Service Guide

VLT® Enclosed Drives FC Series Enclosures D9h-D10h/E5h-E6h

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Contents

1 Introduction

1.1 Purpose of This Service Guide

This guide provides service information for D9h–D10h and E5h–E6h enclosed drive systems. It is intended to be used by authorized technicians to identify faults and perform repairs. The guide includes the following information:

- Data for different enclosed drives and options.
- Description of user interfaces and internal processing.
- Troubleshooting and test instructions.
- Assembly and disassembly instructions for enclosed drive systems.

NOTICE

DRIVE MODULE SERVICE INFORMATION

For disassembly instructions for the drive module within the enclosed drive system, see the *VLT® FC Series Service Guide for D1h–D8h, Da2/Db2/Da4/Db4, E1h–E4h, J8/J9* (130R0296). The drive module in an enclosed drive system is based on a D3h–D4h or E3h–E4h drive.

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1.2 Additional Resources

Other resources are available to understand service, installation, operations, programming, and options.

- The *VLT® FC Series Service Guide for D1h–D8h, Da2/Db2/Da4/Db4, E1h–E4h, J8/J9* (130R0296) contains test procedures and disassembly instructions for the drive module within the enclosed drive system. (Drive modules in enclosed drive systems are based on D3h–D4h/E3h–E4h drives.)
- The product-specific operating guide provides information about installation and operation of the enclosed drive.
- The product-specific programming guide provides greater detail on working with parameters and shows many application examples.
- The product-specific design guide provides detailed information about capabilities and functionality to design motor control systems.
- The *Safe Torque Off Operating Guide, VLT® Frequency Converters* provides detailed specifications, requirements, and installation instructions for the Safe Torque Off function.
- Supplementary publications and manuals are available from Danfoss.

Find these publications at www.danfoss.com.

1.3 Manual Version

This manual is regularly reviewed and updated. All suggestions for improvement are welcome.

The original language of this manual is English.

Table 1: Manual and Software Version

Version	Remarks
MG80J1XX	First version

1.4 Approvals and Certifications

The following list is a selection of possible type approvals and certifications for Danfoss drives:

CE	ErP READY		TÜVRheinland CERTIFIED Functional Safety Type Approved www.tuv.com ID 0600000000	TÜV SÜD	
c UL us	EAC	089	OSHPD	DNV·GL	ABS
BUREAU VERITAS	ClassNK	LR			RINA 1861

The specific approvals and certification for the enclosed drive or drive module are on the nameplate of the drive. For more information, contact the local Danfoss office or partner.

Thermal memory retention requirement

The enclosed drive is UL listed per UL508A and CSA 14 standards. The drive module in the enclosed drive system complies with UL 508C or UL 61800-5-1 thermal memory retention requirements. For more information on UL 508C thermal memory retention requirements, refer to the Motor Thermal Protection section in the product-specific design guide.

NOTICE

OUTPUT FREQUENCY LIMIT

Due to export control regulations, the output frequency of the enclosed drive (with no output filters) is limited to 590 Hz. For demands exceeding 590 Hz, contact Danfoss. For enclosed drives with output filters, the maximum output frequency is limited to 60 Hz without derating and to 100/120 Hz with derating.

ADN-compliance

For more information on compliance with the European Agreement concerning International Carriage of Dangerous Goods by Inland Waterways (ADN), refer to section *ADN-compliant Installation* in the product-specific *design guide*.

1.5 Disposal

Do not dispose of equipment containing electrical components together with domestic waste. Collect it separately in accordance with applicable local regulations.

1.6 Conventions

- Numbered lists indicate procedures.
- Bullet lists indicate other information and description of illustrations.
- Italicized text indicates:
  - Cross reference.
  - Link.
  - Footnote.
  - Parameter name.
  - Parameter group name.
  - Parameter option.
- All dimensions are in mm (inch).

1.7 Abbreviations

Table 2: Abbreviations, Acronyms, and Symbols

Term	Definition
°C	Degrees Celsius
°F	Degrees Fahrenheit
Ω	Ohm
AC	Alternating current
AEO	Automatic energy optimization
ACP	Application control processor
AMA	Automatic motor adaptation
AWG	American wire gauge
CPU	Central processing unit
CSIV	Customer-specific initialization values
CT	Current transformer
DC	Direct current
DVM	Digital voltmeter
EEPROM	Electrically erasable programmable read-only memory
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ESD	Electrostatic discharge
ETR	Electronic thermal relay
$f_{M,N}$	Nominal motor frequency
HF	High frequency
HVAC	Heating, ventilation, and air conditioning
Hz	Hertz

Term	Definition
I_{LIM}	Current limit
I_{INV}	Rated inverter output current
$I_{M,N}$	Nominal motor current
$I_{VLT,MAX}$	Maximum output current
$I_{VLT,N}$	Rated output current supplied by the drive
IEC	International Electrotechnical Commission
IGBT	Insulated-gate bipolar transistor
I/O	Input/output
IP	Ingress protection
kHz	Kilohertz
kW	Kilowatt
L_d	Motor d-axis inductance
L_q	Motor q-axis inductance
LC	Inductor-capacitor
LCP	Local control panel
LED	Light-emitting diode
LOP	Local operation pad
mA	Milliamp
MCB	Miniature circuit breaker
MCCB	Molded-case circuit breaker
MCO	Motion control option
MCP	Motor control processor
MCT	Motion control tool
MDCIC	Multi-drive control interface card
mV	Millivolts
NEMA	National Electrical Manufacturers Association
NTC	Negative temperature coefficient
$P_{M,N}$	Nominal motor power
PCB	Printed circuit board
PE	Protective earth
PELV	Protective extra low voltage
PHF	Passive harmonic filter
PID	Proportional integral derivative
PLC	Programmable logic controller

Term	Definition
P/N	Part number
PROM	Programmable read-only memory
PS	Power section
PTC	Positive temperature coefficient
PWM	Pulse width modulation
R_S	Stator resistance
RAM	Random-access memory
RCD	Residual current device
Regen	Regenerative terminals
RFI	Radio frequency interference
RMS	Root means square (cyclically alternating electric current)
RPM	Revolutions per minute
SCR	Silicon controlled rectifier
SMPS	Switch mode power supply
S/N	Serial number
STO	Safe Torque Off
T_{LIM}	Torque limit
$U_{M,N}$	Nominal motor voltage
V	Volt
VVC	Voltage vector control
X_h	Motor main reactance

2 Safety

2.1 Safety Symbols

The following symbols are used in this manual:

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

Indicates information considered important, but not hazard-related (for example, messages relating to property damage).

2.2 Qualified Personnel

To allow trouble-free and safe operation of the unit, only qualified personnel with proven skills are allowed to transport, store, assemble, install, program, commission, maintain, and decommission this equipment.

Persons with proven skills:

- Are qualified electrical engineers, or persons who have received training from qualified electrical engineers and are suitably experienced to operate devices, systems, plant, and machinery in accordance with pertinent laws and regulations.
- Are familiar with the basic regulations concerning health and safety/accident prevention.
- Have read and understood the safety guidelines given in all manuals provided with the unit, especially the instructions given in the operating guide of the unit.
- Have good knowledge of the generic and specialist standards applicable to the specific application.

2.3 Safety Precautions

WARNING

LACK OF SAFETY AWARENESS

This document gives important information on how to prevent injury and damage to the equipment or the system. Ignoring them can lead to death, serious injury, or severe damage to the equipment.

- Make sure to fully understand the dangers and safety measures incurred in the application.

⚠ WARNING ⚠

DISCHARGE TIME

The drive contains DC-link capacitors and, if input filter options are present, extra capacitors and inductors. These components can remain charged even when the drive is not powered. High voltage can be present even when the warning indicator lights are off.

Failure to wait the specified time after power has been removed before performing service or repair work could result in death or serious injury.

- Stop the motor.
- Disconnect AC mains, permanent magnet type motors, and remote DC-link supplies, including battery back-ups, UPS, and DC-link connections to other drives.
- Wait for the capacitors to discharge fully. The minimum waiting time is specified both in the Discharge Time table and on the nameplate on top of the drive.
- Before performing any service or repair work, use an appropriate voltage measuring device to make sure that the capacitors are fully discharged.

Table 3: Discharge Time

Drive model	Minimum waiting time
D9h/D10h	20 minutes
E5h/E6h	40 minutes

⚠ WARNING ⚠

HIGH VOLTAGE

AC drives contain high voltage when connected to AC mains input. Failure to perform installation , start-up, and maintenance by qualified personnel can result in death or serious injury.

- Only qualified personnel must perform installation, start-up, and maintenance.

⚠ WARNING ⚠

UNINTENDED START

When the drive is connected to the AC mains, DC supply, or load sharing, the motor may start at any time, causing risk of death, serious injury, and equipment, or property damage. The motor may start by activation of an external switch, a fieldbus command, an input reference signal from the LCP or LOP, via remote operation using MCT 10 Set-up software, or after a cleared fault condition.

- Press [Off] on the LCP before programming parameters.
- Disconnect the drive from the mains whenever personal safety considerations make it necessary to avoid unintended motor start.
- Check that the drive, motor, and any driven equipment is in operational readiness.

WARNING

LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the drive properly can result in death or serious injury.

- Ensure the correct grounding of the equipment by a certified electrical installer.

WARNING

ROTATING SHAFTS

Contact with rotating shafts and electrical equipment can result in death or serious injury.

- Ensure that only trained and qualified personnel perform installation, start-up, and maintenance.
- Ensure that electrical work conforms to national and local electrical codes.
- Follow the procedures in this guide.

CAUTION

HOT SURFACES

The drive contains metal components that are still hot even after the drive has been powered off. Failure to observe the high temperature symbol (yellow triangle) on the drive can result in serious burns.

- Be aware that internal components, such as busbars, may be extremely hot even after the drive has been powered off.
- Do not touch exterior areas that are marked by the high temperature symbol (yellow triangle). These areas are hot while the drive is in use and immediately after being powered off.

CAUTION

INTERNAL FAILURE HAZARD

An internal failure in the drive can result in serious injury when the drive is not properly closed.

- Ensure that all safety covers are in place and securely fastened before applying power.

3 Product Overview

3.1 Intended Use

NOTICE

OUTPUT FREQUENCY LIMIT

Due to export control regulations, the output frequency of the drive is limited to 590 Hz. For demands exceeding 590 Hz, contact Danfoss.

The enclosed drive is an electronic motor controller that converts AC mains input into a variable AC waveform output. The frequency and voltage of the output are regulated to control the motor speed or torque. Depending on the configuration, the drive can be used in standalone applications or form part of a larger system or installation. The enclosed drive is designed to:

- Regulate motor speed in response to system feedback or remote commands from external controllers.
- Provide motor overload protection.
- Monitor system and motor status.
- Reduce harmonics and increase the power factor using the optional passive harmonic filter or line reactor.
- Reduce motor acoustic noise and protect motor insulation with the optional output filters.
- Reduce bearing current and shaft voltage with the optional common-mode filter.
- Reduce high-frequency, electromagnetic noise in the motor cables with the optional dU/dt filter.
- Provide sinusoidal output with optional sine-wave filter.

The enclosed drive is designed for residential, industrial, and commercial environments in accordance with local laws and standards. Do not use this drive in applications that are non-compliant with specified operating conditions and environments.

NOTICE

RADIO INTERFERENCE

In a residential environment, this product can cause radio interference.

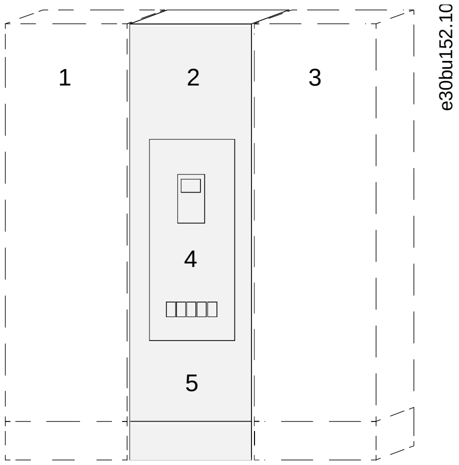
- Take supplementary mitigation measures.

3.2 What is an Enclosed Drive?

The enclosed drive is an IP21/54 (NEMA 1/12) enclosure surrounding an IP20 (Protected Chassis) drive to form the basis of the system. There are 4 enclosed drive models with varying power ratings.

