	mm ²	N·m	mm ²	N·m
3-phase $U_n = 400\text{ V}$							
R1	1	30	0.20/0.25	6/4	1.0	16/16	1.5
R2	1	30	0.5/0.5	16/16	1.5	16/16	1.5
R3	1	30	0.5/0.5	35/25	3.5	35/35	1.5
R4	1	45	0.5/0.5	50	4.0	35/35	2.9
R4 v2	1	45	1.5/1.5	70	5.5	35/35	2.9
R5	1	45	6	70	15	35/35 ³⁾	2.2
R6	1	45	25	150	30	185 ³⁾	9.8
R7	1	54	95	240	40	185 ³⁾	9.8
R8	2	45	2×50	2×150	40	2×185 ³⁾	9.8
R9	2	54	2×95	2×240	70	2×185 ³⁾	9.8

1) Maximum cable diameter accepted. For the lead-through plate hole diameters, refer chapter [Dimension drawings \(page 175\)](#).

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

3) **Note:** Either cable lug (R5, refer page [93](#)) or clamp (R6...R9, refer page [95](#))

Note: For the tightening torques of the grounding terminals, refer sections [Connection procedure, frames R1...R4 \(page 83\)](#), [Connection procedure, frame R5 \(page 89\)](#) and [Connection procedure, frames R6...R9 \(page 94\)](#).

Frame size	Cable lead-throughs		R+, R-, UDC+ and UDC- terminals			
	Per cable type	Ø ¹⁾	Min wire size (solid/stranded) ²⁾	Max wire size (solid/stranded)	T (Wire screw)	
	pcs	mm	mm ²	mm ²	Screw/Bolt	N·m
3-phase $U_n = 400\text{ V}$						
R1	1	23	0.20/0.25	6/4	3)	1.0
R2	1	23	0.5/0.5	16/16	3)	1.5
R3	1	23	0.5/0.5	35/25	3)	3.5
R4	1	39	0.5/0.5	50	3)	4.0
R4 v2	1	39	1.5/1.5	70	3)	5.5
R5	1	39	6	70	M5	15
R6	1	45	25	150	M8	30
R7	1	54	95	240	M10	30
R8	2	45	2×50	2×150	M10	40
R9	2	54	2×95	2×240	M12	70

¹⁾ Maximum cable diameter accepted. For the lead-through plate hole diameters, refer chapter [Dimension drawings \(page 175\)](#).

²⁾ **Note:** Minimum wire size does not necessarily have enough current capability for full load. Make sure the installation complies with local laws and regulations.

³⁾ Either cable lug (R5) or clamp (R6...R9) is used for grounding.

Frame size	Screwdrivers for the terminals of the main circuit
R1	Combo: Slot 4 mm and PH1
R2	Combo: Slot 4.5 mm and PH2
R3, R4	PH2
R4 v2	Torx

Power cables

■ Typical power cable sizes, IEC

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

Refer page 159 for the cable lead-through sizes allowed for the selected drive frame size.

IEC type ACH531-01-	Frame size	Cu cable type ¹⁾
		mm²
3-phase U _n = 400 V		
02A7-4	R1	3×1.5 + 1.5
03A4-4	R1	3×1.5 + 1.5
04A1-4	R1	3×1.5 + 1.5
05A7-4	R1	3×1.5 + 1.5
07A3-4	R1	3×1.5 + 1.5
09A5-4	R1	3×2.5 + 2.5
12A7-4	R1	3×2.5 + 2.5
018A-4	R2	3×2.5 + 2.5
026A-4	R2	3×6 + 6
033A-4	R3	3×10 + 10
039A-4	R3	3×10 + 10
046A-4	R3	3×10 + 10
062A-4	R4, R4 v2	3×25 + 16
073A-4	R4, R4 v2	3×35 + 16
089A-4	R4 v2	3×50 + 25
106A-4	R5	3×70 + 35
145A-4	R6	3×95 + 50
169A-4	R7	3×120 + 70
206A-4	R7	3×150 + 70
246A-4	R8	2×(3×70+35)
293A-4	R8	2×(3×95+50)
363A-4	R9	2×(3×120+70)
430A-4	R9	2×(3×150+70)
490A-4	R9	2×(3×240+120)

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. Refer page 159 for the accepted cable sizes 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.

Terminal and lead-through data for the control cables

■ IEC

Control cable lead-throughs, wire sizes and tightening torques (T) are given below.

Frame size	Cable lead-throughs		Control cable entries and terminal sizes			
	Holes	Max cable size	+24V, DCOM, DGND, EXT. 24V terminals		DI, AI/O, AGND, RO, STO terminals	
			Wire size	T	Wire size	T
	pcs	mm	mm ²	N·m	mm ²	N·m
3-phase $U_n = 400\text{ V}$						
R1	3	17	0.2...2.5	0.5...0.6	0.14...1.5	0.5...0.6
R2	3	17	0.2...2.5	0.5...0.6	0.14...1.5	0.5...0.6
R3	3	17	0.2...2.5	0.5...0.6	0.14...1.5	0.5...0.6
R4, R4 v2	4	17	0.2...2.5	0.5...0.6	0.14...1.5	0.5...0.6
R5	3	17	0.2...2.5	0.5...0.6	0.14...1.5	0.5...0.6
R6	4	17	0.14...2.5	0.5...0.6	0.14...2.5	0.5...0.6
R7	4	17	0.14...2.5	0.5...0.6	0.14...2.5	0.5...0.6
R8	4	17	0.14...2.5	0.5...0.6	0.14...2.5	0.5...0.6
R9	4	17	0.14...2.5	0.5...0.6	0.14...2.5	0.5...0.6

Electrical power network specification

Voltage (U_1)

ACH531-01-xxxx-4 drives: Input voltage range 3~ 380...480 V AC +10%...-15%.

Network type

Public low voltage networks. Symmetrically grounded TN-S system, IT (ungrounded), corner-grounded delta, midpoint-grounded delta and TT systems, refer sections:

[IEC: When to disconnect EMC filter or ground-to-phase varistor: TN-S, IT, corner-grounded delta and midpoint-grounded delta systems \(page 76\)](#) and [Guidelines for installing the drive to a TT system \(page 77\)](#).

Note: Frames R1 and R5 cannot be used in corner-grounded or midpoint-grounded delta systems.

Rated conditional short-circuit current (IEC 61800-5-1)

Maximum allowable prospective short-circuit current is 65kA when protected by fuses given in the fuse tables.

Frequency (f_1)

47 to 63 Hz. This is indicated in the type designation label as typical input frequency level f_1 (50 Hz).

Imbalance

Max. $\pm 3\%$ of nominal phase to phase input voltage

Fundamental power factor ($\cos \phi_1$)

0.98 (at nominal load)

**Minimum short-circuit power
(IEC/EN 61000-3-12)**

The minimum short-circuit power S_{sc} given for each drive type for the R_{sc} (transformer short circuit ratio) value of 350.

Type ACH531-01	Input rating	Min. short circuit power		Frame size
		400 V	480 V	
	I_1	Ssc	Ssc	
	A	MVA	MVA	
3-phase U_n = 400 V, IEC ratings				
02A7-4	2.6	0.63	0.61	R1
03A4-4	3.3	0.80	0.87	R1
04A1-4	4.0	0.97	1.02	R1
05A7-4	5.6	1.36	1.40	R1
07A3-4	7.2	1.75	1.75	R1
09A5-4	9.4	2.28	2.21	R1
12A7-4	12.6	3.06	3.49	R1
018A-4	17.0	4.12	4.07	R2
026A-4	25.0	6.06	6.69	R2
033A-4	32.0	7.76	7.86	R3
039A-4	38.0	9.21	9.89	R3
046A-4	45.0	10.91	12.80	R3
062A-4	62	15.03	15.13	R4, R4 v2
073A-4	73	17.70	18,91	R4, R4 v2
089A-4	89	21.6	22.4	R4 v2
106A-4	106	25.70	27.93	R5
145A-4	145	35.16	36.08	R6
169A-4	169	40.98	45.39	R7
206A-4	206	49.95	52.38	R7
246A-4	246	59.65	69.84	R8
293A-4	293	71.05	75.66	R8
363A-4	363	88.02	105.05	R9
430A-4	430	104.27	120.47	R9
490A-4	430	104.27	120.47	R9

Motor connection data

Motor types

Asynchronous AC induction motors and permanent magnet motors

**Short-circuit current protection
(IEC/EN 1800-5-1)**

The drive provides solid state short circuit protection for the motor connection per IEC/EN 61800-5-1.

Frequency (f_2)

0...500 Hz. This is indicated in the type designation label as output frequency level f_1 (0...500 Hz).

Frequency resolution

0.01 Hz

Current

Refer [Ratings \(page 143\)](#).

Switching frequency

2 kHz, 4 kHz (default), 8 kHz, 12 kHz

Maximum recommended motor cable length**Operational functionality and motor cable length**

The drive is designed to operate with optimum performance with the following maximum motor cable lengths.

Note: Conducted and radiated emissions of these motor cable lengths do not comply with EMC requirements.

Frame size	Maximum motor cable length, 4 kHz
	m
Standard drive, without external options	
R1	100
R2	200
R3	300
R4, R4 v2	300
R5	300
R6	300
R7	300
R8	300
R9	300

Note:

1. In multimotor systems, the calculated sum of all motor cable lengths must not exceed the maximum motor cable length given in the table.
2. Longer motor cables cause a motor voltage decrease which limits the available motor power. The decrease depends on the motor cable length and characteristics. Contact your local ABB representative for more information.
3. When using longer motor cables than 50 m 8 and 12 kHz switching frequencies are not allowed. With motor cable length over 100 m, disconnect EMC DC screw if applicable.
4. Acceptable motor cable length for motor manufactures may be different. Check with specific motor manufacturer for maximum allowable distance.

EMC compatibility and motor cable length

To comply with the European EMC Directive (standard EN 61800-3), use the following maximum motor cable lengths at 4 kHz switching frequency. Refer the table that follows.

Frame size	Maximum motor cable length, 4 kHz
	m
EMC limits for Category C2¹⁾ Standard drive with an internal EMC filter. Refer notes 1 and 2.	
R1	100
R2	100
R3	100
R4, R4 v2	100
R5	100
R6	150
R7	150
R8	150
R9	150
EMC limits for Category C3¹⁾ Standard drive with an internal EMC filter. Refer note 3.	
R1	150
R2	150
R3	150
R4, R4 v2	150
R5	150
R6	150
R7	150
R8	150
R9	150

¹⁾ See the terms in section [Definitions \(page 171\)](#)

Note:

1. Radiated and conducted emissions are according to category C2 with an internal EMC filter. The internal EMC filter must be connected.
2. Categories C1 and C2 meet requirements for connecting equipment to the public low-voltage networks.
3. Radiated and conducted emissions are according to category C3 with an internal EMC filter. The internal EMC filter must be connected.

Brake resistor connection data for frames R1...R3

Short-circuit protection (IEC/EN 61800-5-1, IEC 61439-1)

The brake resistor output is conditionally short-circuit proof by IEC/EN 61800-5-1. Rated conditional short-circuit current as defined in IEC 61439-1.

Auxiliary circuit power consumption

Maximum external power supply:
Frames R1...R5: 25 W, 1.04 A at 24 V AC/DC (with option modules CMOD-01, CMOD-02)
Frames R6...R9: 36 W, 1.50 A at 24 V AC/DC (as standard, terminals 40...41)

Efficiency

Approximately 98% at nominal power level. The efficiency is not calculated according to IEC 61800-9-2.

Energy efficiency data (ecodesign)

Energy efficiency data according to IEC 61800-9-2 is available from the ecodesign tool (<https://ecodesign.drivesmotors.abb.com>). The drive complies with the IE efficiency class IE2.



Ecodesign

Energy efficiency data according to IEC-61800-9-2 is available from the ecodesign tool (<https://ecodesign.drivesmotors.abb.com>).

Energy efficiency data is not provided for 1-phase 230 V drives. The drives with 1-phase input are not in the scope of the EU ecodesign requirements (Regulation EU 2019/1781).

Protection classes for module

Degrees of protection (IEC/EN 60529)	IP20 (standard)
Overvoltage category (IEC/EN 60664-1)	III
Protective class (IEC/EN 61800-5-1)	I

Applicable standards

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

IEC 60146-1-1:2009 EN 60146-1-1:2010	<i>Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements</i>
IEC 60529:1989 + AMD1:1999 + AMD2: 2013, EN 60529:1991 + A1:2000 + A2: 2013	<i>Degrees of protection provided by enclosures (IP code)</i>
IEC 61000-3-2:2018, EN 61000-3-2:2014	<i>Electromagnetic compatibility (EMC) – Limits for harmonic current emissions (input current > 16 A per phase)</i>
IEC/EN 61000-3-12:2011	<i>Electromagnetic compatibility (EMC) – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current input current > 16 A and < 75 A per phase</i> This drive complies with the standard provided that the short-circuit power S_{sc} is greater than or equal to the minimum short-circuit power given for the drive (listed for each drive type on page 302) at the interface point between the user's supply and the public system. It is the responsibility of the installer or user of the drive to ensure, by consultation with the distribution network operator if necessary, that the drive is connected only to a supply with a short-circuit power S_{sc} greater than or equal to the minimum short-circuit power given for the drive.
EN 61800-3:2004 + A1:2012 IEC 61800-3:2017	<i>Adjustable speed electrical power drive systems. Part 3: EMC requirements and specific test methods</i>
EN 61800-5-1:2007+A1:2017+A11:2021 IEC 61800-5-1:2007+AMD1:2016	<i>Adjustable speed electrical power drive systems. Part 5-1: Safety requirements – electrical, thermal and energy</i>
IEC/EN 61800-9-2:2017	<i>Adjustable speed electrical power drive systems. Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and motor starters</i>
IEC 60664-1:2007	<i>Insulation coordination for equipment within low-voltage systems. Part 1: Principles, requirements and tests.</i>

Ambient conditions

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

	Operation installed for stationary use	Storage in the package	Transportation in the package
Installation site altitude	0...4000 m (13123 ft) above sea level ¹⁾ 0...2000 m (6561 ft) above sea level ²⁾ Above 1000 m (3281 ft), see section Altitude derating (page 148).	-	-
Air temperature	-15...+50 °C (5...122 °F). 0...-15 °C (32...5 °F): No frost allowed. See section Ratings (page 143). Above 40 °C (104 °F) refer section Surrounding air temperature derating, IP21 (UL Type 1) (page 146). Keypad display: -20...+50 °C (-4...122 °F)	-40...+70 °C (-40...+158 °F)	-40...+70 °C (-40...+158 °F)
Relative humidity	5...95%	Max. 95%	Max. 95%
	No condensation allowed. Maximum allowed relative humidity is 60% ³⁾ in the presence of corrosive gases at level C4.		
Contamination levels	IEC 60721-3-3:2019 and ISO9223: ANSI-ISA 71.04	IEC 60721-3-1:2018	IEC 60721-3-2:2018
Chemical gases	Base drive: IEC Class C3 ⁴⁾ ANSI G2 +B056/+B063/+B066: IEC Class C4 ANSI G3/GX up to 2300 Å /30d corrosivity	Class 1C2	Class 2C2
	Conformal coated circuit boards as standard on all drives		
Solid particles	Class 3S6. No conductive dust allowed.	Class 1S3 (packaging must be Class 2S2, otherwise this is 1S2)	Class 2S2
Pollution degree (IEC/EN 60664-1)	2	-	-
Atmospheric pressure	70...106 kPa 0.7...1.05 atmospheres	70...106 kPa 0.7...1.05 atmospheres	60...106 kPa 0.6...1.05 atmospheres

Sinusoidal vibration (IEC 60068-2-6, Test Fc 2007-12)	frequency 10...150 Hz; amplitude ±0.075 mm (0.003 in), 10...57,56 Hz; constant peak acceleration 10 m/s ² (33 ft/s ²), 57,56...150 Hz; sweep: 1 oct/min; 10 sweep cycles in each axis with STO active; uncertainty ±5.0%; normal mounting	-	-															
Vibration (ISTA)	-	<u>R1...R4</u> (ISTA 1A): Displacement, 25 mm peak to peak, 14200 vibratory impacts <u>R5...R9</u> (ISTA 3E): Random, overall Grms level of 0.52																
Shock/Drop (ISTA)	Not permitted	<u>R1...R4</u> (ISTA 1A): Drop, 6 faces, 3 edges and 1 corner <table><tr><td>Weight range</td><td>mm</td><td>in</td></tr><tr><td>0...10 kg (0...22 lb)</td><td>760</td><td>29.9</td></tr><tr><td>10...19 kg (22...42 lb)</td><td>610</td><td>24.0</td></tr><tr><td>19...28 kg (42...62 lb)</td><td>460</td><td>18.1</td></tr><tr><td>28...41 kg (62...90 lb)</td><td>340</td><td>13.4</td></tr></table> <u>R5...R9</u> (ISTA 3E): Shock, incline impact: 1.1 m/s (3.61 ft/s) Shock, rotational edge drop: 200 mm (7.9 in)		Weight range	mm	in	0...10 kg (0...22 lb)	760	29.9	10...19 kg (22...42 lb)	610	24.0	19...28 kg (42...62 lb)	460	18.1	28...41 kg (62...90 lb)	340	13.4
Weight range	mm	in																
0...10 kg (0...22 lb)	760	29.9																
10...19 kg (22...42 lb)	610	24.0																
19...28 kg (42...62 lb)	460	18.1																
28...41 kg (62...90 lb)	340	13.4																

¹⁾ For symmetrically grounded TN-S systems, TT systems, and ungrounded or symmetrically high-resistance grounded IT systems. See also section [Limiting relay output maximum voltages at high installation altitudes \(page 71\)](#).

²⁾ For corner-grounded delta systems, midpoint-grounded delta systems and corner-grounded (via high resistance) IT systems.

³⁾ Contact ABB for higher humidity levels than 60% in the presence of corrosive gases.

⁴⁾ For IEC60721-3-3:2002, the level is 3C2 as standard and 3C3 for +B056/+B063/+B066.

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

Storage conditions

Store the drive in humidity-controlled enclosed environments. Keep the drive in its package.

Colors

Drive enclosure

- NCS 1502-Y (RAL 9002 / PMS 1C Cool Grey) and RAL 9002.
- NCS 1502-Y

Markings

These markings are attached to the drive:

	CE mark The product complies with the applicable European Union legislation. For fulfilling the EMC requirements, refer to the additional information concerning the drive EMC compliance (IEC/EN 61800-3).
	TÜV Safety Approved mark (functional safety) The product contains Safe torque off and possibly other (optional) safety functions that 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 its life, the product should enter the recycling system at an appropriate collection point and not be placed in the normal waste stream.

Declarations of conformity



[Link to Declaration of conformity according to Ecodesign Directive 2009/125/EC\(3AXD10002935657\)](#)



[Link to Declaration of conformity \(3AXD10002935596\)](#)



[Link to Declaration of conformity according to Low Voltage Directive 2014/35/EU and EMC Directive 2014/30/EU \(3AXD10002935658\)](#)



[Link to Declaration of conformity according to RoHS Directive 2011/65/EU and Delegated Directives \(EU\) 2015/863 \(3AXD10002935660\)](#)



[Link to Declaration of conformity according to Machinery Directive 2006/42/EC \(3AXD10002935659\)](#)

Compliance with the EN 61800-3

■ Definitions

EMC stands for Electromagnetic Compatibility. 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.

The first environment includes establishments connected to a low-voltage network that supplies buildings used for domestic purposes.

The second environment includes establishments connected to a network that do not supply domestic premises.

Drive of Category C1: Drive with a rated voltage of less than 1000 V that is intended for use in the first environment.

Drive of Category C2: Drive with a rated voltage of less than 1000 V that is intended to be installed and started up only by a professional when used in the first environment.

Note: A professional is a person or organization with the necessary skills to install or start power drive systems, and includes their EMC aspects.

Drive of Category C3: Drive with a rated voltage of less than 1000 V that is intended for use in the second environment and not intended for use in the first environment.

Drive of Category C4: Drive with a rated voltage equal to or more than 1000 V, or a rated current equal to or more than 400 A, or intended for use in complex systems in the second environment.

■ Category C1

The emission limits are complied with the following provisions:

1. The optional EMC C1 filter is selected according to the documentation and installed as specified in the EMC C1 filter manual.
2. The motor and control cables are selected as specified in this manual.
3. The drive is installed according to the instructions given in this manual.
4. The maximum motor cable length with 2 kHz switching frequency is 10 m.



▲WARNING In a domestic environment, this product may cause radio interference, in which case supplementary mitigation measures may be required.

■ Category C2

The emission limits are complied with the following provisions:

1. The motor and control cables are selected as specified in this manual.
 2. The drive is installed according to the instructions given in this manual.
 3. For the maximum motor cable length with 4 kHz switching frequency, refer [Maximum recommended motor cable length \(page 164\)](#).
-



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

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

Note: Do not install the drive with the ground-to-phase varistor connected to a system that the varistor is not suitable for. It can cause damage to the varistor circuit.

If you install the drive to any other system than symmetrically grounded TN-S system, you may need to disconnect the EMC filter or the ground-to-phase varistor. Refer sections:

IEC: Grounding system compatibility check (page 75)

■ **Category C3**

The drive complies with the standard with the following provisions:

1. The motor and control cables are selected as specified in this manual.
2. The drive is installed according to the instructions given in this manual.
3. For the maximum motor cable length with 4 kHz switching frequency, refer **Maximum recommended motor cable length (page 164)**

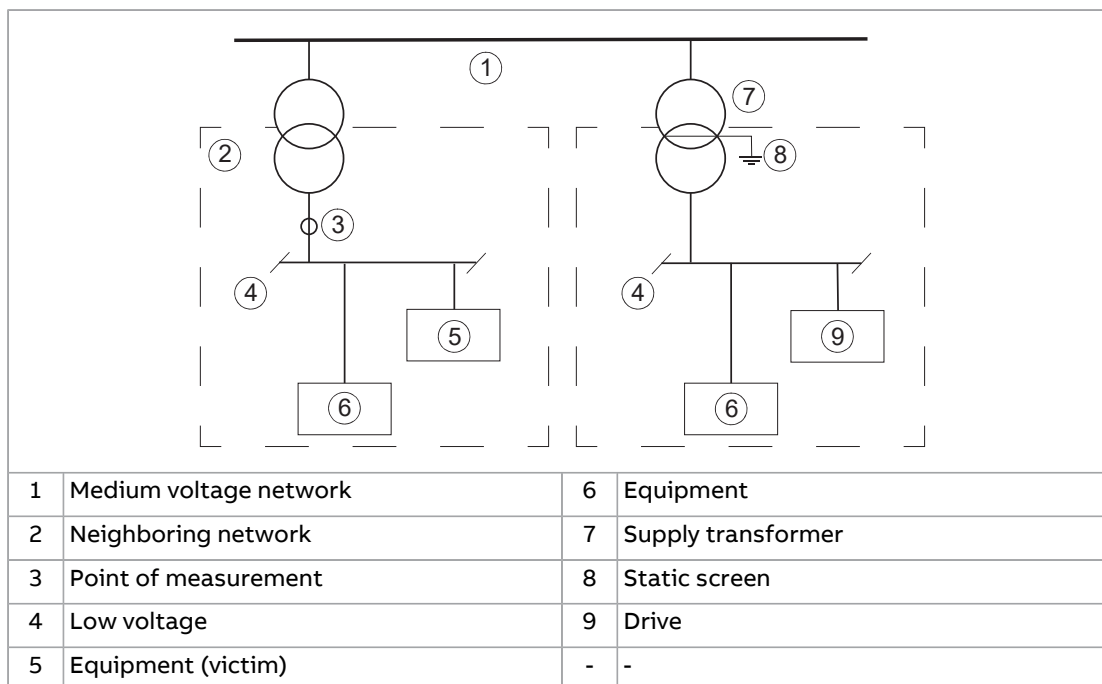


⚠ WARNING To prevent radio-frequency interference, do not use a drive of category C3 on a low-voltage public network that supplies domestic premises.

■ **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.
-



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.

NOTICE To prevent radio-frequency interference, do not use a drive of category C4 on a low-voltage public network that supplies domestic premises.

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 the Customer's sole responsibility to provide and continuously ensure a secure connection between the product and the Customer network or any other network (as the case may be). The 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.

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Dimension drawings

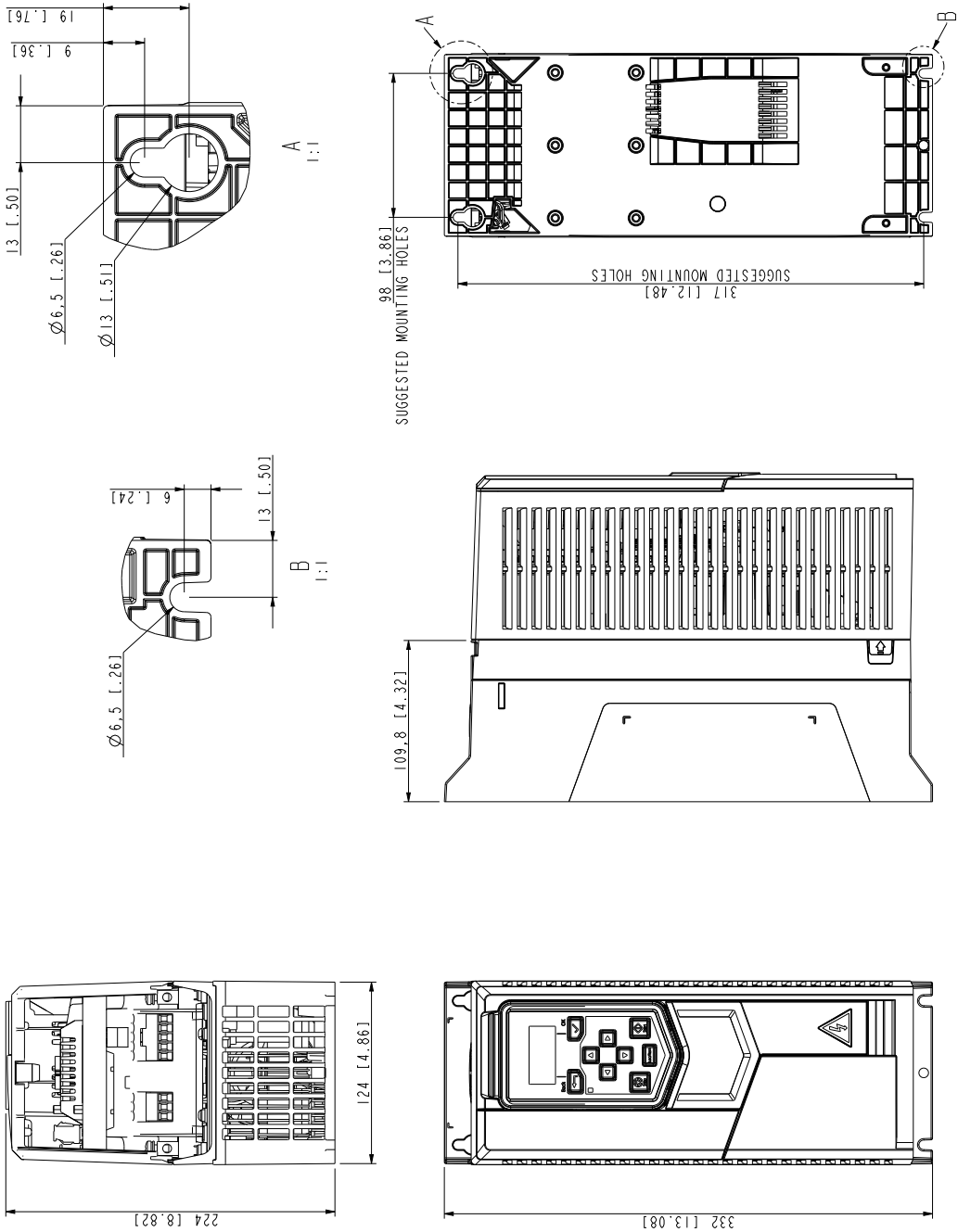
Contents of this chapter

This chapter shows the dimension drawings of the ACH531-01.