- D9h model: 90–132 kW (100–200 hp).
- D10h model: 160–315 kW (200–350 hp).
- E5h model: 315–560 kW (400–600 hp).
- E6h model: 450–710 kW (600–750 hp).

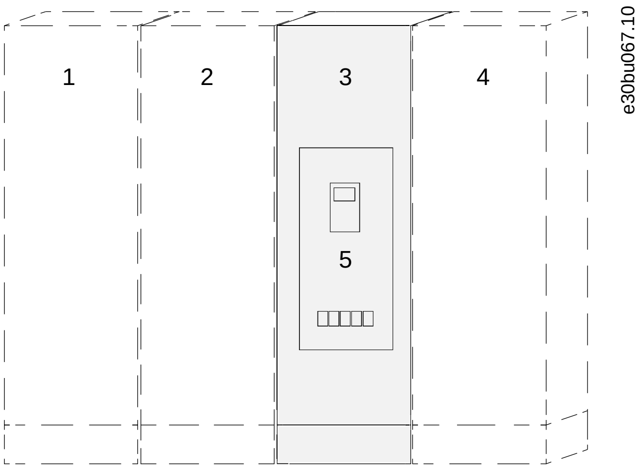
The enclosed drive is available with various power options and input and output filters to create a factory-built, custom drive. Some options and filters result in extra cabinets attached to the left or right side of the drive cabinet. These optional cabinets are shown with dotted lines, while the drive cabinet is shaded.



1	Input filter cabinet (passive harmonic filter or line reactor)	**2**	Drive cabinet
3	Sine-wave filter cabinet	**4**	Control compartment
5	Input power options [(1)]		

[1] *The D9h enclosure does not require an input power options cabinet – the input power options are placed in the drive cabinet.*

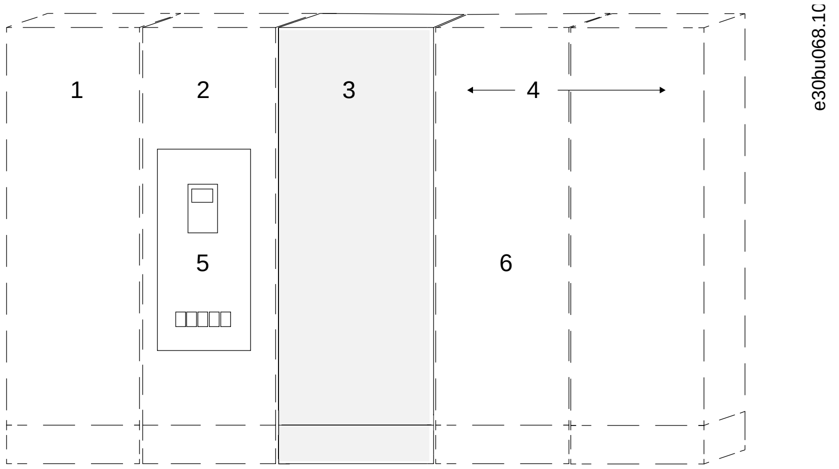
Illustration 1: Possible Configurations for a D9h Enclosed Drive



1	Input filter cabinet (passive harmonic filter or line reactor)	**2**	Input power options cabinet [(1)]
3	Drive cabinet	**4**	Sine-wave filter cabinet
5	Control compartment		

[1] *If more than 1 input power option is ordered, the D10h enclosed drive requires an input power options cabinet. Otherwise the single input power option is placed below the control compartment in the drive cabinet.*

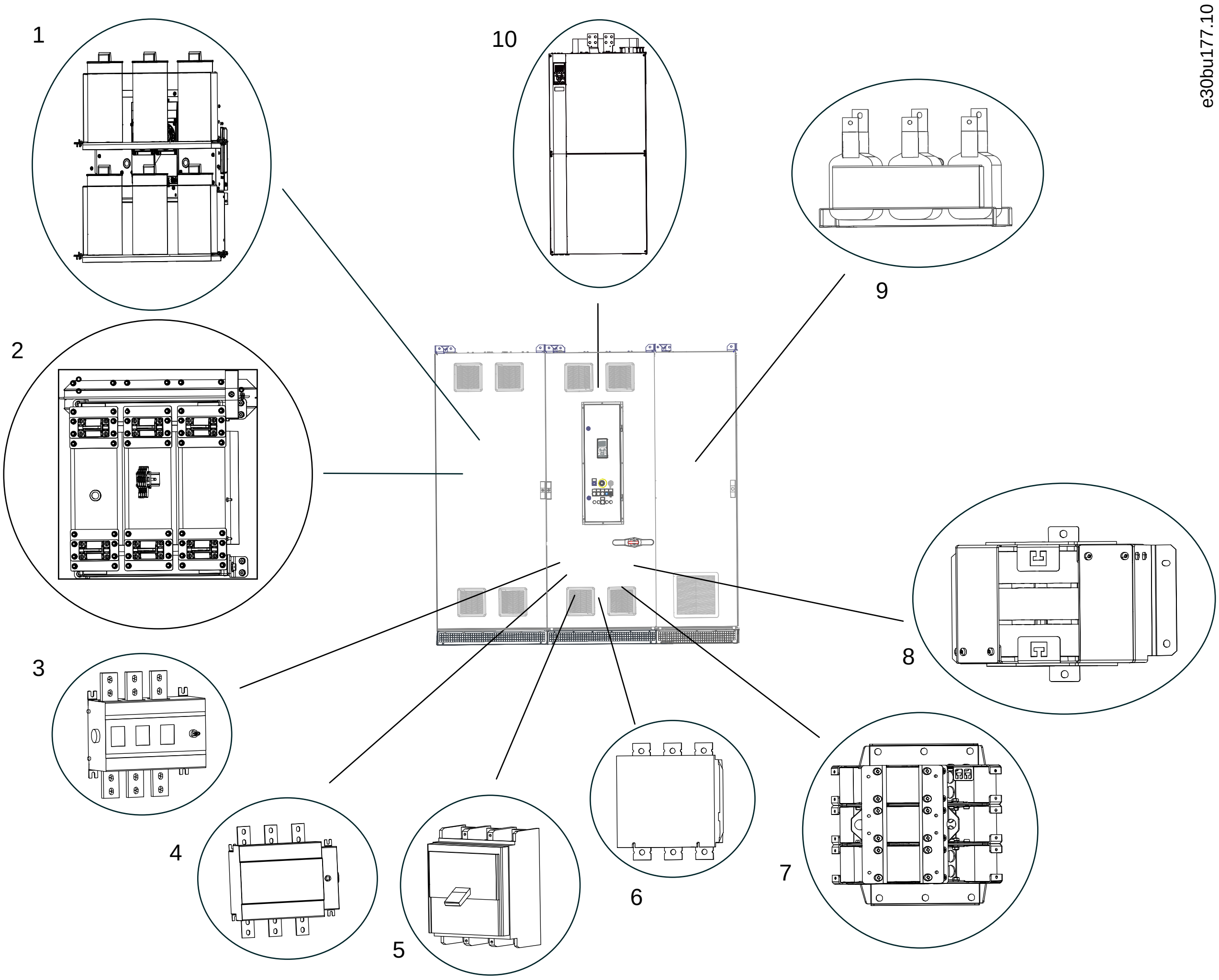
Illustration 2: Possible Configurations for a D10h Enclosed Drive



1	Input filter cabinet (passive harmonic filter or line reactor)	**2**	Input power options cabinet
3	Drive cabinet	**4**	Sine-wave filter cabinet
5	Control compartment	**6**	dU/dt filter cabinet

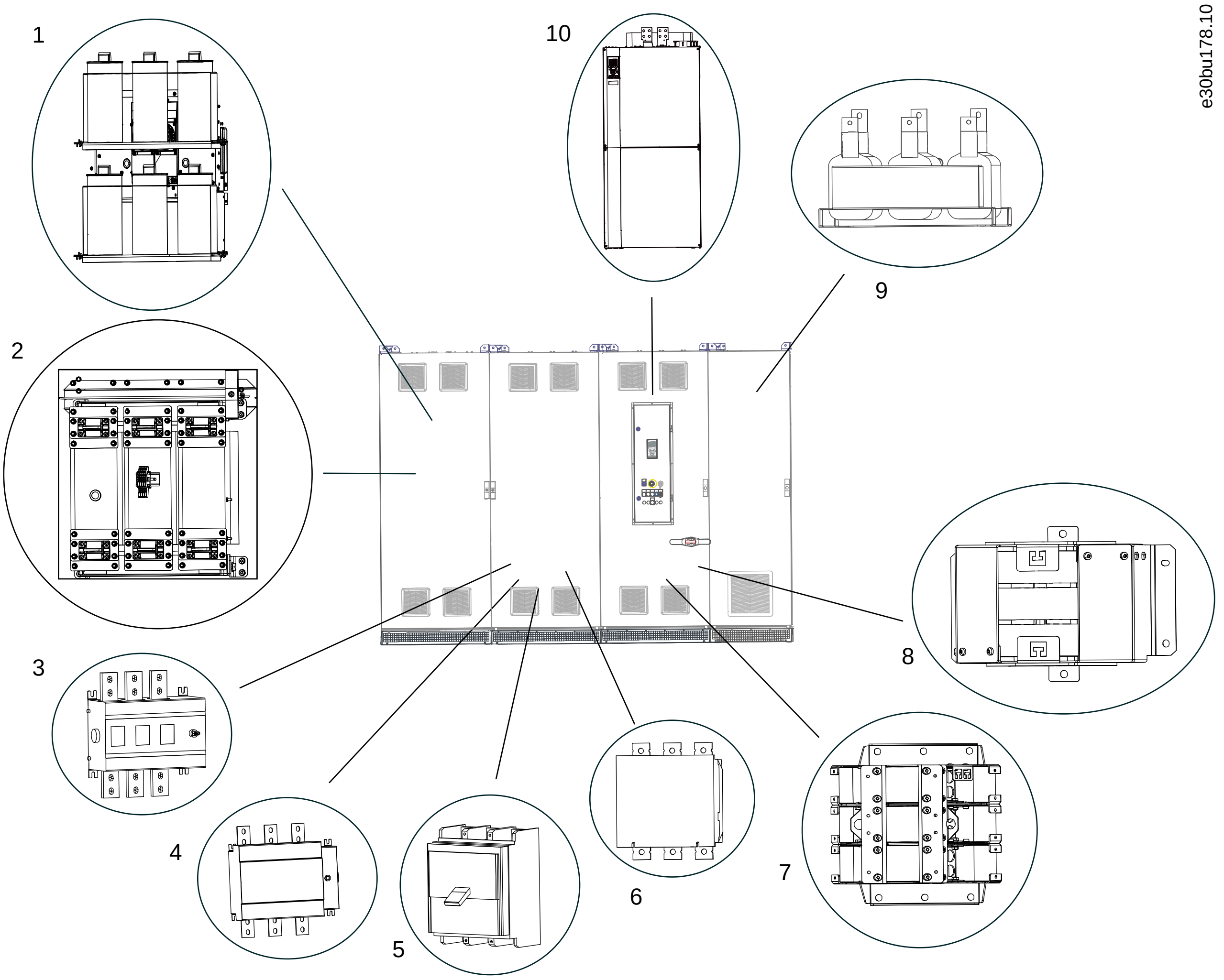
Illustration 3: Possible Configurations for an E5h or E6h Enclosed Drive