Note: The dimensions are given in millimeters.

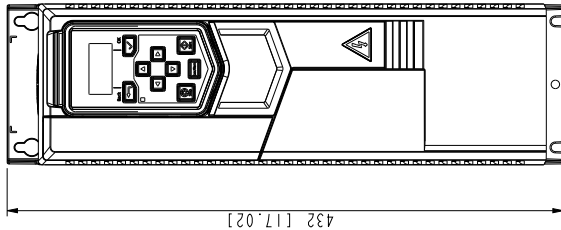
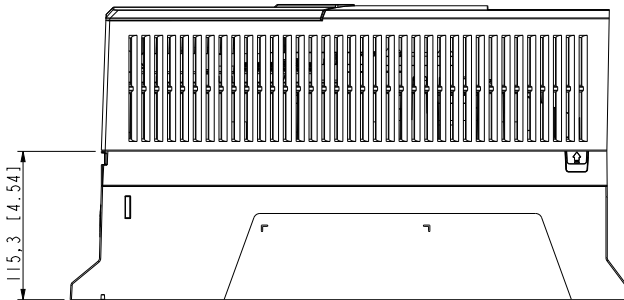
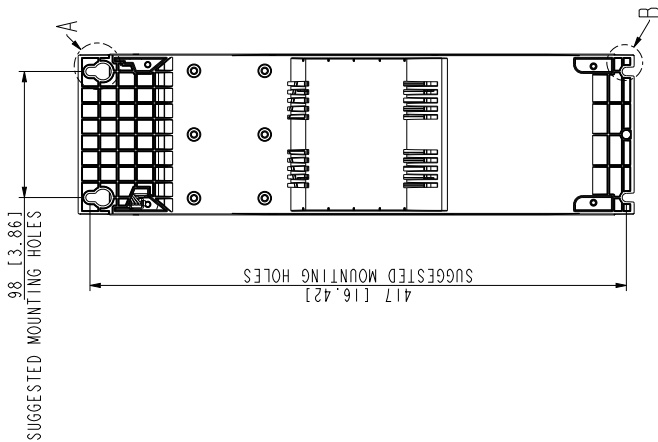
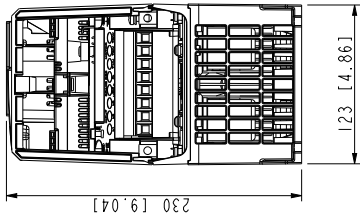
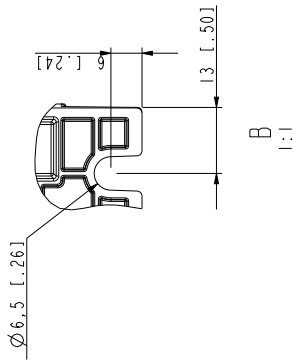
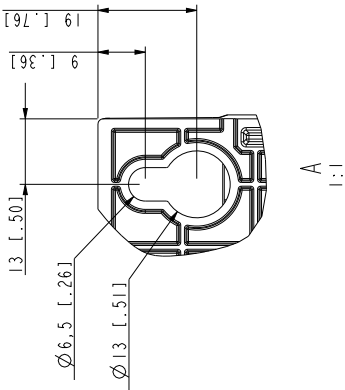
Frame R1, IP20

Frame R1, IP20

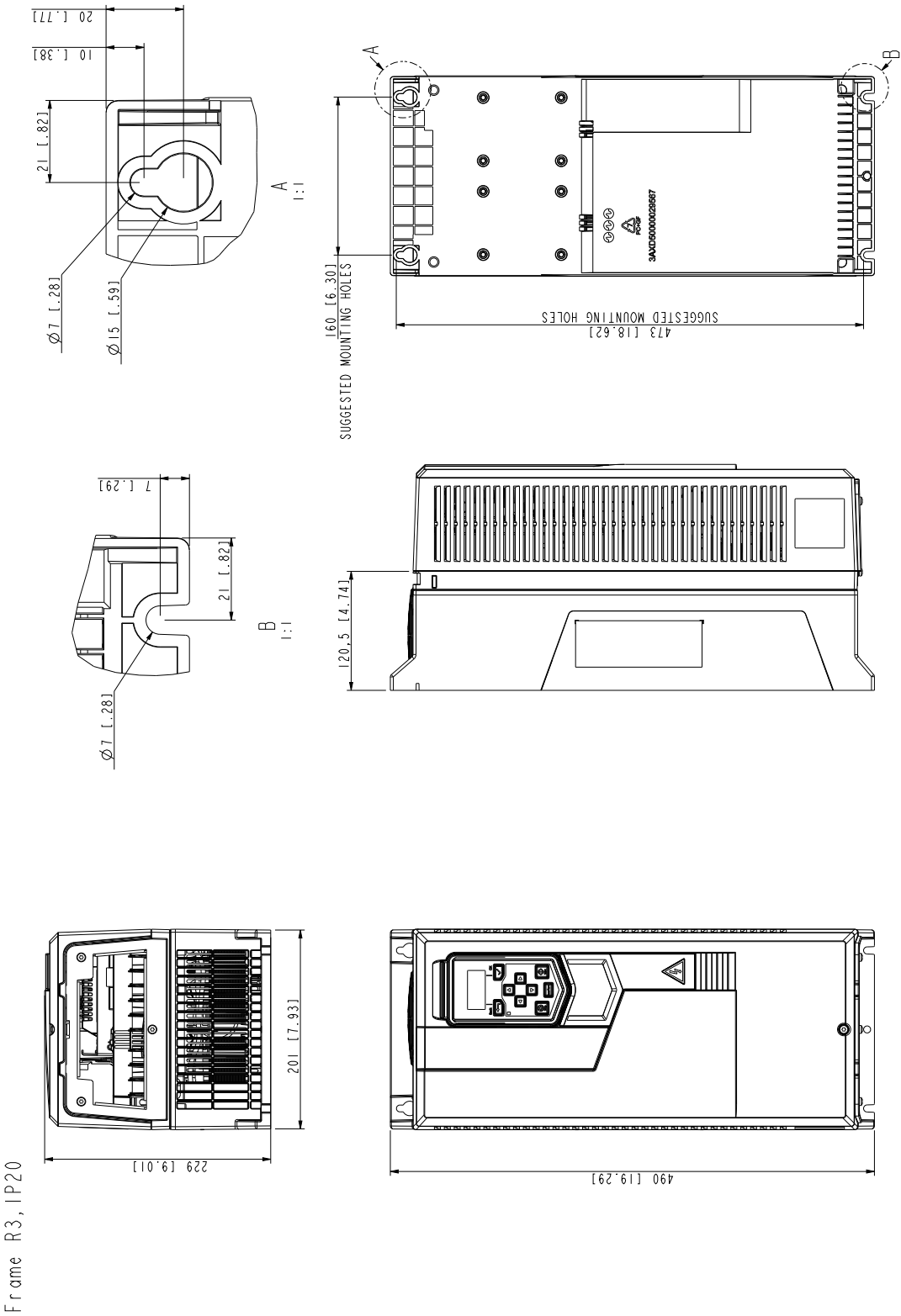


Frame R2, IP20

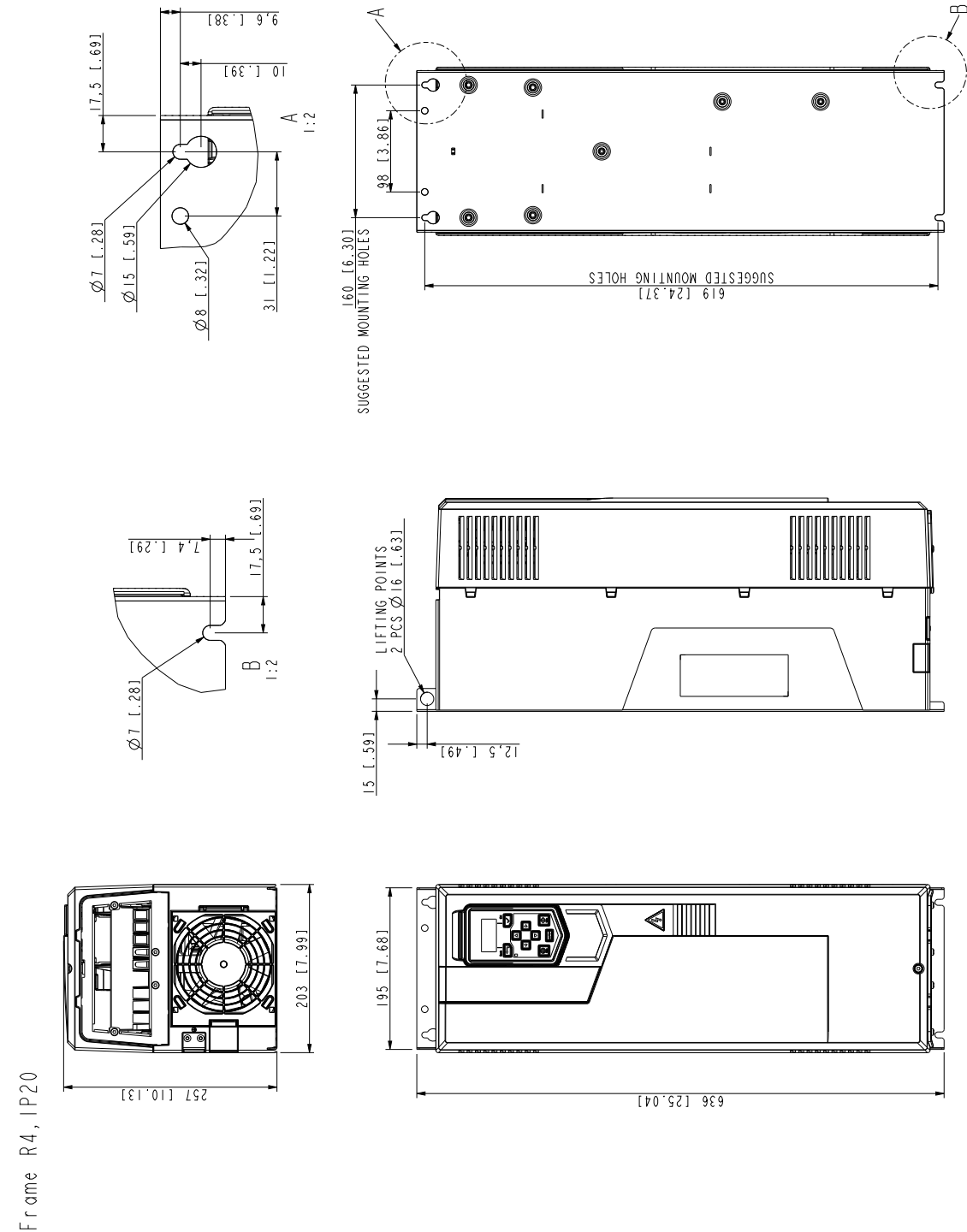
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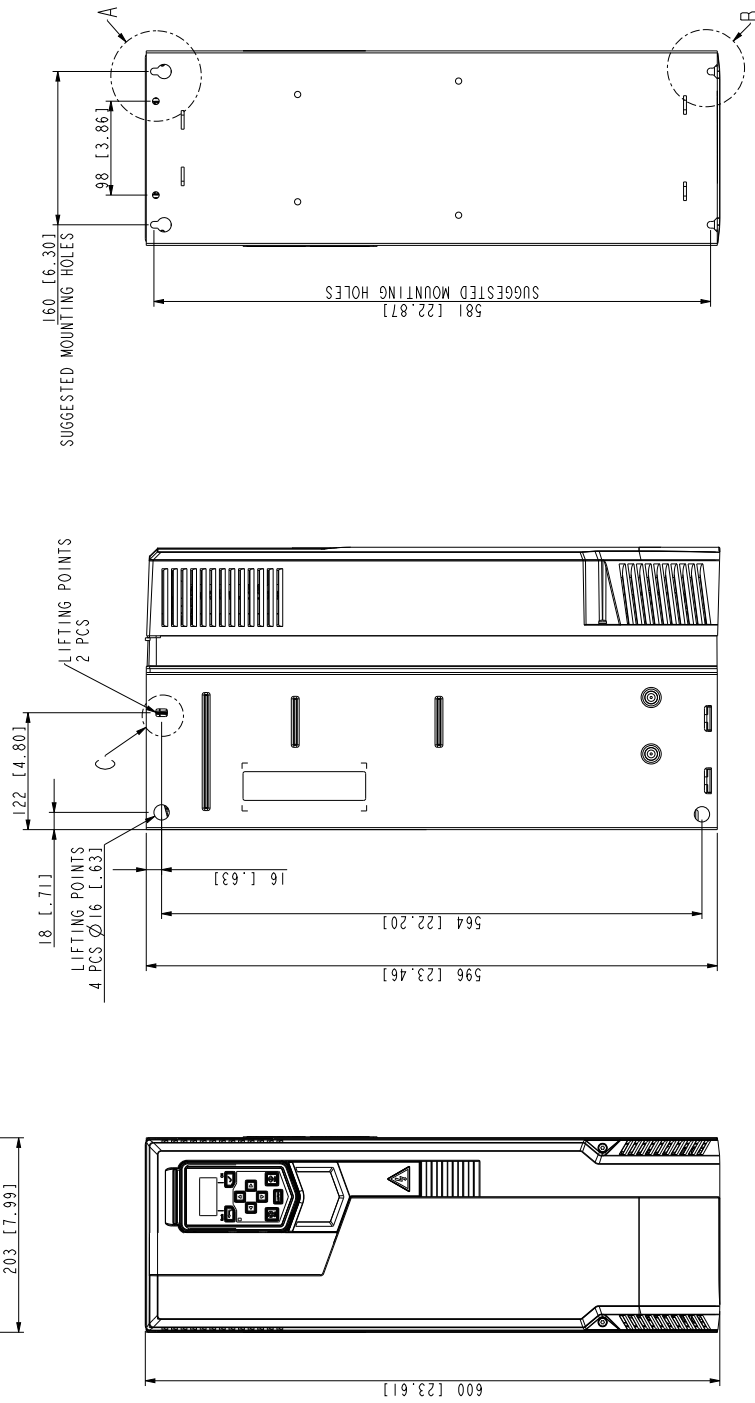
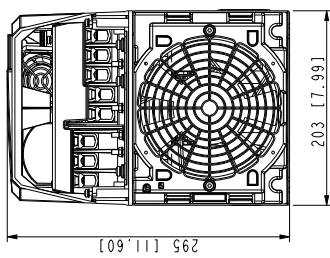
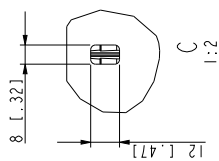
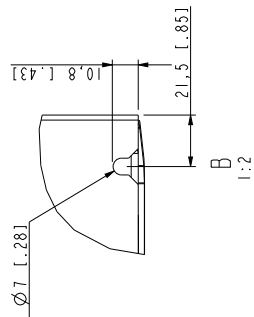


Frame R3, IP20



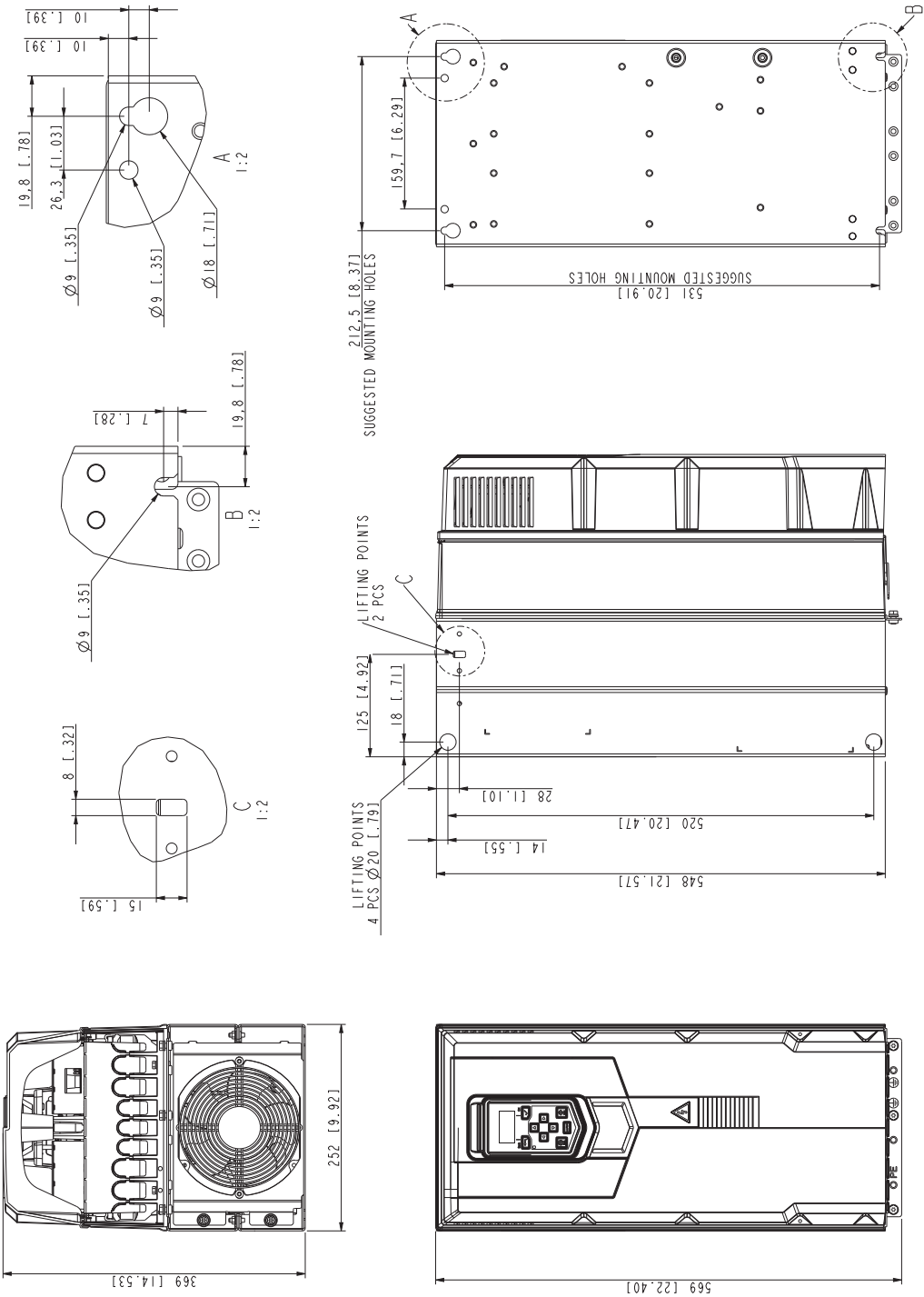
Frame R4, IP20

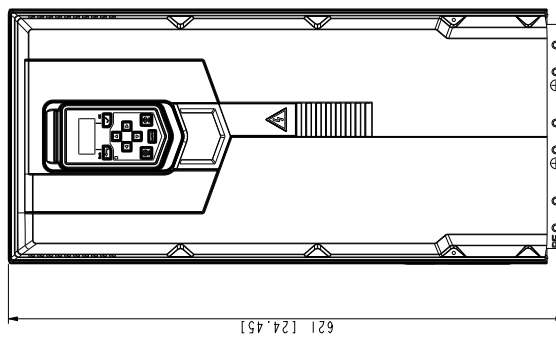
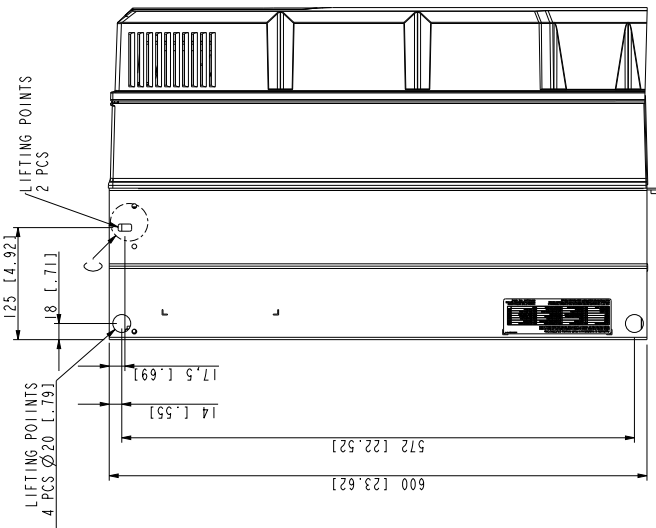
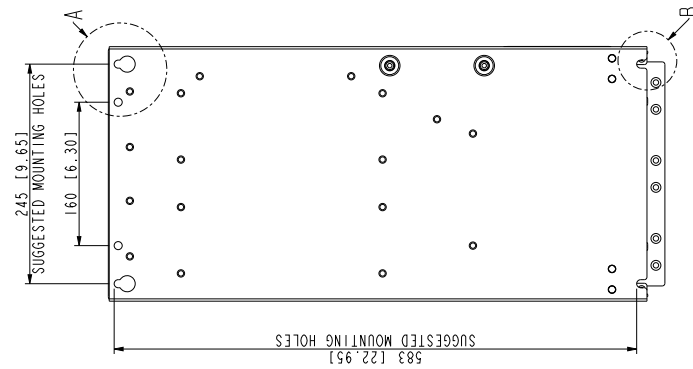
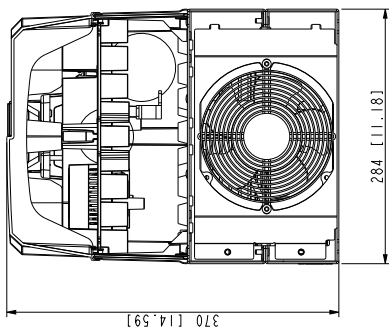
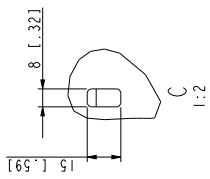
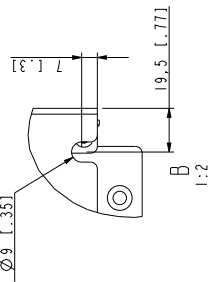