3.3 Location of Options within an Enclosed Drive



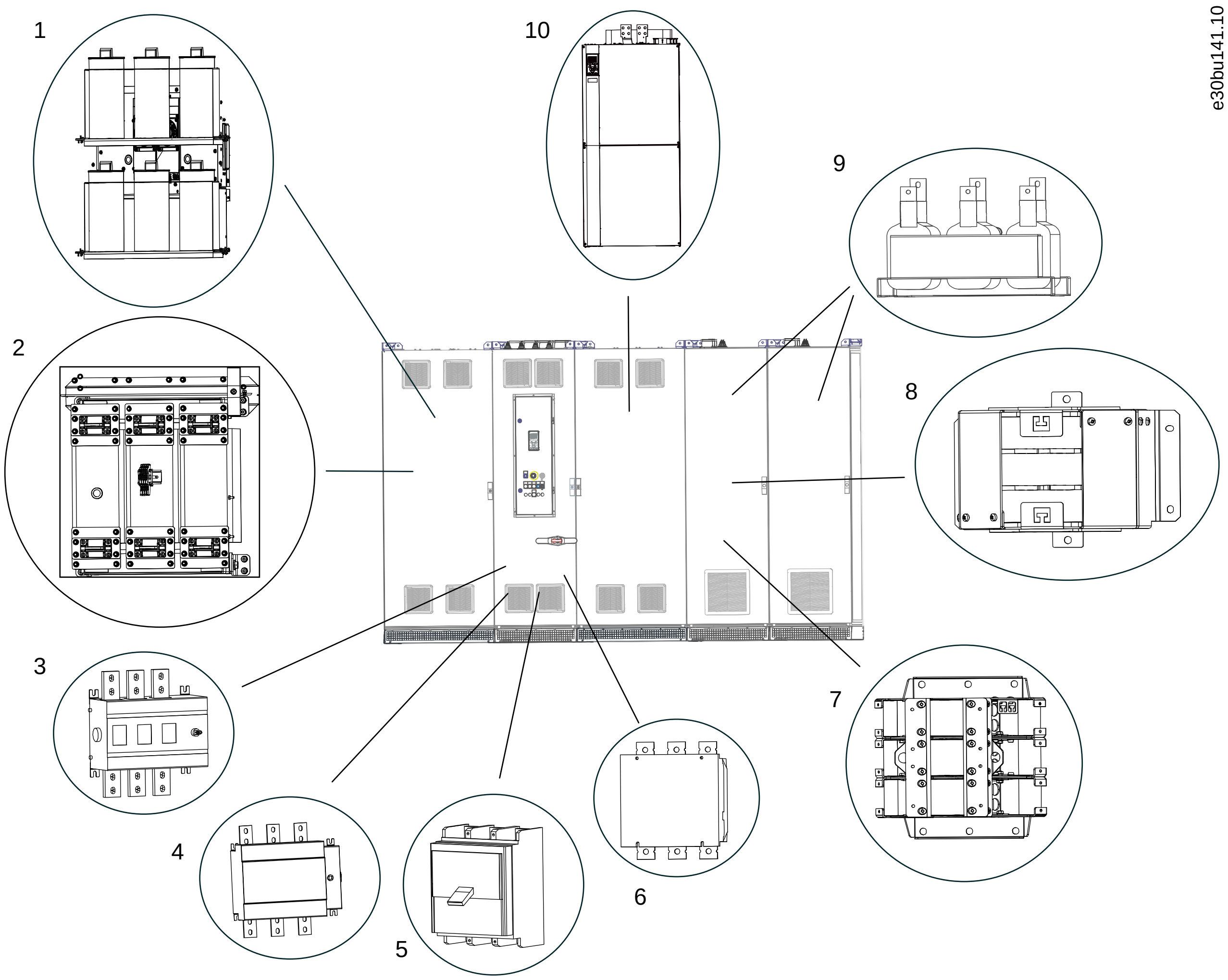
1	Passive harmonic filter (PHF)	**2**	Line reactor
3	Non-fusible disconnect	**4**	Fusible disconnect
5	Molded-case circuit breaker (MCCB)	**6**	Mains contactor
7	dU/dt filter	**8**	Common-mode filter
9	Sine-wave filter	**10**	Drive module (varies in power rating)

Illustration 4: Visual Representation of a D9h Enclosure and the Locations of Available Options



1	Passive harmonic filter (PHF)	**2**	Line reactor
3	Non-fusible disconnect	**4**	Fusible disconnect
5	Molded-case circuit breaker (MCCB)	**6**	Mains contactor
7	dU/dt filter	**8**	Common-mode filter
9	Sine-wave filter	**10**	Drive module (varies in power rating)

Illustration 5: Visual Representation of a D10h Enclosure and the Locations of Available Options

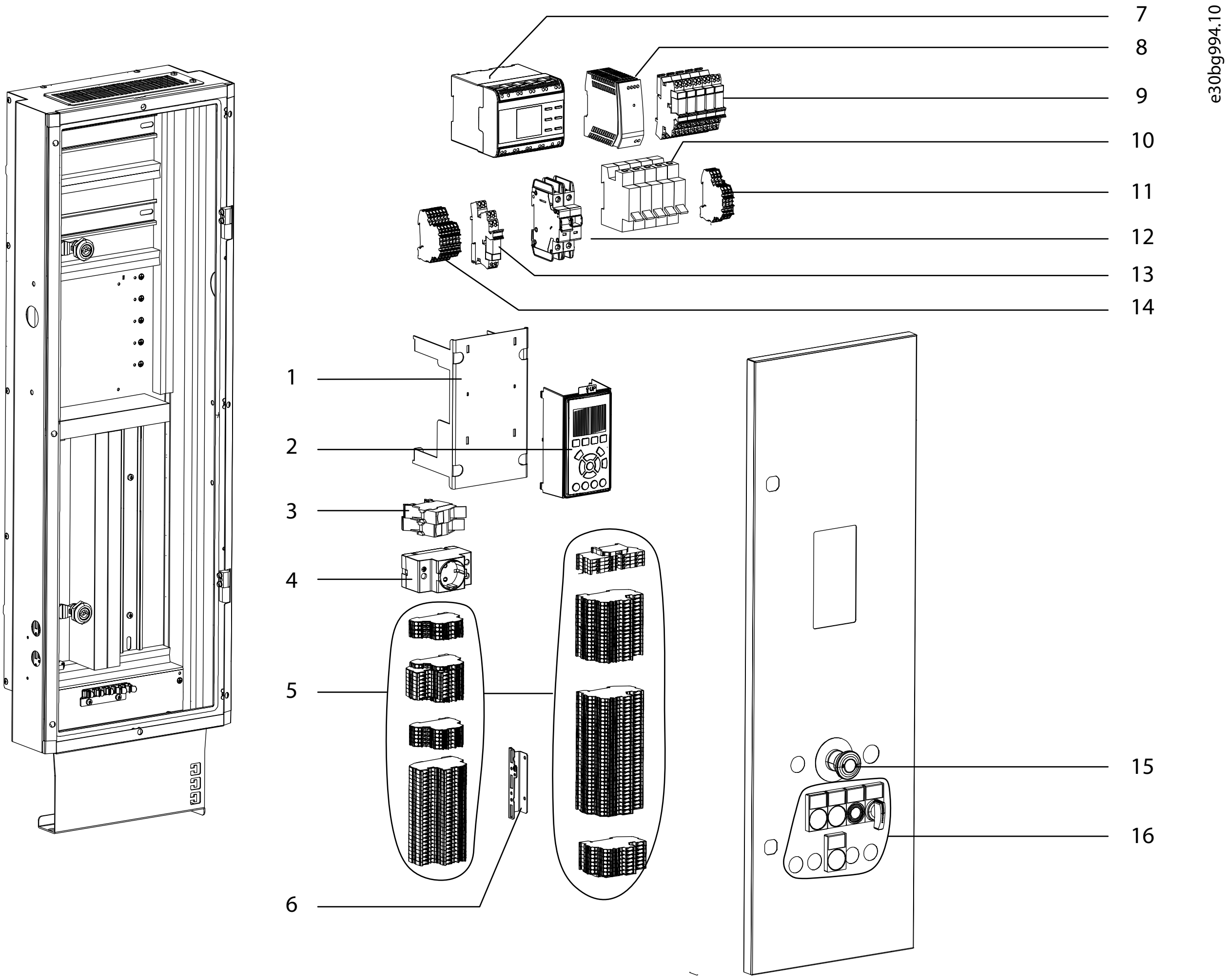


1	Passive harmonic filter (PHF)	**2**	Line reactor
3	Non-fusible disconnect	**4**	Fusible disconnect
5	Molded-case circuit breaker (MCCB)	**6**	Mains contactor
7	dU/dt filter	**8**	Common-mode filter
9	Sine-wave filter	**10**	Drive module (varies in power rating)

Illustration 6: Visual Representation of a E5h/E6h Enclosure and the Locations of Available Options

3.4 Exploded Views

3.4.1 Control Compartment

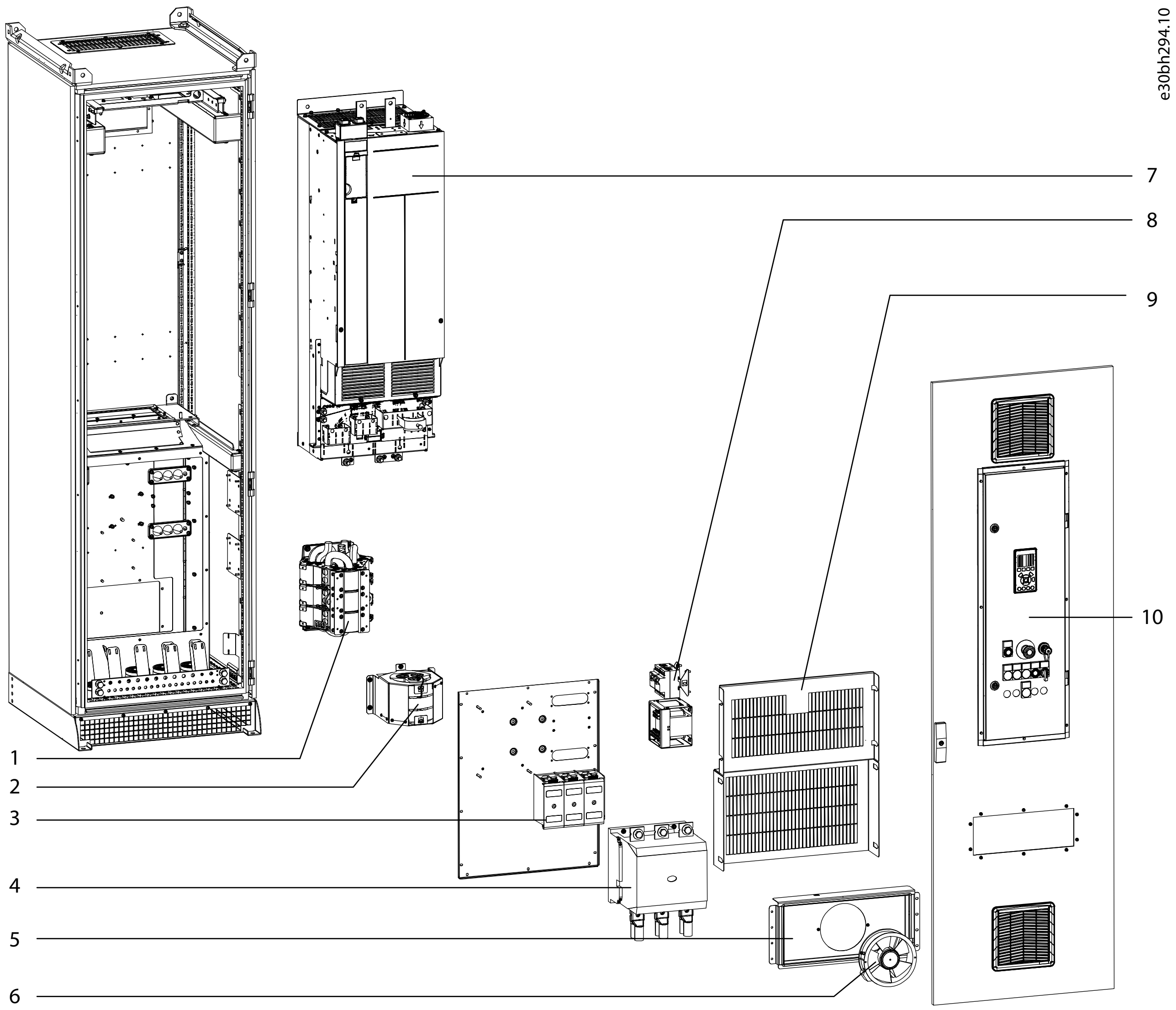


1	Local control panel (LCP) bracket	**2**	LCP
3	RJ45 terminals	**4**	Customer socket
5	Control terminals	**6**	Customer ground plate
7	Insulation monitor	**8**	24 V DC supply
9	Thermal trip relays	**10**	Miniature circuit breakers
11	DC distribution circuit terminals	**12**	AC protection miniature circuit breakers
13	Auxiliary relay for heater	**14**	AC distribution circuit terminals
15	Emergency push-button	**16**	Start switch and signal lights