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Frame R6, IP20

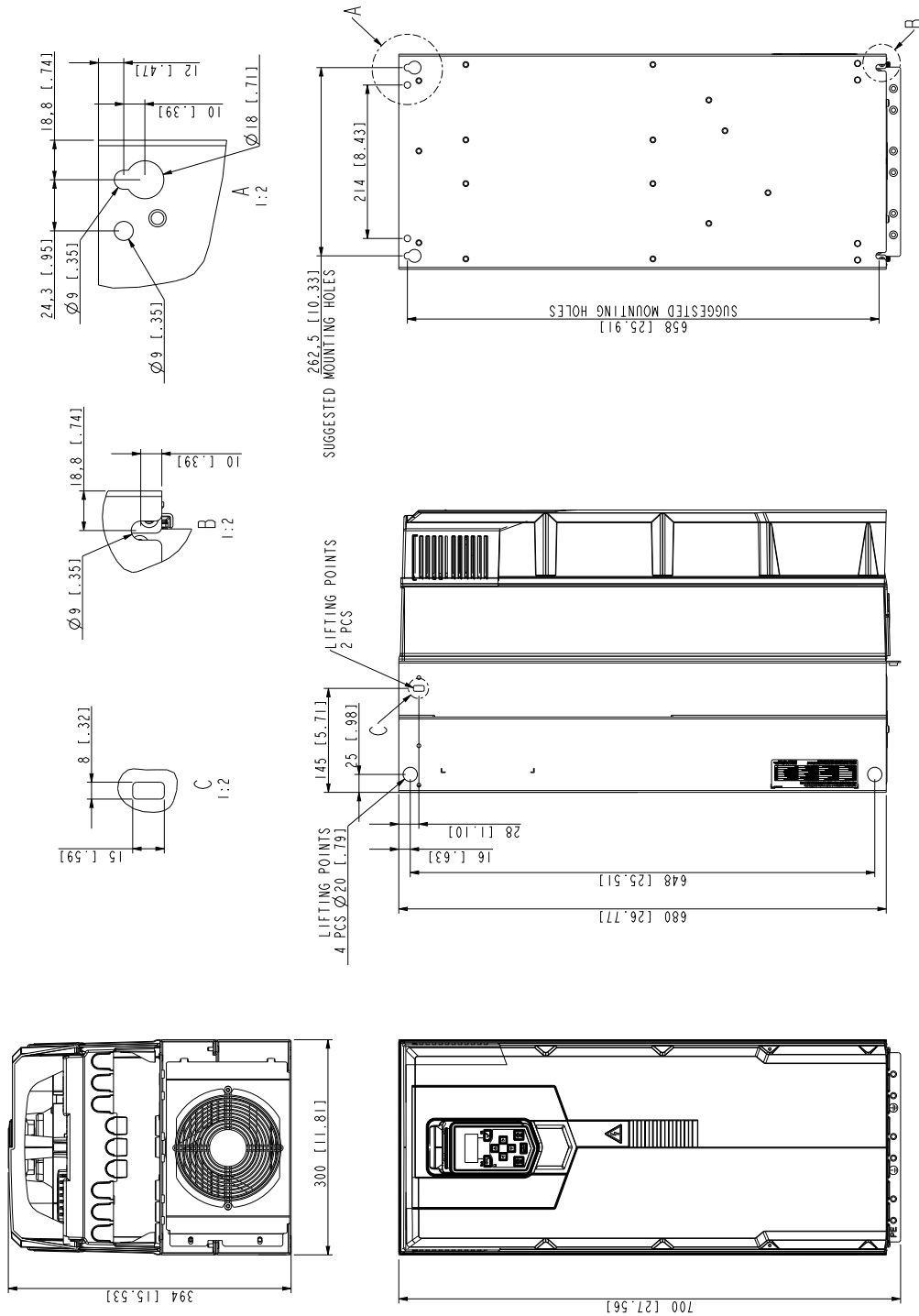
Frame R6, IP20





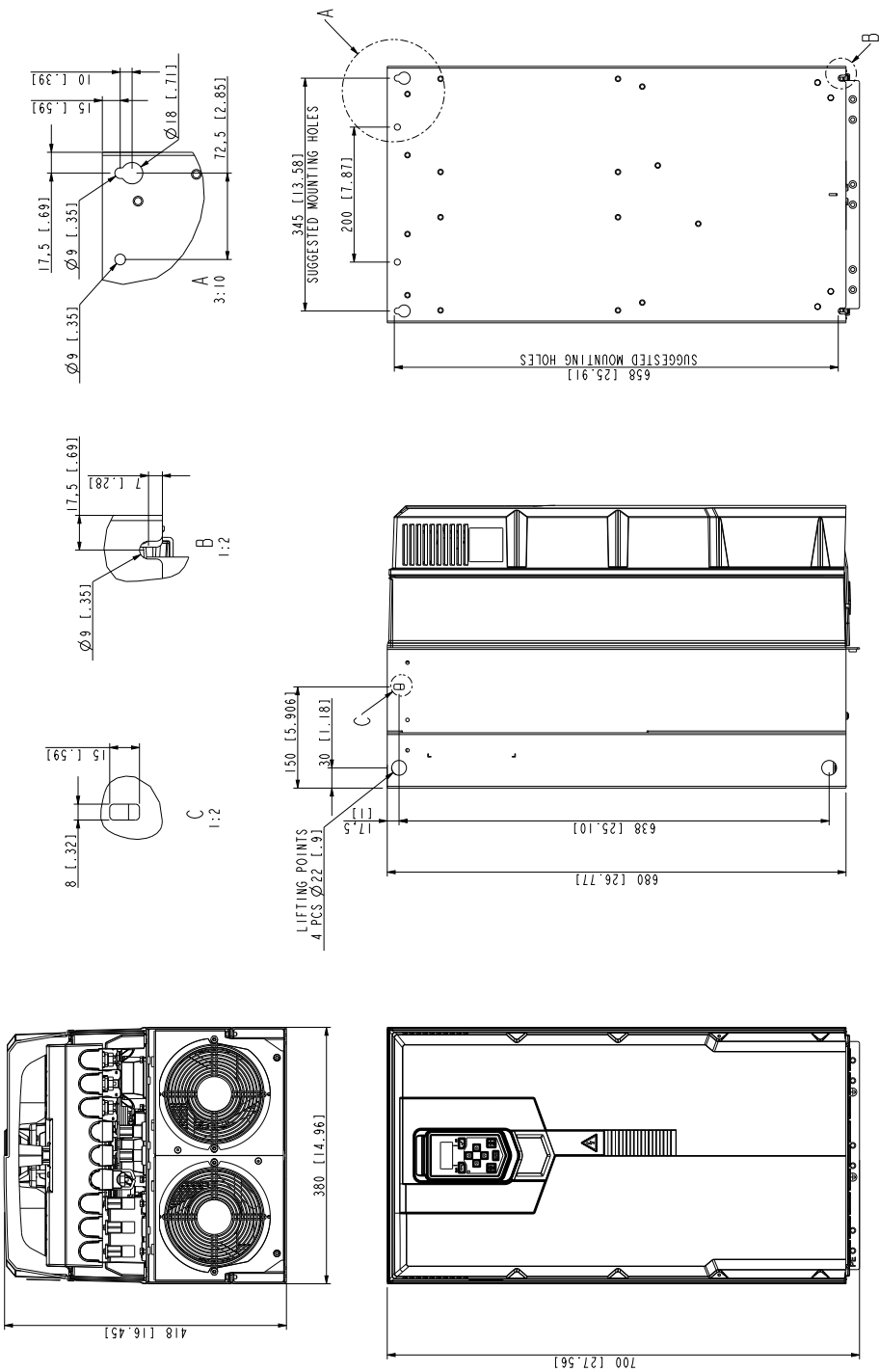
Frame R8, IP20

Frame R8, IP20



Frame R9, IP20

Frame R9, IP20



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Resistor braking

Contents of this chapter

This chapter contains information and instructions on resistor braking, brake choppers and brake resistors.

Operation principle and hardware description

The brake chopper handles the energy generated by a decelerating motor. The chopper connects the brake resistor to the intermediate DC circuit whenever the voltage in the circuit exceeds the limit defined by the control program. Energy consumption by the resistor losses lowers the voltage until the resistor can be disconnected.

For frame R1...R3 internal brake choppers and resistors, see below. For R4...R9 external brake choppers and resistors, refer [Resistor braking, frames R4...R9 \(page 189\)](#).

Resistor braking, frames R1...R3

■ Planning the braking system

Selecting the brake resistor

Frames R1...R3 have an built-in brake chopper as standard equipment. The brake resistor is selected using the table and equations presented in this section.

1. Determine the required maximum braking power P_{Rmax} for the application. P_{Rmax} must be smaller than P_{BRmax} given in the table on page 186 for the used drive type.
 2. Calculate resistance R with Equation 1.
 3. Calculate energy E_{Rpulse} with Equation 2.
 4. Select the resistor so that the following conditions are met:
-

186 Resistor braking

- The rated power of the resistor must be greater than or equal to P_{Rmax} .
- Resistance R must be between R_{min} and R_{max} given in the table for the used drive type.
- The resistor must be able to dissipate energy E_{Rpulse} during the braking cycle T .

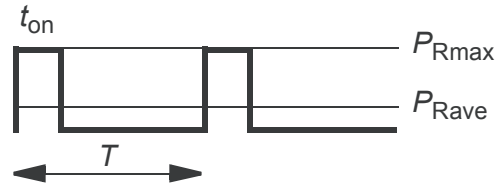
Equations for selecting the resistor:

$$\text{Eq. 1.} \quad U_N = 400V : R = \frac{450000}{P_{Rmax}}$$

$$U_N = 480V : R = \frac{615000}{P_{Rmax}}$$

$$\text{Eq. 2.} \quad E_{Rpulse} = P_{Rmax} \cdot t_{on}$$

$$\text{Eq. 3.} \quad P_{Rave} = P_{Rmax} \cdot \frac{t_{on}}{T}$$



For conversion, use 1 hp = 746 W.

where

R = calculated brake resistor value (ohm). Make sure that: $R_{min} < R < R_{max}$.

P_{Rmax} = maximum power during the braking cycle (W)

P_{Rave} = average power during the braking cycle (W)

E_{Rpulse} = energy conducted into the resistor during a single braking pulse (J)

t_{on} = length of the braking pulse (s)

T = length of the braking cycle (s).

The tables below show reference resistor types for the maximum braking power.

IEC

Type ACH531-01-	R_{min} ohm	R_{max} ohm	P_{BRmax} kW	Reference resistor types
3-phase $U_n = 400$ V				
02A7-4	52	864	0.6	Danotherm CBH 360 C T 406 210R
03A4-4	52	582	0.9	Danotherm CBH 360 C T 406 210R
04A1-4	52	392	1.4	Danotherm CBH 360 C T 406 210R
05A7-4	52	279	2.0	Danotherm CBH 360 C T 406 210R
07A3-4	52	191	2.9	Danotherm CBR-V 330 D T 406 78R UL
09A5-4	52	140	3.9	Danotherm CBR-V 330 D T 406 78R UL
12A7-4	52	104	5.3	Danotherm CBR-V 330 D T 406 78R UL
018A-4	31	75	7.3	Danotherm CBR-V 560 D HT 406 39R UL
026A-4	22	52	10	Danotherm CBR-V 560 D HT 406 39R UL
033A-4	16	37	15	Danotherm CBT-H 560 D HT 406 19R
039A-4	10	27	20	Danotherm CBT-H 760 D HT 406 16R
046A-4	10	22	25	Danotherm CBT-H 760 D HT 406 16R

Symbols

R_{min} = minimum allowed brake resistor that can be connected to the brake chopper

R_{max} = maximum allowed brake resistor that allows P_{BRmax}

P_{BRmax} = maximum braking capacity of the drive, must exceed the desired braking power.



⚠ WARNING Do not use a brake resistor with a resistance below the minimum value specified for the particular drive. The drive and the internal chopper are not able to handle the overcurrent caused by the low resistance.

Selecting and routing the brake resistor cables

Use a shielded cable with the conductor size specified in section Terminal and lead-through data for the power cables on page 159.

Minimizing electromagnetic interference

Follow these rules in order to minimize electromagnetic interference caused by the rapid current changes in the resistor cables:

- Install the cables away from other cable routes.
- Avoid long parallel runs with other cables. The minimum parallel cabling separation distance should be 0.3 meters.
- Cross the other cables at right angles.
- Keep the cable as short as possible in order to minimize the radiated emissions and stress on chopper IGBTs. The longer the cable the higher the radiated emissions, inductive load and voltage peaks over the IGBT semiconductors of the brake chopper.

Note: ABB has not verified that the EMC requirements are fulfilled with external user-defined brake resistors and cabling. The EMC compliance of the complete installation must be considered by the customer.

Maximum cable length

The maximum length of the resistor cable(s) is 10 m.

Placing the brake resistor

Install the resistors outside the drive in a place where they will cool.

Arrange the cooling of the resistor in a way that:

- no danger of overheating is caused to the resistor or nearby materials
- the temperature of the room the resistor is located in does not exceed the allowed maximum.

Supply the resistor with cooling air/water according to the resistor manufacturer's instructions.



⚠ WARNING The materials near the brake resistor must be non-flammable. The surface temperature of the resistor is high. Airflow from the resistor can have a high temperature. If the exhaust vents connect to a ventilation system, make sure that the material withstands high temperatures. Protect the resistor against contact.

Protecting the system in brake circuit fault situations

Protecting the system in cable and brake resistor short-circuit situations

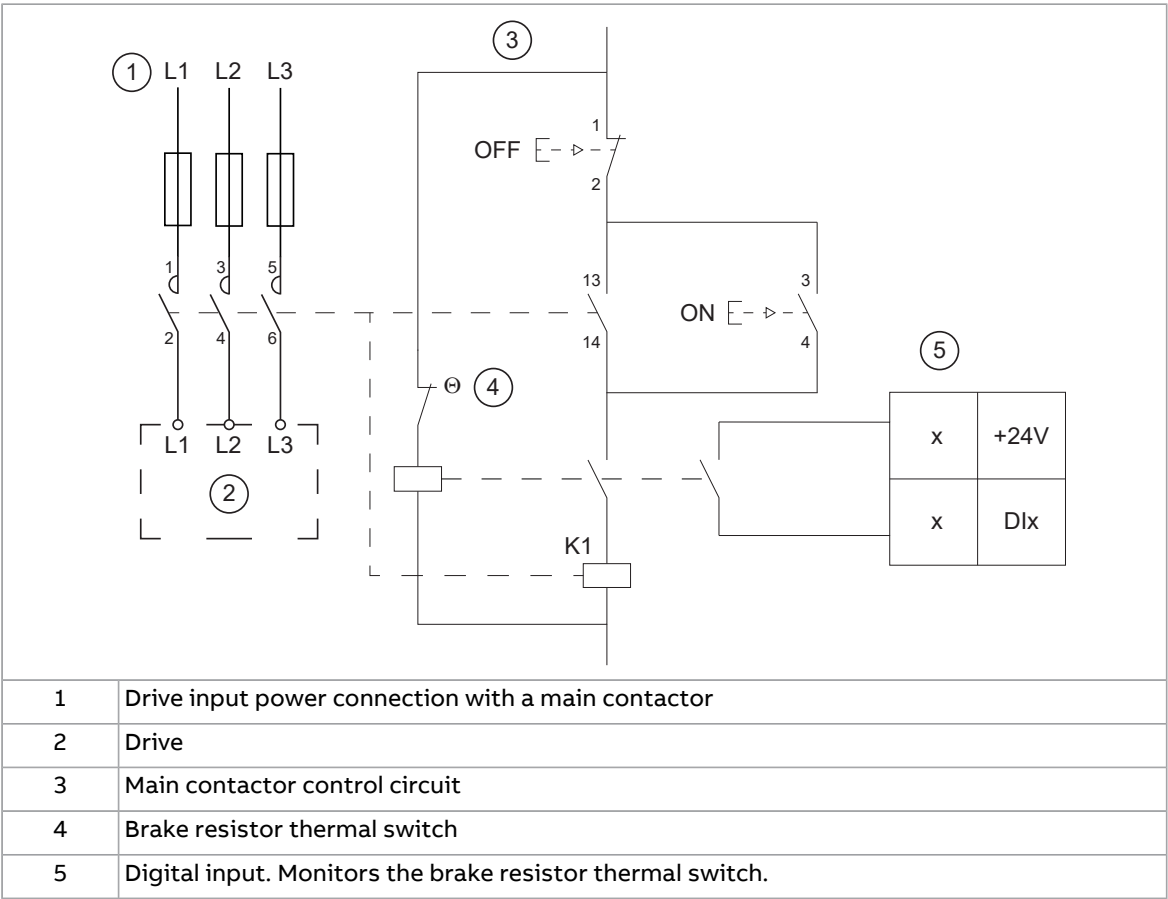
The drive input fuses also protect the resistor cable when it is identical to the input power cable.

Protecting the system against thermal overload

The drive has a brake thermal model that protects the brake resistor against overload. ABB recommends that you enable the thermal model at start up.