Illustration 7: Control Compartment Exploded View

3.4.2 D-sized Enclosed Drive with Power Options

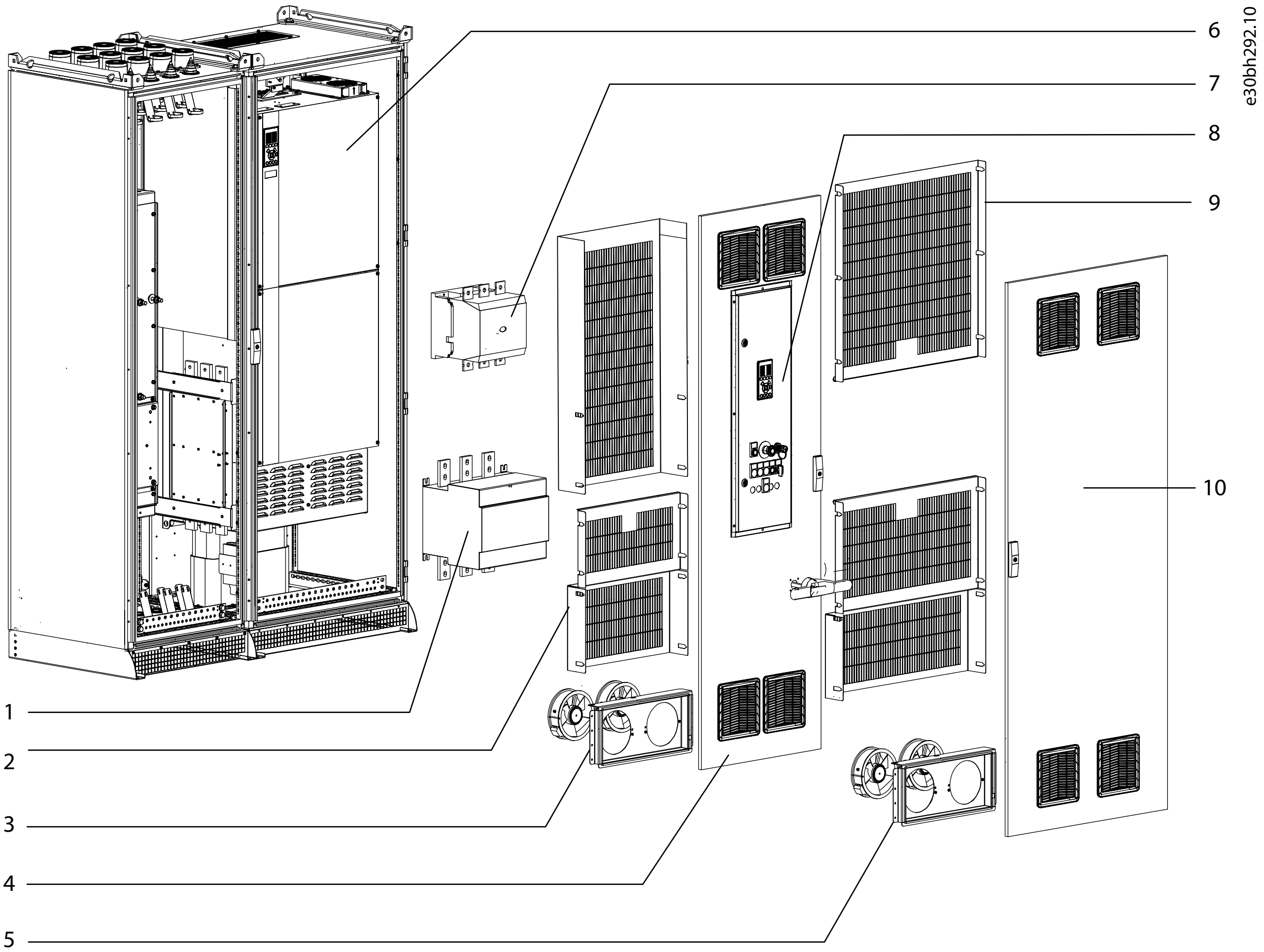
The D9h enclosed drive houses the input power options below the drive module in the same cabinet. If the D10h enclosed drive includes a single input power option, it is housed in the drive module cabinet. If more than 1 input power option is present in the D10h, all input power options are housed in a separate cabinet
.



1 dU/dt filter	**2** Common-mode filter (optional)
3 Terminal block	**4** Mains contactor (optional)
5 Door fan mounting plate	**6** Door fan
7 D10h drive module	**8** Circuit breaker (optional)
9 Safety shield	**10** Control compartment

Illustration 8: D-sized Enclosed Drive with Power Options

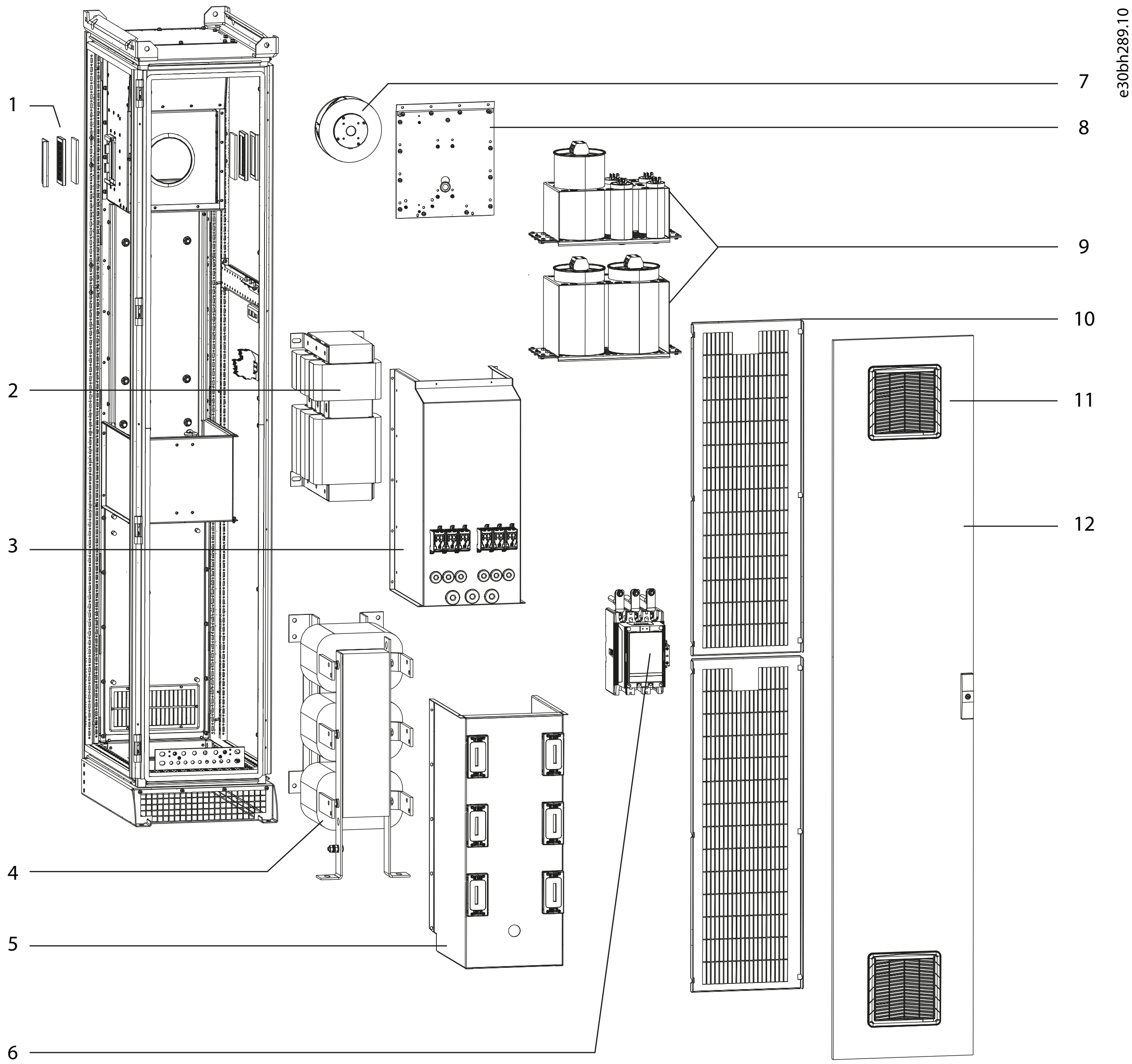
3.4.3 E-sized Enclosed Drive with Power Options



1 Non-fusible disconnect	**2** Safety shields for option cabinet
3 Door fan assembly for options cabinet	**4** Option cabinet door
5 Door fan assembly for drive module cabinet	**6** E6h drive module
7 Mains contactor	**8** Control compartment
9 Safety shields for drive module cabinet	**10** Drive module cabinet door

Illustration 9: E6h Enclosed Drive with Power Options (E5h is similar)

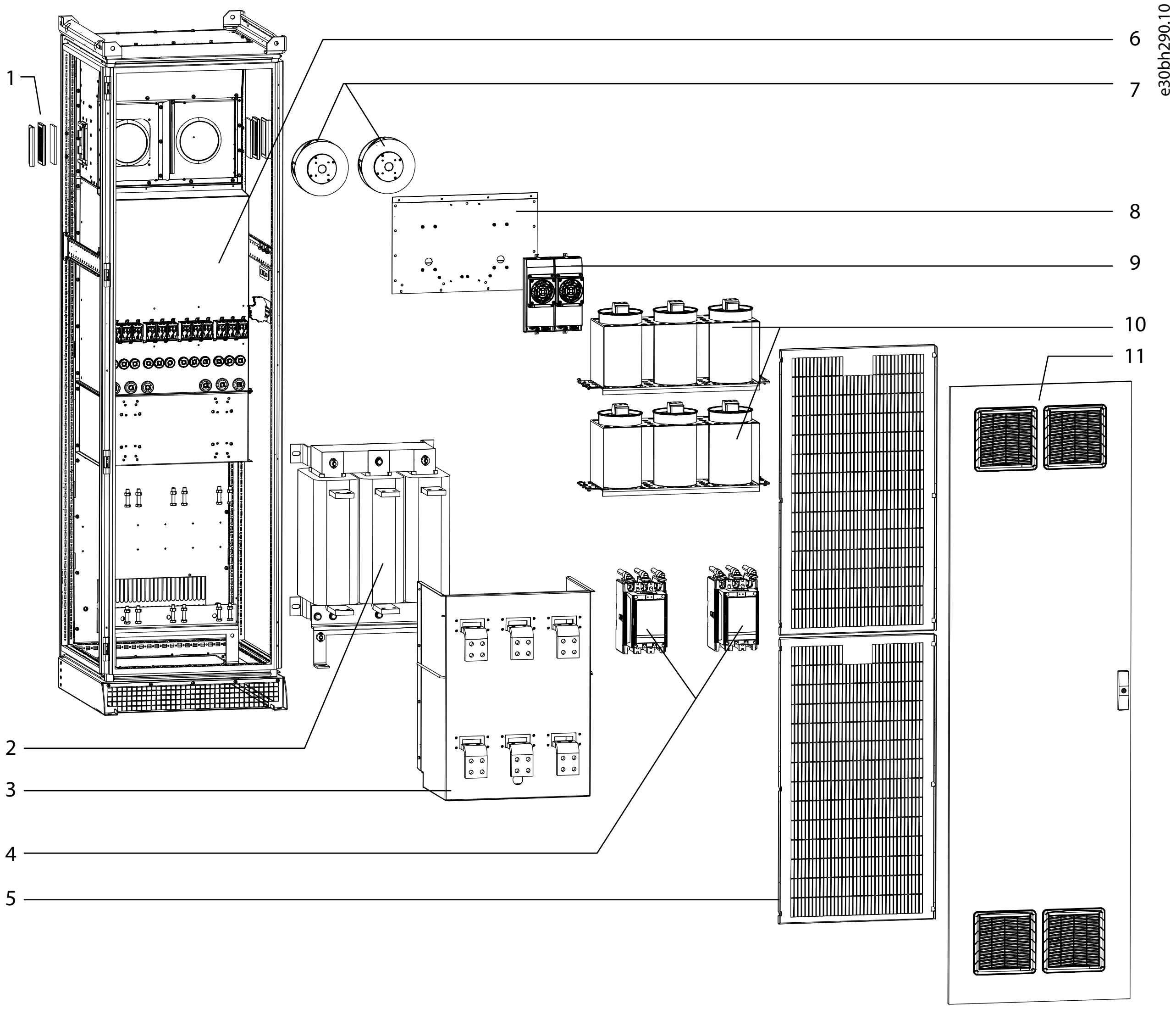
3.4.4 Passive Harmonic Filter (400 mm)