ABB recommends that you use a main contactor with the drive for safety reasons even when you have enabled the resistor thermal model. Connect the contactor so that it opens if the resistor overheats. This is essential for safety, since the drive will not otherwise be able to interrupt the main supply if the chopper conducts in a fault situation. The figure shows an example connection diagram. ABB recommends that you use resistors equipped with a thermal switch (1) in the resistor assembly. The switch indicates overtemperature.

ABB recommends that you connect the thermal switch to a digital input of the drive, and configure the input to cause a fault trip at resistor overtemperature indication.



■ Mechanical installation

All brake resistors must be installed outside the drive. Obey the resistor manufacturer's instructions.

■ Electrical installation

Checking the insulation of the assembly

For instructions, refer to [Brake resistor assembly for R1...R3 \(page 75\)](#).

Connection diagram

Refer section [Connection diagram \(page 83\) \(IEC\)](#).

Connection procedure

Refer section

Connect the thermal switch of the brake resistor as described in [Protecting the system against thermal overload \(page 188\)](#).

■ Start-up

Start-up



CAUTION Make sure that there is sufficient ventilation. New brake resistors can have a protective grease coating. When the resistor warms up for the first time, the grease burns off and can produce some smoke.

Set the following parameters (HVAC control program):

- Set parameter 30.30 Overvoltage control to disable.
- Set parameter 31.01 External event 1 source to point to the digital input where the thermal switch of the brake resistor is wired.
- Set parameter 31.02 External event 1 type to Fault.
- Check the resistance value of parameter 43.10 Brake resistance.

With these parameter settings, the drive stops by coasting on brake resistor overtemperature.

Resistor braking, frames R4...R9

■ Planning the braking system

Frames R4...R9 need external brake choppers and resistors. The table below lists suitable choppers and resistors.

IEC

Type ACH531-01-	Brake chopper	R_{min}	R_{max}	P_{BRmax}	Reference resistor types ¹⁾
		ohm	ohm	kW	
3-phase $U_n = 400\text{ V}$ (380...415 V)					
062A-4	ACS-BRK-D	7.8	18.1	30	Built in with the brake chopper
073A-4	ACS-BRK-D	7.8	13.1	42	Built in with the brake chopper
088A-4	ACS-BRK-D	7.8	10.7	51	Built in with the brake chopper
106A-4	NBRA-658	1.3	8.7	63	SAFUR125F500
145A-4	NBRA-658	1.3	7.1	77	SAFUR125F500
169A-4	NBRA-658	1.3	5.2	105	SAFUR200F500
206A-4	NBRA-658	1.3	4.3	126	SAFUR200F500
246A-4	NBRA-658	1.3	3.5	156	2xSAFUR125F500
293A-4	NBRA-658	1.3	2.9	187	2xSAFUR210F575

Type ACH531-01-	Brake chopper	R_{min}	R_{max}	P_{BRmax}	Reference resistor types ¹⁾
		ohm	ohm	kW	
363A-4	NBRA-659	0.7	2.4	227	2xSAFUR200F500
430A-4	NBRA-659	0.7	1.9	284	2xSAFUR200F500

¹⁾ Other resistors can be used if they meet the minimum resistance value and required power values.

Symbols	
R_{min}	= minimum allowed brake resistor that can be connected to the brake chopper
R_{max}	= maximum allowed brake resistor that allows P_{BRmax}
P_{BRmax}	= maximum braking capacity of the drive, must exceed the desired braking power.



⚠ WARNING Do not use a brake resistor with a resistance below the minimum value specified for the particular drive. The drive and the internal chopper are not able to handle the overcurrent caused by the low resistance.

■ Parameter settings for external braking chopper and resistor

Disable the overvoltage control of the drive with parameter 30.30 Overvoltage control.

Disable parameter 43.06 Braking chopper function as parameter group 43 Brake chopper is used for internal braking chopper and resistor only.

For more information, refer *NBRA-6xx Braking Choppers Installation and start-up guide* (3AFY58920541 [English]) and *ACS-BRK Brake Units Installation and start-up guide* (3AFY61514309 [English]).

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 actuating device of safety circuits (such as an emergency stop circuit) that stop the drive in case of danger. Another typical application is the prevention of unexpected start-up that enables short-term maintenance operations such as cleaning and work on the 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

Refer to the technical data.

Wiring

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

■ 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 multiple drives
 - 60 m (200 ft) between external power supply and first 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 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 PLC logic output value is 0, 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 (refer to 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 disconnecter.	☐
Check the STO circuit connections against the wiring diagram.	☐
Close the disconnecter 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 (refer to 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 (refer to 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 (refer to 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 (refer to 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 (refer to the firmware manual of the drive).
4. The motor coasts to a stop (if it operated). The drive will not restart while the activation switch or safety relay contacts are open.
5. Deactivate the STO: Close the activation switch or reset the safety functionality that is wired to the STO connection.
6. Reset any faults before you restart the drive.



⚠ 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 $180/2p$ 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: Refer to [Safety data \(page 200\)](#). 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 \(page 195\)](#).

Note: Refer also to 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 [Validation test procedure \(page 195\)](#).

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.

Refer to 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 table shows the safety data for the Safe torque off function.

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

- The STO is a type A 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
 - STO response time: 2 ms (typical), 5 ms (maximum)
 - 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. Refer 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 in the [ABB Library](#).

15

Optional I/O extension and adapter modules

Contents of this chapter

This chapter gives the procedures for installing and starting the how to install and start up the optional CAIO-01, CHDI-01, CMOD-01 and CMOD-02 IO multifunction extension modules. The chapter also contains diagnostics and technical data.

CHDI-01 115/230 V digital input extension module

■ Product overview

The CHDI-01 115/230 V digital input extension module expands the inputs of the drive control unit. It has six high voltage inputs and two relay outputs.

■ Layout and connection examples

The diagram illustrates the CHDI-01 115/230V AC digital extension module. It features a central chassis with a 'CHASSIS' label and a 'STATUS' LED. The module is connected to a power source (115/230V AC) via terminal blocks. The terminal blocks are labeled with pin numbers and functions: 70 HDI7, 71 HDI8, 72 NEUTRAL, 73 HDI9, 74 HDI10, 75 NEUTRAL, 76 HDI11, 77 HDI12, 78 NEUTRAL. The relay outputs are labeled: 50 RO4C, 51 RO4A, 52 RO4B, 53 RO5C, 54 RO5A, 55 RO5B. The module is also connected to a 'CHASSIS' ground and a 'STATUS' LED. The diagram includes a 'CHDI-01' label and a '115/230V AC digital extension' label.

4	3-pin terminal blocks for 115/230 V inputs	3	Relay outputs		
	115/230 V AC 70 HDI7 71 HDI8 72 NEUTRAL		24 V DC 50 RO4C 51 RO4A 52 RO4B		
70	HDI7	115/230 V input 1	50	RO4C	Common, C
71	HDI8	115/230 V input 2	51	RO4A	Normally closed, NC
72	NEUTRAL ¹⁾	Neutral point	52	RO4B	Normally open, NO
73	HDI9	115/230 V input 3	53	RO5C	Common, C
74	HDI10	115/230 V input 4	54	RO5A	Normally closed, NC
75	NEUTRAL ¹⁾	Neutral point	55	RO5B	Normally open, NO
76	HDI11	115/230 V input 5	1	Grounding screw	
77	HDI12	115/230 V input 5	2	Hole for mounting screw	
78	NEUTRAL ¹⁾	Neutral point	5	Diagnostic LED. Green = The extension module is powered up.	

¹⁾ Neutral points 72, 75 and 78 are connected.

■ 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

Refer [Installing option modules \(page 103\)](#).

■ 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 \(page 16\)](#) 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 cables 360 degrees under a grounding clamp on the grounding shelf of the control cables.

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

Parameter setting example for relay output

This example shows how make the 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

Parameter	Setting
15.08 RO4 ON delay	1 s
15.09 RO4 OFF delay	1 s

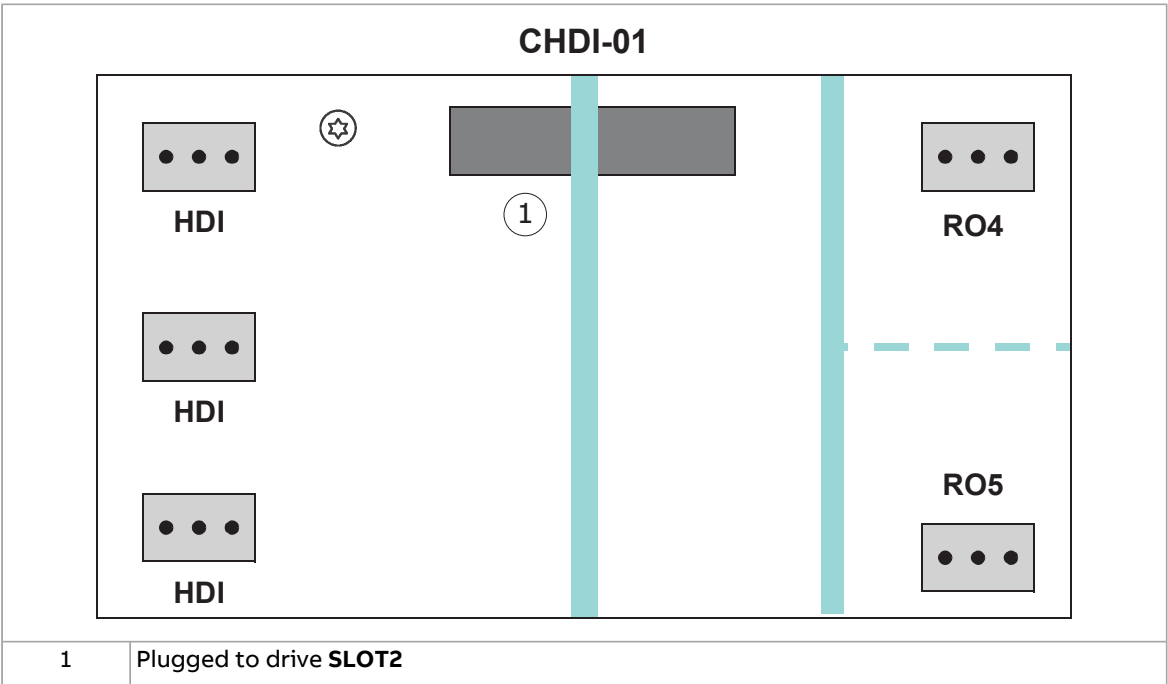
■ **Fault and warning messages**

Warning A7AB *Extension I/O configuration failure.*

■ **Technical data**

Installation	Into an option slot on the drive control unit
Degree of protection	IP20
Ambient conditions	Refer the drive technical data.
Package	Cardboard
Relay outputs (50...52, 53...55)	
Maximum wire size	1.5 mm ²
Minimum contact rating	12 V / 10 mA
Maximum contact rating	250 V AC / 30 V DC / 2 A
Maximum breaking capacity	1500 VA
115/230 V inputs (70...78)	
Maximum wire size	1.5 mm ²
Input voltage	115 to 230 V AC ±10%
Maximum current leakage in digital off state	2 mA

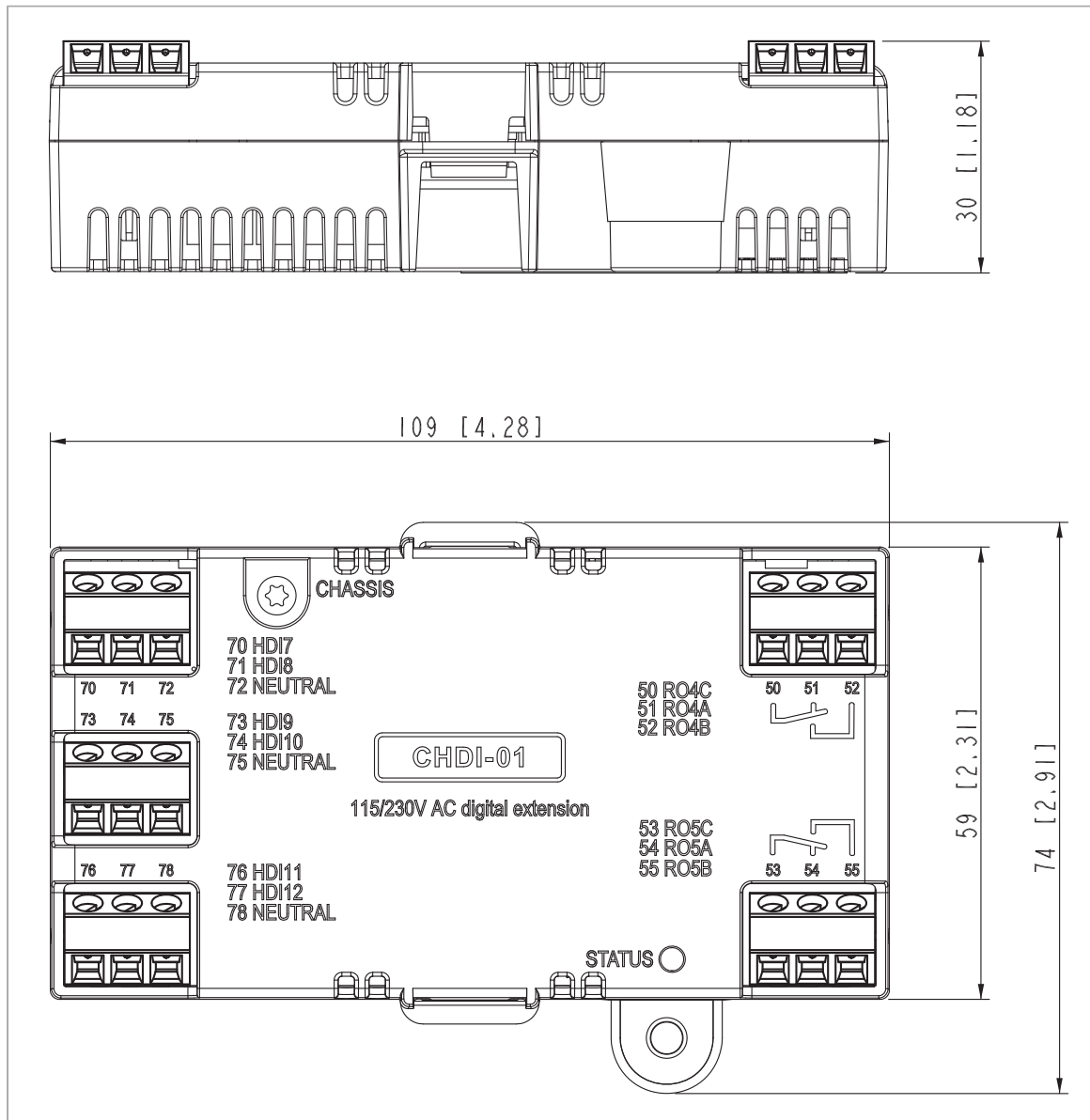
Isolation areas



	Reinforced insulation (IEC 61800-5-1:2007)
	Functional insulation (IEC 61800-5-1:2007)

■ Dimension drawing

The dimensions are in millimeters and [inches].

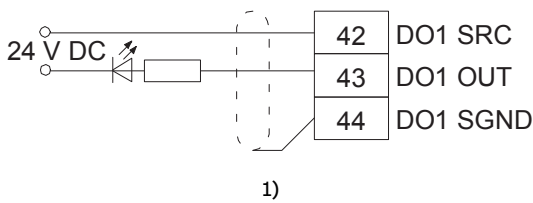
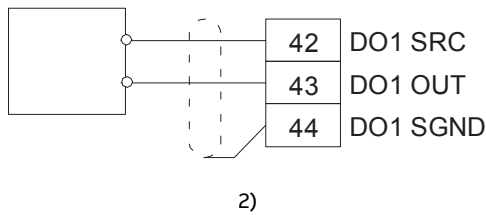


CMOD-01 multifunction extension module (external 24 V AC/DC and digital I/O)

■ 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 function 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 back-up power supply, you do not have to connect it because the module is powered from the drive control unit by default.

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

Refer section [Installing option modules \(page 103\)](#).

■ 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 \(page 16\)](#) 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 cables 360 degrees under a grounding clamp on the grounding shelf of the control cables.



⚠ 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	1000 Hz
15.37 Freq out 1 at src max	10000 Hz

Diagnostics

Faults and warning messages

Warning A7AB Extension I/O configuration failure.

LEDs

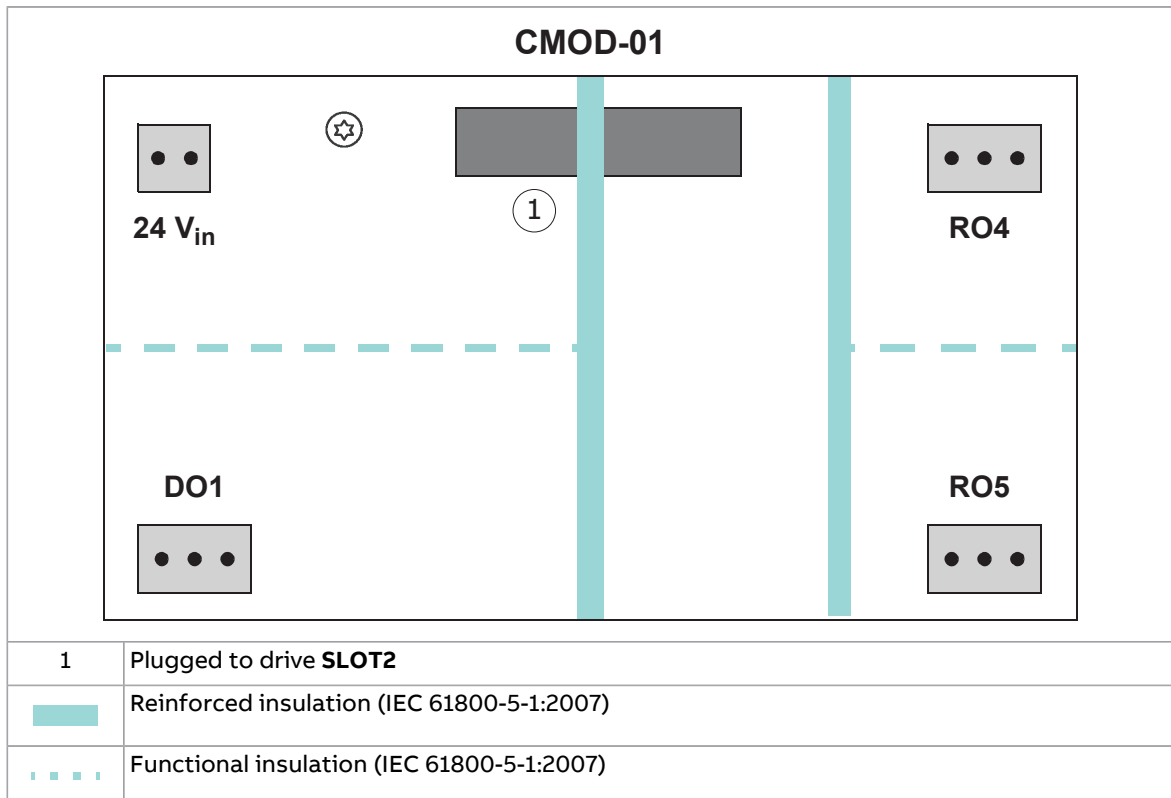
The extension module has one diagnostic LED.

Color	Description
Green	The extension module is powered up.

■ Technical data

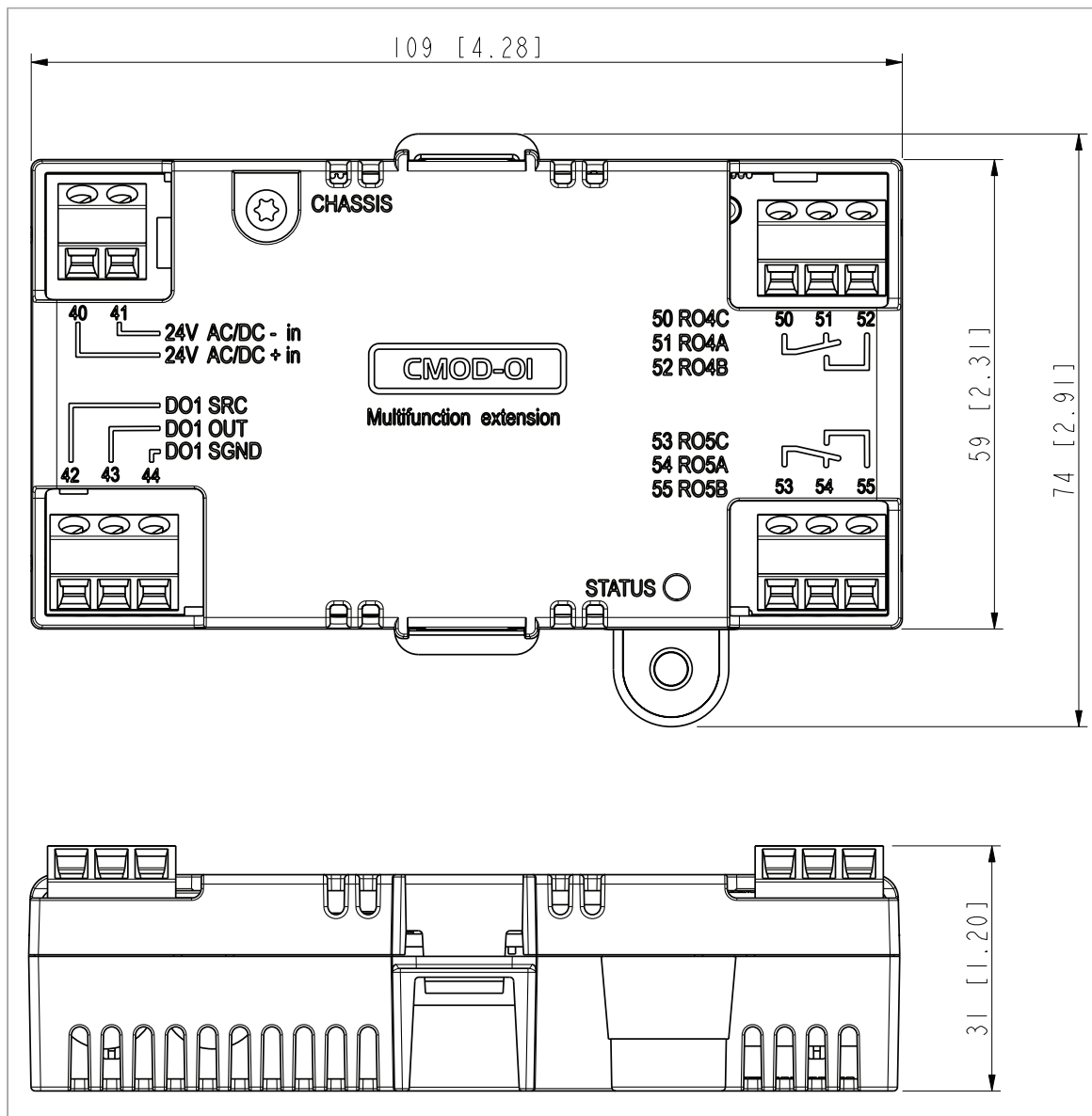
Installation	Into an option slot on the drive control unit
Degree of protection	IP20
Ambient conditions	Refer the drive technical data.
Package	Cardboard
Relay outputs (50...52, 53...55)	
Maximum wire size	1.5 mm ²
Minimum contact rating	12 V / 10 mA
Maximum contact rating	250 V AC / 30 V DC / 2 A
Maximum breaking capacity	1500 VA
Transistor output (42...44)	
Maximum wire size	1.5 mm ²
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 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



■ Dimension drawing

The dimensions are in millimeters and [inches].



CMOD-02 multifunction extension module (external 24 V AC/DC and isolated PTC interface)

■ 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.

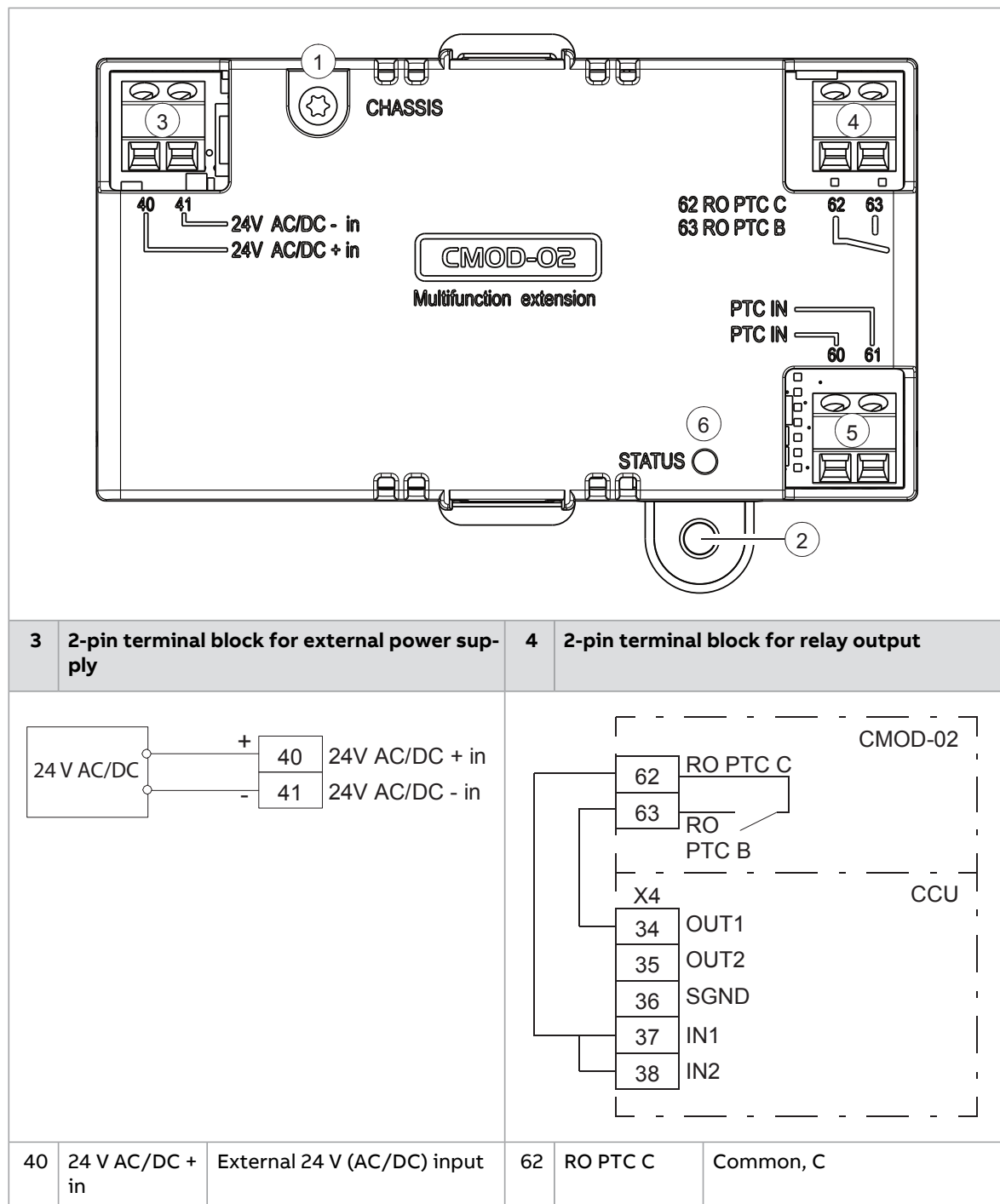
In addition, the extension module has an external power supply interface, which can be used to power up the drive control unit in case the drive power supply is not on. If

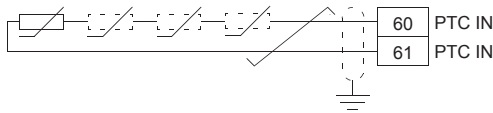
you do not need the back-up power supply, you do not have to connect it because the module is powered from the drive control unit by default.