1	Back-channel air filter	**2**	Filter inductor
3	Filter inductor cover	**4**	Mains inductor
5	Mains inductor cover	**6**	PHF contactor
7	Back-channel fan	**8**	Fan mounting plate
9	Upper and lower capacitor shelves	**10**	Safety shields
11	Air filter	**12**	Cabinet door

Illustration 10: Passive Harmonic Filter (400 mm) Exploded View

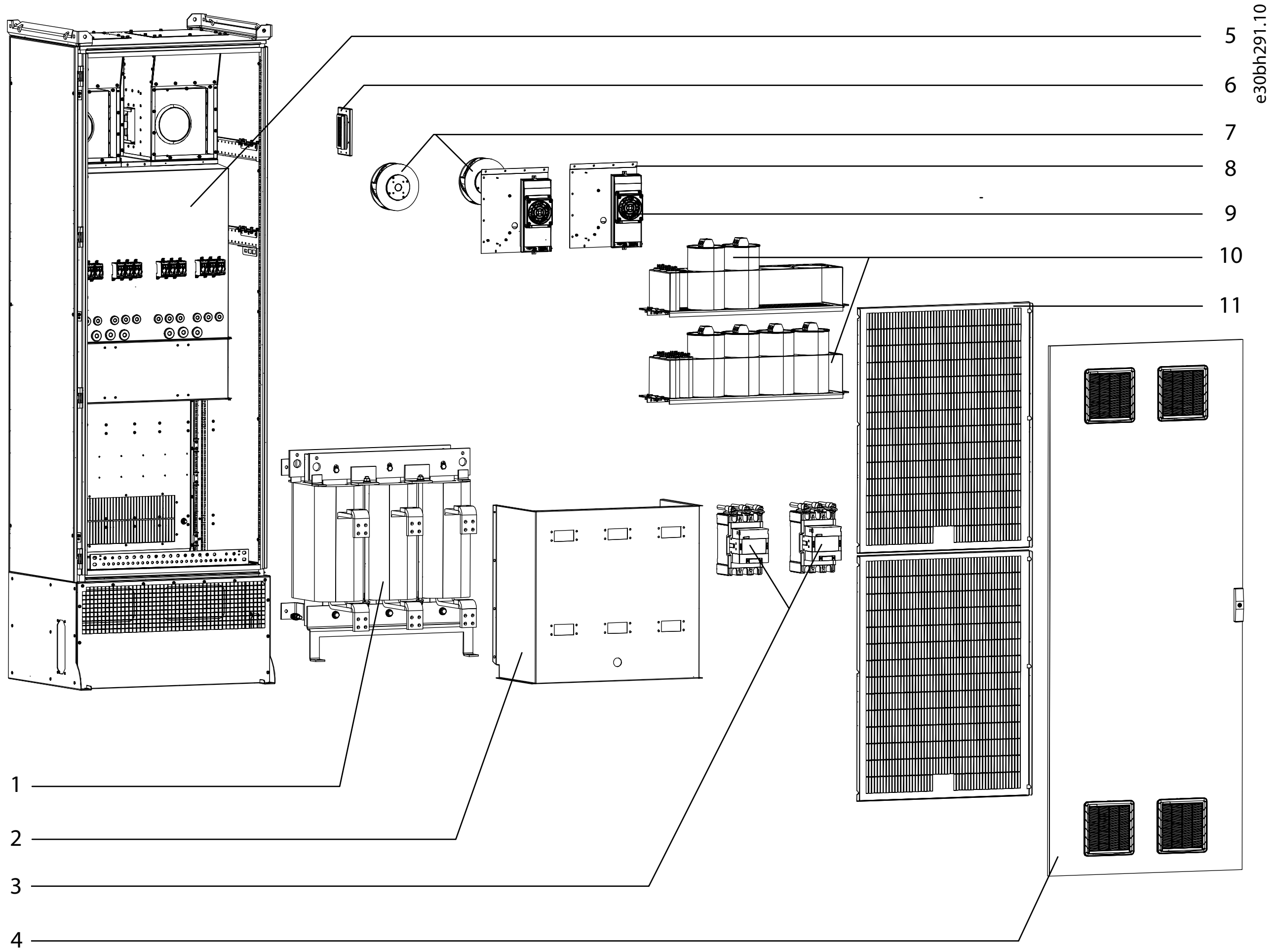
3.4.5 Passive Harmonic Filter (600 mm)



1 Back-channel air filter	**2** Mains inductor
3 Mains inductor cover	**4** PHF capacitor disconnect contactors
5 Safety shields	**6** Filter inductors
7 Back channel fans	**8** Fan mounting plate
9 Fan supply	**10** Upper and lower capacitor shelves
11 Cabinet door with air filters	

Illustration 11: Passive Harmonic Filter (600 mm) Exploded View

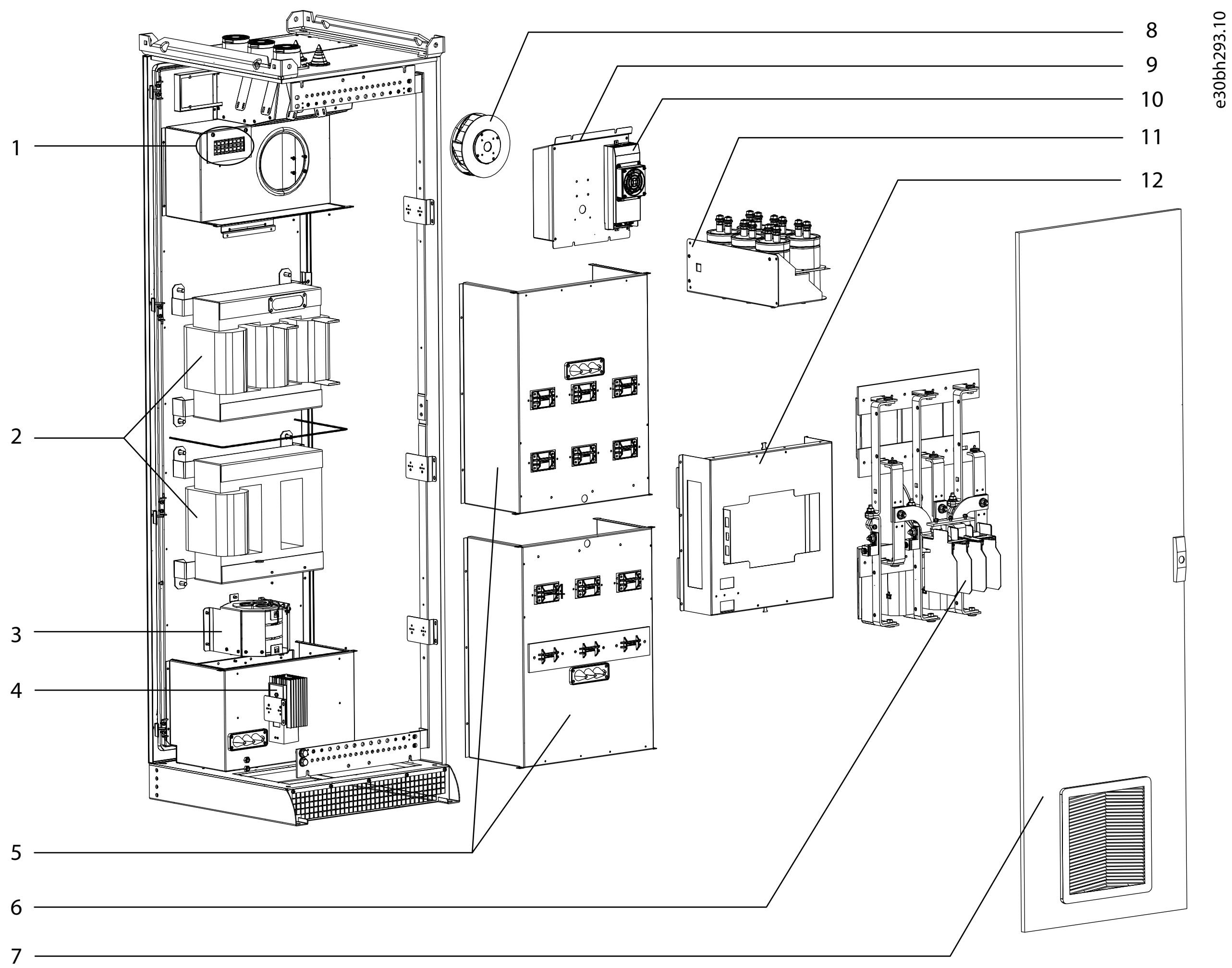
3.4.6 Passive Harmonic Filter (800 mm)



1	Mains inductor	**2**	Mains inductor cover
3	PHF capacitor disconnect contactors	**4**	Door with air filters
5	Filter inductor	**6**	Air filter for internal cooling
7	Back channel fans	**8**	Fan mounting plate
9	Fan supply	**10**	Upper and lower capacitor shelves
11	Safety shield		

Illustration 12: Passive Harmonic Filter (800 mm) Exploded View

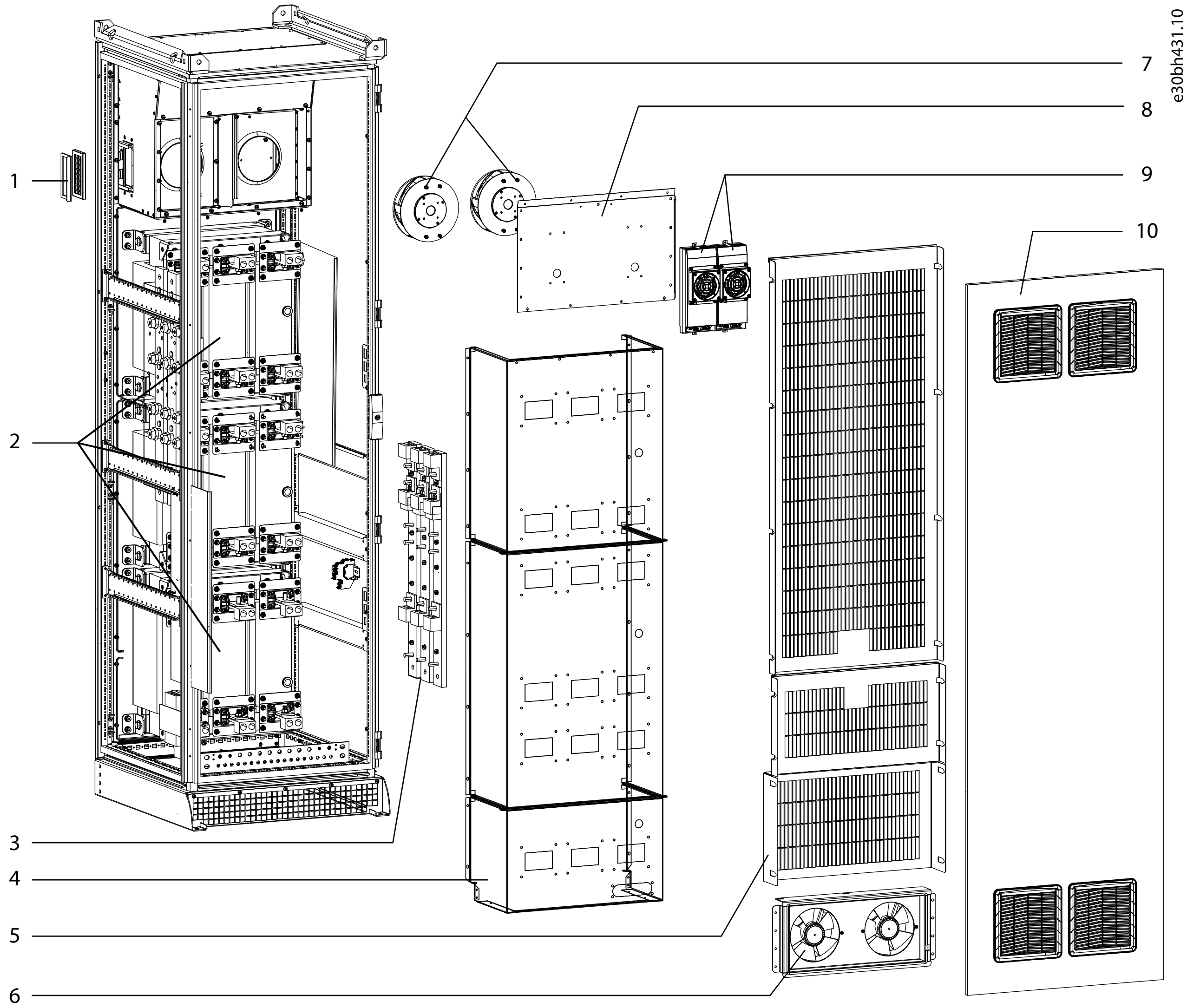
3.4.7 Sine-wave Filter



1	Internal air filter	**2**	Inductors
3	Common-mode filter	**4**	Condensation heater
5	Inductor covers	**6**	Motor terminals and busbars
7	Door with air filters	**8**	Back-channel fan
9	Fan mounting plate	**10**	Fan supply
11	Capacitor shelf	**12**	Busbar cover