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.

Note: 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



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

Refer section [Installing option modules \(page 103\)](#).

■ 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 \(page 16\)](#) 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 cables 360 degrees under a grounding clamp on the grounding shelf of the control cables.



▲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.

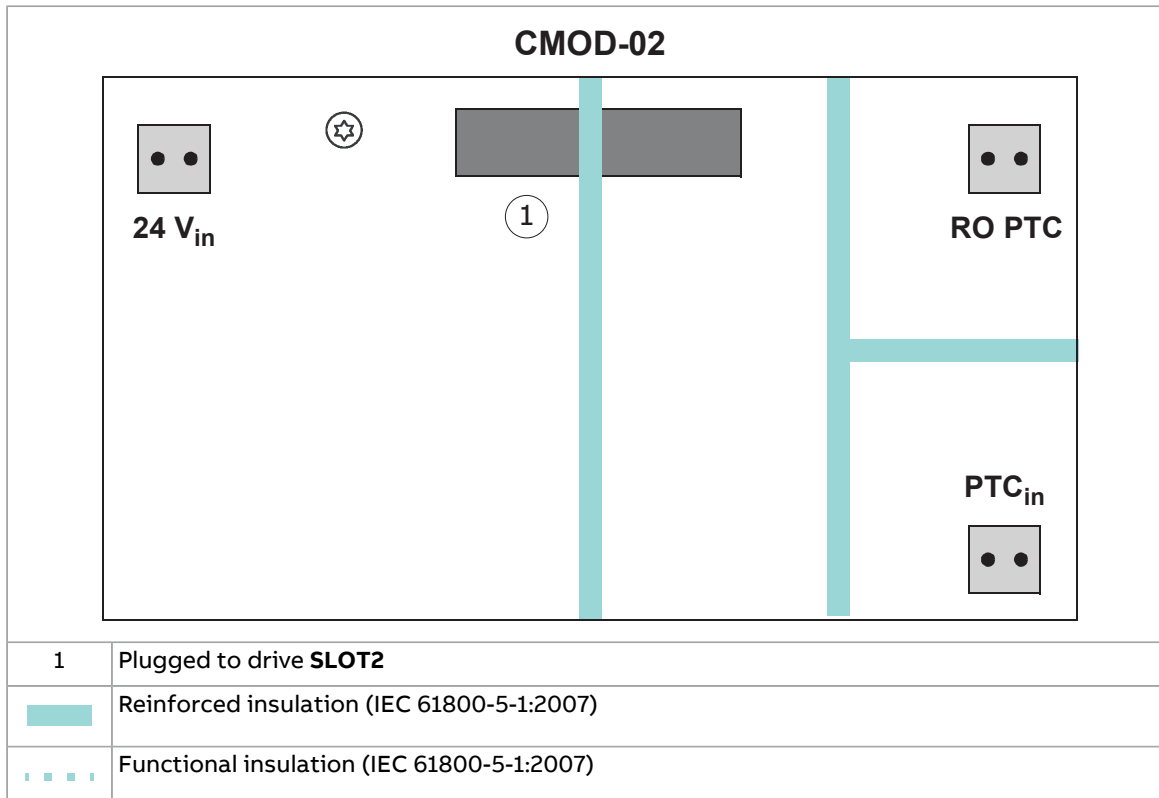
■ Technical data

Installation	Into option slot 2 on the drive control unit
Degree of protection	IP20
Ambient conditions	Refer 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)	

220 Optional I/O extension and adapter modules

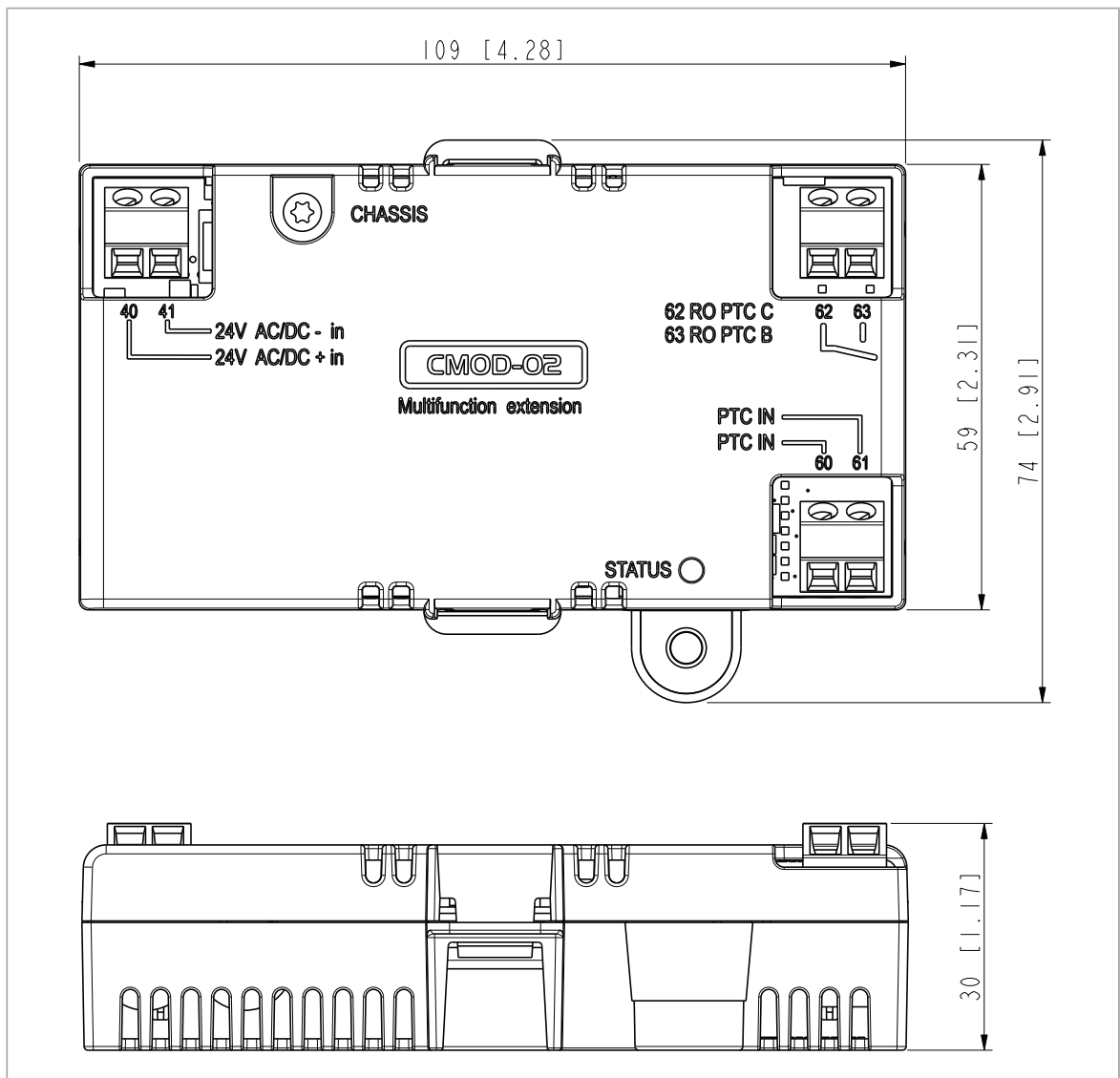
Maximum wire size	1.5 mm ²
Input voltage	24 V AC / V DC ±10% (GND, user potential)
Maximum power consumption	25 W, 1.04 A at 24 V DC

Isolation areas



■ Dimension drawing

The dimensions are in millimeters and [inches].



16

Common mode, du/dt and sine filters

Content of this chapter

This chapter describes how to select external filters for the drive.

Common mode filters

■ When is a common mode filter needed?

Refer section [Examining the compatibility of the motor and drive \(page 56\)](#).

Common mode filter kits are available from ABB, refer the table below. A kit includes three wound cores. For installation instructions of the cores, refer the instruction included in the core package.

■ Common mode filter types

IEC ratings at $U_n = 400\text{ V}$

For common mode filters for smaller types, contact your local representative.

IEC type ACH531-01-	Common mode filters ABB drives	Frame size
062A-4	64315811	R4
073A-4	64315811	R4
089A-4	64315811	R4 v2
106A-4	64315811	R5
145A-4	3AXD50000017269	R6
169A-4	3AXD50000017270	R7
206A-4	3AXD50000017270	R7
246A-4	3AXD50000018001	R8

IEC type ACH531-01-	Common mode filters ABB drives	Frame size
293A-4	3AXD50000018001	R8
363A-4	3AXD50000017940	R9
430A-4	3AXD50000017940	R9
490A-4	3AXD50000017940	R9

du/dt filters

■ When is a du/dt filter needed?

Refer section [Examining the compatibility of the motor and drive \(page 56\)](#).

Refer the table of du/dt filters below.

■ du/dt filter types

IEC ratings at $U_n = 400\text{ V}$

Type ACH531-01-	du/dt filters ABB drives	Frame size
02A7-4	LOCH0016-60 or NOCH0016-6x	R1
03A4-4	LOCH0016-60 or NOCH0016-6x	R1
04A1-4	LOCH0016-60 or NOCH0016-6x	R1
05A7-4	LOCH0016-60 or NOCH0016-6x	R1
07A3-4	LOCH0016-60 or NOCH0016-6x	R1
09A5-4	LOCH0016-60 or NOCH0016-6x	R1
12A7-4	LOCH0016-60 or NOCH0016-6x	R1
018A-4	LOCH0030-60 or NOCH0016-6x	R2
026A-4	LOCH0030-60 or NOCH0016-6x	R2
033A-4	LOCH0070-60 or NOCH0070-6x	R3
039A-4	LOCH0070-60 or NOCH0070-6x	R3
046A-4	LOCH0070-60 or NOCH0070-6x	R3
062A-4	LOCH0070-60 or NOCH0070-6x	R4
073A-4	NOCH0070-6x or NOCH0120-6x	R4
089A-4	NOCH0120-6x	R4 v2
106A-4	NOCH0120-6x	R5
145A-4	FOCH0260-70	R6
169A-4	FOCH0260-70	R7
206A-4	FOCH0260-70	R7
246A-4	FOCH0260-70	R8
293A-4	FOCH0260-70	R8
363A-4	FOCH0320-50	R9
430A-4	FOCH0320-50	R9
490A-4	FOCH0320-50	R9

■ Description, installation and technical data of the FOCH filters

Refer *FOCH du/dt filters hardware manual* (3AFE68577519 [English]).

■ Description, installation and technical data of the NOCH filters

Refer *AOCH and NOCH du/dt filters hardware manual* (3AFE58933368 [English]).

Sine filters

■ IEC ratings at $U_n = 400$ and 480 V

Type ACH531-01-	Sine filter type		Frame size
	Epcos sine filter (IP00)	Housing (IP20)	
02A7-4	B84143V0004R229	B84143Q0002R229	R1
03A4-4	B84143V0004R229	B84143Q0002R229	R1
04A1-4	B84143V0004R229	B84143Q0002R229	R1
05A7-4	B84143V0006R229	B84143Q0002R229	R1
07A3-4	B84143V0011R229	B84143Q0004R229	R1
09A5-4	B84143V0011R229	B84143Q0004R229	R1
12A7-4	B84143V0016R229	B84143Q0006R229	R1
018A-4	B84143V0016R229	B84143Q0006R229	R2
026A-4	B84143V0025R229	B84143Q0008R229	R2
033A-4	B84143V0033R229	B84143Q0008R229	R3
039A-4	B84143V0050R229	B84143Q0010R229	R3
046A-4	B84143V0050R229	B84143Q0010R229	R3
062A-4	B84143V0066R229	B84143Q0010R229	R4
073A-4	B84143V0066R229	B84143Q0010R229	R4
089A-4	B84143V0095R229	B84143Q0012R229	R4,v2
106A-4	B84143V0095R229	B84143Q0012R229	R5
145A-4	B84143V0162S229	B84143Q0014R229	R6
169A-4	B84143V0162S229	B84143Q0014R229	R7
206A-4	B84143V0230S229	B84143Q0016R229	R7
246A-4	B84143V0230S229	B84143Q0016R229	R8
293A-4	B84143V0390S229	B84143Q0018R229	R8
363A-4	B84143V0390S229	B84143Q0018R229	R9
430A-4	B84143V0390S229	B84143Q0018R229	R9
490A-4	B84143V0390S229	B84143Q0018R229	R9

■ Description, installation and technical data

Refer *Sine filters hardware manual* (3AXD50000016814 [English]).



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 new.abb.com/contact-centers.

Product training

For information on ABB product training, navigate to new.abb.com/service/training.

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