Illustration 13: Sine-wave Filter Exploded View

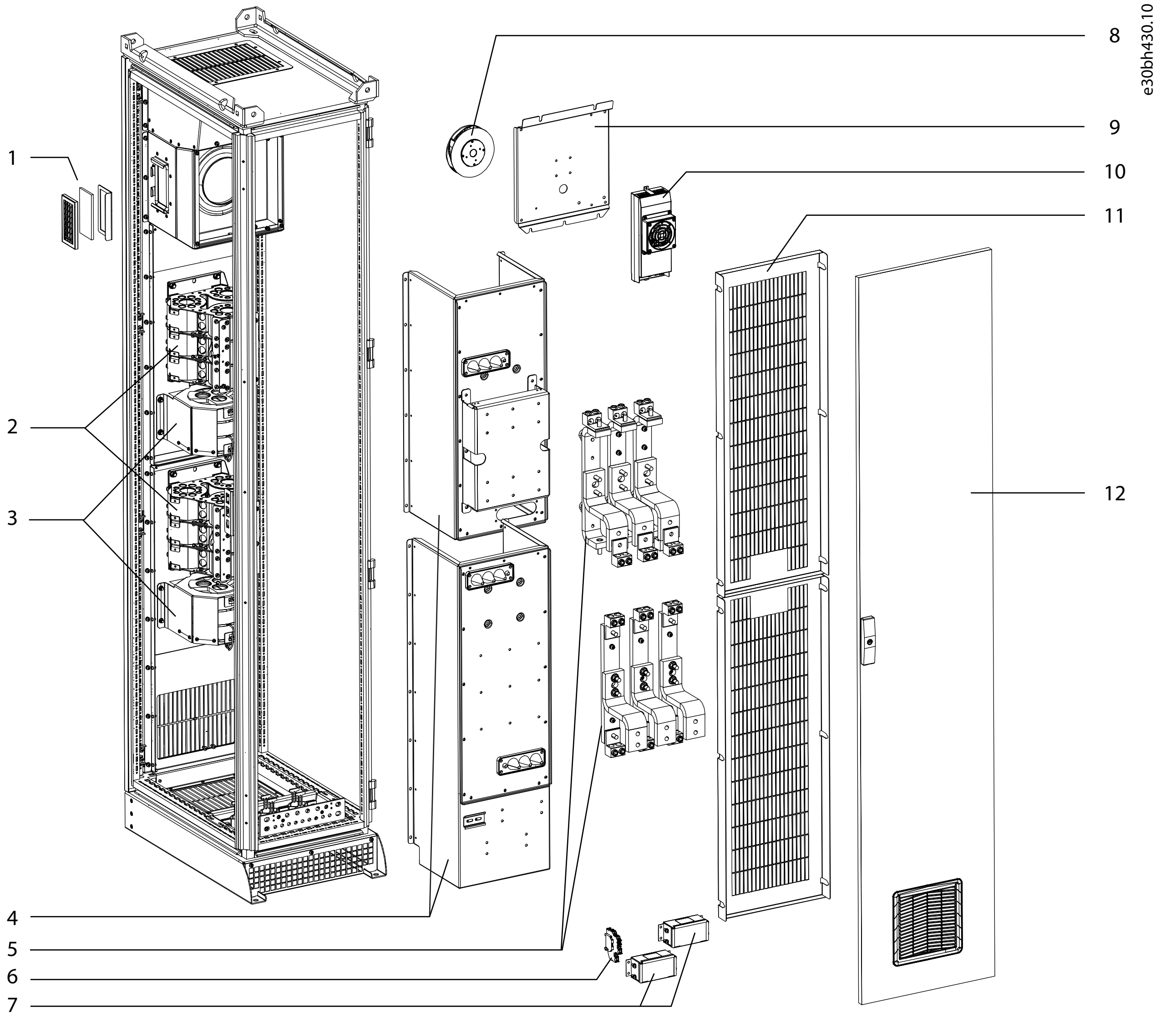
3.4.8 Line Reactor



1	Internal air filter (1 of 2 in cabinet)	**2**	Line reactors (3 shown)
3	Busbars	**4**	Line reactor covers
5	Safety shields	**6**	Door fan assembly
7	Back-channel fans	**8**	Fan mounting plate
9	Fan supply	**10**	Door with air filters

Illustration 14: Line Reactor Exploded View

3.4.9 dU/dt Filter



1 Internal air filter (1 of 2 in cabinet)	**2** dU/dt filter (2 shown)
3 Common-mode filter (2 shown)	**4** Upper and lower covers
5 Busbars	**6** Thermal magnetic circuit
7 dU/dt capacitors	**8** Back-channel fan
9 Fan mounting plate	**10** Fan supply
11 Safety shields	**12** Door with air filters

Illustration 15: dU/dt Filter Exploded View

3.5 Drive Identification

3.5.1 Identifying the Drive and Its Options

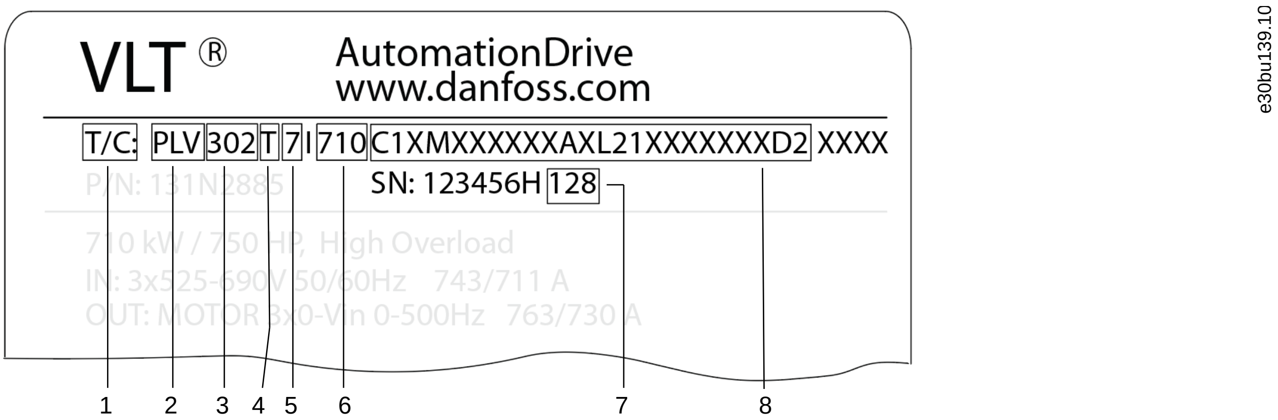
Context:

Enclosure size and specific options are used throughout this guide whenever procedures or components differ based on the drive and its options. Use the following steps to identify the enclosed drive:

Procedure

1. Locate the type code (T/C) on the nameplate. The nameplate is found on the exterior of the drive by the bottom grill and on the control compartment door.
2. Using the type code, refer to 3.5.3 Type Code Identification to identify the drive.
   - **A** Product group and drive series (characters 1–6).
   - **B** Voltage rating (character 8).
   - **C** Model/power rating (characters 10–12).
3. Go to table 4 and use the model number and voltage rating to find the enclosure size.
4. To identify installed options, reference the remaining type code characters and 3.5.3 Type Code Identification.

Example:



1 Type code	**2** Product group (PLV = enclosed drive)
3 Drive series	**4** Low harmonic filter option (if any)
5 Mains voltage	**6** Model/power rating
7 Build date (wwy, where ww = the week and y = the last digit of the year)	**8** Option codes

Illustration 16: Nameplate and Type Code Identification

3.5.2 Enclosure Size Identification

Table 4: Model/power Rating by Drive Voltage

Model/power rating	Enclosure size (380–500 V)	Enclosure size (525–690 V)
N90K	D9h	D9h
N110	D9h	D9h
N132	D9h	D9h
N160	D10h	D10h
N200	D10h	D10h
N250	D10h	D10h
N315	E5h	D10h
N355	E5h	E5h
N400	E5h	E5h
N450	E6h	–
N500	E6h	E5h
N560	–	E5h
N630	–	E6h
N710	–	E6h

3.5.3 Type Code Identification

Table 5: Product Group Code

Character position	Code	Description
1–3	PLV	VLT® Enclosed Drives

Table 6: Drive Series Codes

Character position	Code	Description
4–6	102	VLT® HVAC Drive FC 102
	103	VLT® Refrigeration Drive FC 103
	202	VLT® AQUA Drive FC 202
	302	VLT® AutomationDrive FC 302

Table 7: Low-harmonic Filter Codes

Character position	Code	Description
7	T	None
	A	Active filter
	P	Passive filter, THDi=5%, 50 Hz
	H	Passive filter, THDi=8%, 50 Hz
	L	Passive filter, THDi=5%, 60 Hz
	U	Passive filter, THDi=8%, 60 Hz

Table 8: Mains Voltage Codes

Character position	Code	Description
8	4	380–480 V
	5	380–500 V
	7	525–625 V

Table 9: Norms and Standards Codes

Character position	Code	Description
9	I	IEC
	U	UL

Table 10: Power Rating Codes

Character position	Code	Description
10–12	90K	(N90K) 90 kW/125 hp
	110	(N110) 110 kW/150 hp
	132	(N132) 132 kW/200 hp
	160	(N160) 160 kW/250 hp
	200	(N200) 200 kW/300 hp
	250	(N250) 250 kW/350 hp
	315	(N315) 315 kW/450 hp
	355	(N355) 355 kW/500 hp
	400	(N400) 400 kW/550 hp
	450	(N450) 450 kW/600 hp
	500	(N500) 500 kW/650 hp
	560	(N560) 560 kW/750 hp
	630	(N639) 630 kW/900 hp
	710	(N710) 710 kW/1000 hp
	800	(N800) 800 kW/1200 hp

Table 11: Drive Module PCB Coating Codes

Character position	Code	Description
13	C	Coated PCB
	R	Coated PCB + ruggedized

Table 12: Plinth (Pedestal) Codes

Character position	Code	Description
14	1	100 mm high pedestal
	2	200 mm high pedestal
	4	400 mm high pedestal
	5	Marine pedestal

Table 13: Drive Module Braking and Safety Codes

Character position	Code	Description
15	X	No brake IGBT
	B	Brake IGBT
	T	Safe Torque Off
	U	Brake IGBT + Safe Torque Off

Table 14: Mains Option Codes

Character position	Code	Description
16–17	MX	None
	M1	Fusible disconnect
	M2	Non-fusible disconnect
	M3	Circuit breaker (MCCB)
	M4	Mains contactor
	M5	AC reactor
	M6	Fuses
	MA	Fusible disconnect + mains contactor
	MB	Non-fusible disconnect + mains contactor
	MC	AC reactor + fusible disconnect
	MD	AC reactor + fusible disconnect + mains contactor
	ME	AC reactor + non-fusible disconnect
	MF	AC reactor + circuit breaker (MCCB)
	MG	AC reactor + mains contactor
	MH	AC reactor + non-fusible disconnect + mains contactor

Table 15: Output Filter Codes

Character position	Code	Description
18	X	None
	D	dU/dt filter
	S	Sine-wave filter
	C	Common-mode filter
	1	Common-mode + dU/dt filters
	2	Common-mode + sine-wave filters

Table 16: Reserved Code

Character position	Code	Description
19	X	None

Table 17: Cable Infeed Codes

Character position	Code	Description
20	X	Bottom
	T	Top
	L	Mains top, motor bottom
	M	Mains bottom, motor top

Table 18: Auxiliary Power Supply Codes

Character position	Code	Description
21	1	230 V AC external
	2	230 V AC internal
	4	230 V AC internal + 24 V DC internal
	5	230 V AC external + 24 V DC internal
	6	120 V AC external
	7	120 V AC internal
	8	120 V AC internal + 24 V DC internal
	9	120 V AC external + 24 V DC internal

Table 19: Back-channel Cooling Codes

Character position	Code	Description
22	X	Bottom in, top out
	1	Back in, back out
	C	Back in, top out
	D	Bottom in, back out
	N	None

Table 20: Auxiliary Function Codes

Character position	Code	Description
23–24	XX	No auxiliary options
	A1	AC socket+cabinet light
	A2	Extended I/O terminals
	A3	Cabinet heater
	A4	Motor heater control
	A5	Insulation monitor
	AA	AC socket + cabinet light + extended I/O terminals
	AB	AC socket + cabinet light + cabinet heater
	AC	AC socket + cabinet light + motor heater control
	AD	AC socket + cabinet light + insulation monitor
	AE	AC socket + cabinet light + extended I/O terminals + cabinet heater
	AF	AC socket + cabinet light + extended I/O terminals + motor heater control
	AG	AC socket + cabinet light + extended I/O terminals + insulation monitor
	AH	AC socket + cabinet light + extended I/O terminals + cabinet heater + motor heater control
	AI	AC socket + cabinet light + extended I/O terminals + cabinet heater + insulation monitor
	AJ	AC socket + cabinet light + extended I/O terminals + motor heater control + insulation monitor
	AK	AC socket + cabinet light + extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AL	AC socket + cabinet light + cabinet heater + motor heater control
	AM	AC socket + cabinet light + cabinet heater + insulation monitor
	AN	AC socket + cabinet light + cabinet heater + motor heater control + insulation monitor
	AO	AC socket + cabinet light + motor heater control + insulation monitor
	AP	Extended I/O terminals + cabinet heater
	AQ	Extended I/O terminals + motor heater control
	AR	Extended I/O terminals + insulation monitor
	AS	Extended I/O terminals + cabinet heater + motor heater control
	AT	Extended I/O terminals + cabinet heater + insulation monitor
	AU	Extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AV	Extended I/O terminals + motor heater control + insulation monitor
	AW	Cabinet heater + motor heater control
	A8	Cabinet heater + insulation monitor
	AY	Cabinet heater + motor heater control + insulation monitor
	AZ	Motor heater control + insulation monitor

Table 21: LCP Mounting Codes

Character position	Code	Description
25	L	LCP in the door
	N	No LCP in the door
	B	LCP + HMI basic
	E	LCP + HMI extended

Table 22: Protection Rating Codes

Character position	Code	Description
26–27	21	IP21
	54	IP54

Table 23: Door-mounted Codes

Character position	Code	Description
28–29	XX	None
	D1	Indicator lights and reset button
	D2	Emergency switch off + emergency push-button
	D3	STO with emergency push-button (basic functional safety)
	D4	STO/SS1 with emergency push-button + safely limited speed (TTL encoder)
	D5	STO/SS1 with emergency push-button + safely limited speed (HTL encoder)
	DA	Indicator lights and reset button + emergency switch off and emergency push-button
	DB	Indicator lights and reset button + STO with emergency push-button (no functional safety)
	DC	Indicator lights and reset button + STO/SS1 with emergency push-button + safely limited speed (TTL encoder)
	DE	Indicator lights and reset button + STO/SS1 with emergency push-button + safely limited speed (HTL encoder)

Table 24: A Option Codes

Character position	Code	Description
30	X	No A option
	0	VLT® PROFIBUS DP-V1 MCA 101
	4	VLT® DeviceNet MCA 104
	6	VLT® CANopen MCA 105
	8	VLT® EtherCAT MCA 124
	G	VLT® LonWorks MCA 108
	J	VLT® BACnet MCA 109
	L	VLT® PROFINET MCA 120
	N	VLT® EtherNet/IP MCA 121
	Q	VLT® Modbus TCP MCA 122
	T	VLT® PROFIBUS Converter VLT 300 MCA 113
	U	VLT® PROFIBUS Converter VLT 5000 MCA 114
	Y	VLT® POWERLINK MCA 123
	W	VLT® DeviceNet Converter MCA 194

Table 25: B Option Codes

Character position	Code	Description
31	X	No B option
	0	VLT® Analog I/O MCB 109
	2	VLT® PTC Thermistor Card MCB 112
	4	VLT® Sensor Input MCB 114
	K	VLT® General Purpose I/O Option MCB 101
	P	VLT® Relay Option MCB 105
	Y	VLT® Extended Cascade Controller MCO 101
	R	VLT® Encoder Option MCB 102
	U	VLT® Resolver Option MCB 103
	Z	VLT® Safety PLC Interface MCB 108
	6	VLT® Safe Option TTL MCB 150
	7	VLT® Safe Option HTL MCB 151
	8	VLT® Safety Option MCB 152

Table 26: C0 Option MCO Codes

Character position	Code	Description
32	X	No C option software
	4	VLT® Motion Control MCO 305

Table 27: C1 Option Codes

Character position	Code	Description
33	X	No C1 option
	5	VLT® Advanced Cascade Controller MCO 102
	R	VLT® Extended Relay Card MCB 113

Table 28: C Option Software Codes

Character position	Code	Description
34	X	No software option
	0	VLT® Synchronizing Controller MCO 350
	1	VLT® Positioning Controller MCO 351
	2	VLT® Center Winder MCO 352
	5	VLT® SALT Controller MCO 360

Table 29: D Option Codes

Character position	Code	Description
35	X	No D option
	0	VLT® 24-V DC Supply MCB 107

Table 30: EMC Filter Codes

Character position	Code	Description
36	2	(H2) RFI class A2 (C3)
	4	(H4) RFI class A1 (C2)
	6	IT-Grid

Table 31: Reserved Code

Character position	Code	Description
37–39	X	None

Table 32: Documentation Language Codes

Character position	Code	Description
40	X	English, no 2nd language
	G	English + German
	F	English + French

3.6 Power Ratings, Weight, and Dimensions

Table 33: Power Ratings and Dimensions for D9h–D10h and E5h–E6h Enclosures (Standard Configurations)

Enclosed drive	D9h	D10h	E5h	E6h
Rated power at 380–500 V [kW (hp)]	90–132 (125–200)	160–250 (250–350)	315–400 (450–550)	450–500 (600–650)
Rated power at 525–690 V [kW (hp)]	90–132 (100–150)	160–315 (200–350)	355–560 (400–600)	630–710 (650–750)
Protection rating	IP21 (NEMA 1)/ IP54 (NEMA 12)	IP21 (NEMA 1)/IP54 (NEMA 12)	IP21 (NEMA 1)/IP54 (NEMA 12)	IP21 (NEMA 1)/IP54 (NEMA 12)
Drive cabinet	**D9h**	**D10h**	**E5h**	**E6h**
Height [mm (in)] (1)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)
Width [mm (in)] (2)	400 (15.8)	600 (23.6)	600 (23.6)	800 (31.5)
Depth [mm (in)]	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)
Weight [kg (lb)] (2)	280 (617)	355 (783)	400 (882)	431 (950)
Input filter cabinet	**D9h**	**D10h**	**E5h**	**E6h**
Height [mm (in)] (1)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)
Width [mm (in)]	400 (15.8)	400 (15.8)/600 (23.6)	600 (23.6)	600 (23.6)/800 (31.5)
Depth [mm (in)]	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)
Weight [kg (lb)]	410 (904)	410 (904)/530 (1168)	530 (1168)	530 (1168)/955 (2105)
Input power options cabinet	**D9h**	**D10h**	**E5h**	**E6h**
Height [mm (in)] (1)	–	2100 (82.7)	2100 (82.7)	2100 (82.7)
Width [mm (in)]	–	600 (23.6)	600 (23.6)	600 (23.6)
Depth [mm (in)]	–	600 (23.6)	600 (23.6)	600 (23.6)
Weight [kg (lb)]	–	380 (838)	380 (838)	380 (838)
Sine-wave filter cabinet	**D9h**	**D10h**	**E5h**	**E6h**
Height [mm (in)] (1)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)
Width [mm (in)]	600 (23.6)	600 (23.6)	1200 (47.2)	1200 (47.2)
Depth [mm (in)]	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)
Weight [kg (lb)]				
dU/dt filter cabinet	**D9h**	**D10h**	**E5h**	**E6h**

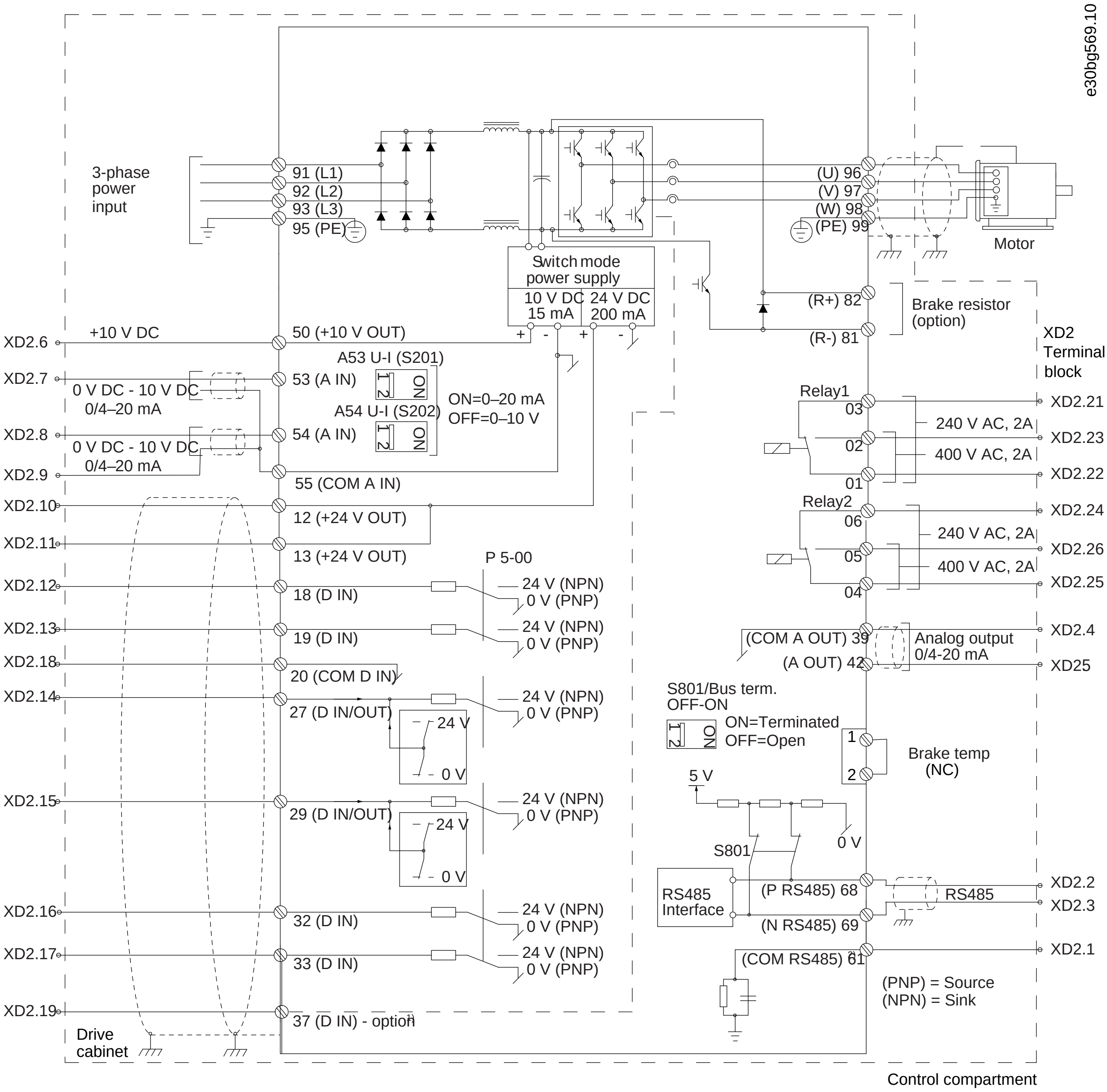
Enclosed drive	D9h	D10h	E5h	E6h
Height [mm (in)] (1)	–	–	2100 (82.7)	2100 (82.7)
Width [mm (in)] (3)	–	–	400 (15.8)	400 (15.8)
Depth [mm (in)]	–	–	600 (23.6)	600 (23.6)
Weight [kg (lb)]	–	–	240 (529)	240 (529)
Top entry/exit cabinet	**D9h**	**D10h**	**E5h**	**E6h**
Height [mm (in)] (1)	2100 (82.7)	2100 (82.7)	2100 (82.7)	2100 (82.7)
Width [mm (in)] (3)	400 (15.8)	400 (15.8)	400 (15.8)	400 (15.8)
Depth [mm (in)]	600 (23.6)	600 (23.6)	600 (23.6)	600 (23.6)
Weight [kg (lb)]	164 (362)	164 (362)	164 (362)	164 (362)

[1] *Cabinet height includes standard 100 mm (3.9 in) pedestal. A 200 mm (7.9 in) or 400 mm (15.8 in) pedestal is optional.*

[2] *Without options.*

[3] *The E5h and E6h enclosures contain 2 sine-wave cabinets. The provided width is the total of both cabinets.*

3.7 Wiring Overview for D9h and D10h Enclosed Drives



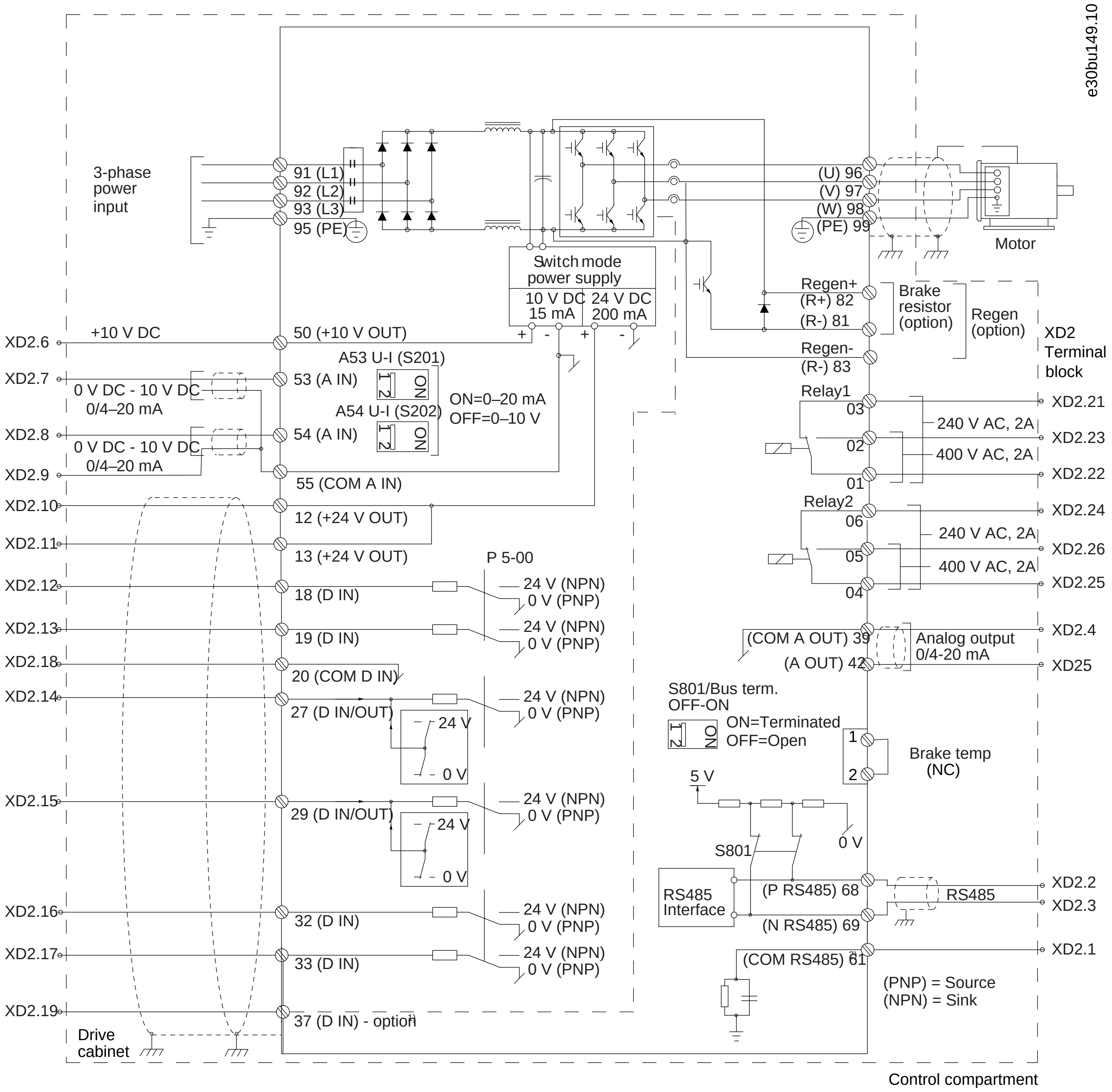
1	Terminal 37 (optional) is used for Safe Torque Off. Refer to the *VLT® FC Series - Safe Torque Off Operating Guide* for installation instructions.

Illustration 17: Basic Wiring Overview for Enclosures D9h and D10h

3.8 Wiring Overview for E5h and E6h Enclosed Drives

1 Terminal 37 (optional) is used for Safe Torque Off. Refer to the *VLT® FC Series - Safe Torque Off Operating Guide* for installation instructions.

Illustration 18: Basic Wiring Overview for Enclosures E5h and E6h



4 Control Compartment and Local Control Panel (LCP)

4.1 Safety Instructions

See 2.3 Safety Precautions for general safety warnings.

NOTICE

APPLICATIONS WITH MULTIPLE MOTORS

To provide overcurrent protection, extra protective equipment such as short-circuit protection or motor thermal protection between drive and motor is required for applications with multiple motors.

NOTICE

WIRE TYPE AND RATINGS

All wiring must comply with local and national regulations regarding cross-section and ambient temperature requirements. For power connections, minimum 75 °C (167 °F) rated copper wire is recommended.

⚠ WARNING ⚠

INDUCED VOLTAGE

Induced voltage from output motor cables that run together can charge equipment capacitors, even with the equipment turned off and locked out. Failure to run output motor cables separately or to use shielded cables could result in death or serious injury.

- Run output motor cables separately or use shielded cables.
- Simultaneously lock out all the drives.

⚠ WARNING ⚠

SHOCK HAZARD

The drive can cause a DC current in the PE conductor. Failure to use a Type B residual current-operated protective device (RCD) may lead to the RCD not providing the intended protection and therefore may result in death or serious injury.

- When an RCD is used for protection against electrical shock, only a Type B device is allowed on the supply side.

⚠ CAUTION ⚠

MOTOR OVERLOAD

Protection against motor overload is not included in the default setting. For the North American market, the ETR function provides class 20 motor overload protection in accordance with NEC. Failure to set the ETR function means that motor overload protection is not provided and property damage can occur if the motor overheats.

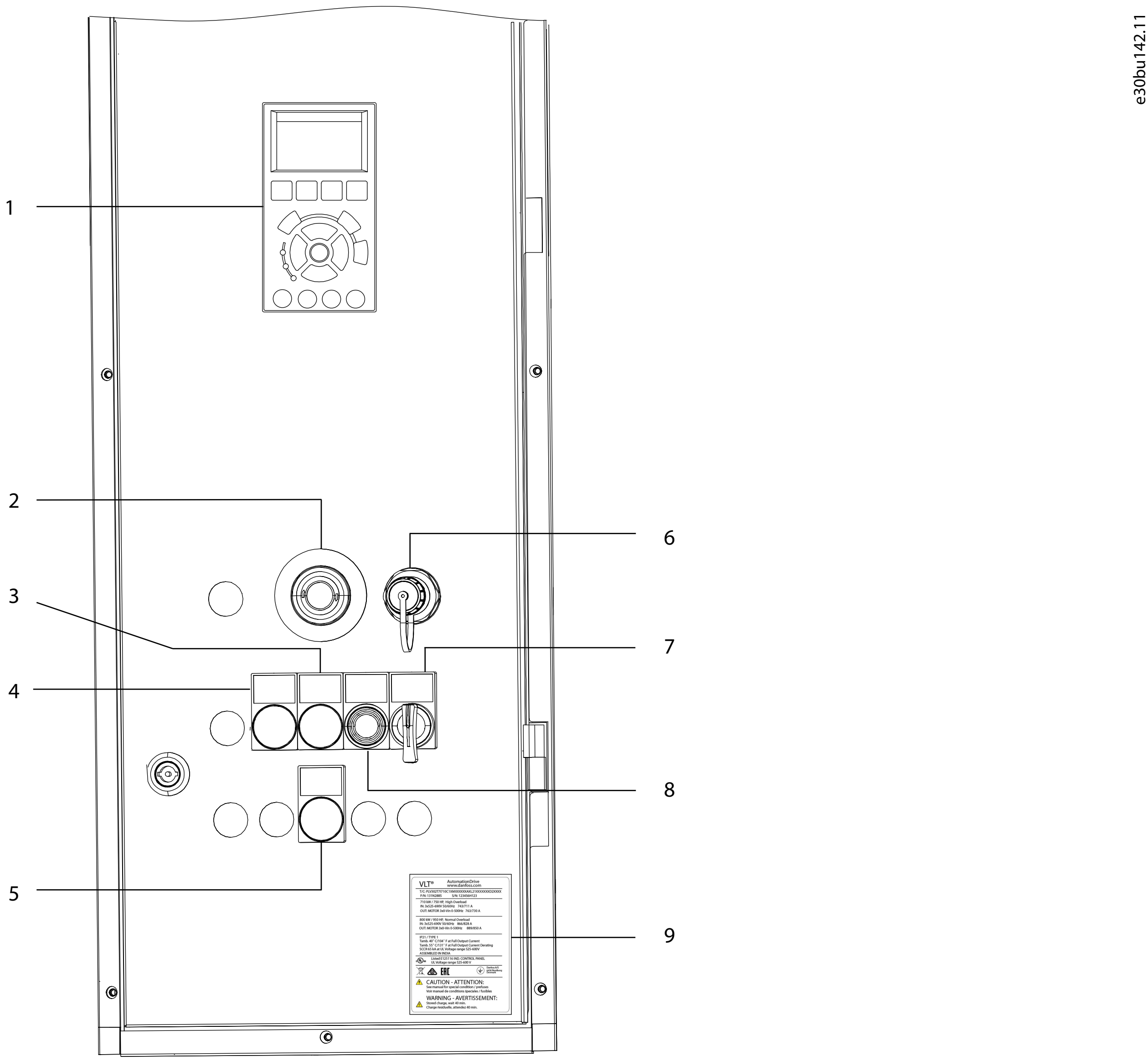
- Enable the ETR function by setting *parameter 1-90 Motor Thermal Protection* to *[ETR trip]* or *[ETR warning]*.

4.2 Control Compartment Overview

The control compartment is a self-contained space that can be accessed without opening the drive enclosure. The control compartment contains the following:

- Control terminals.
- Relay terminals.
- Terminals for option cards.
- Optional components:
  - Auxiliary supply terminals.
  - Auxiliary voltage transformer connections.
  - +24 V DC external supply.
  - AC customer socket.
  - Extended I/O terminals.
  - Cabinet heater connections.
  - Motor heater control connections.
  - Thermal trip indicator relays.
  - Insulation monitor.
  - Magnetic cabinet light.
- Buttons and indicator lights (on the exterior door).
- Local control panel (LCP).
- Product nameplate.

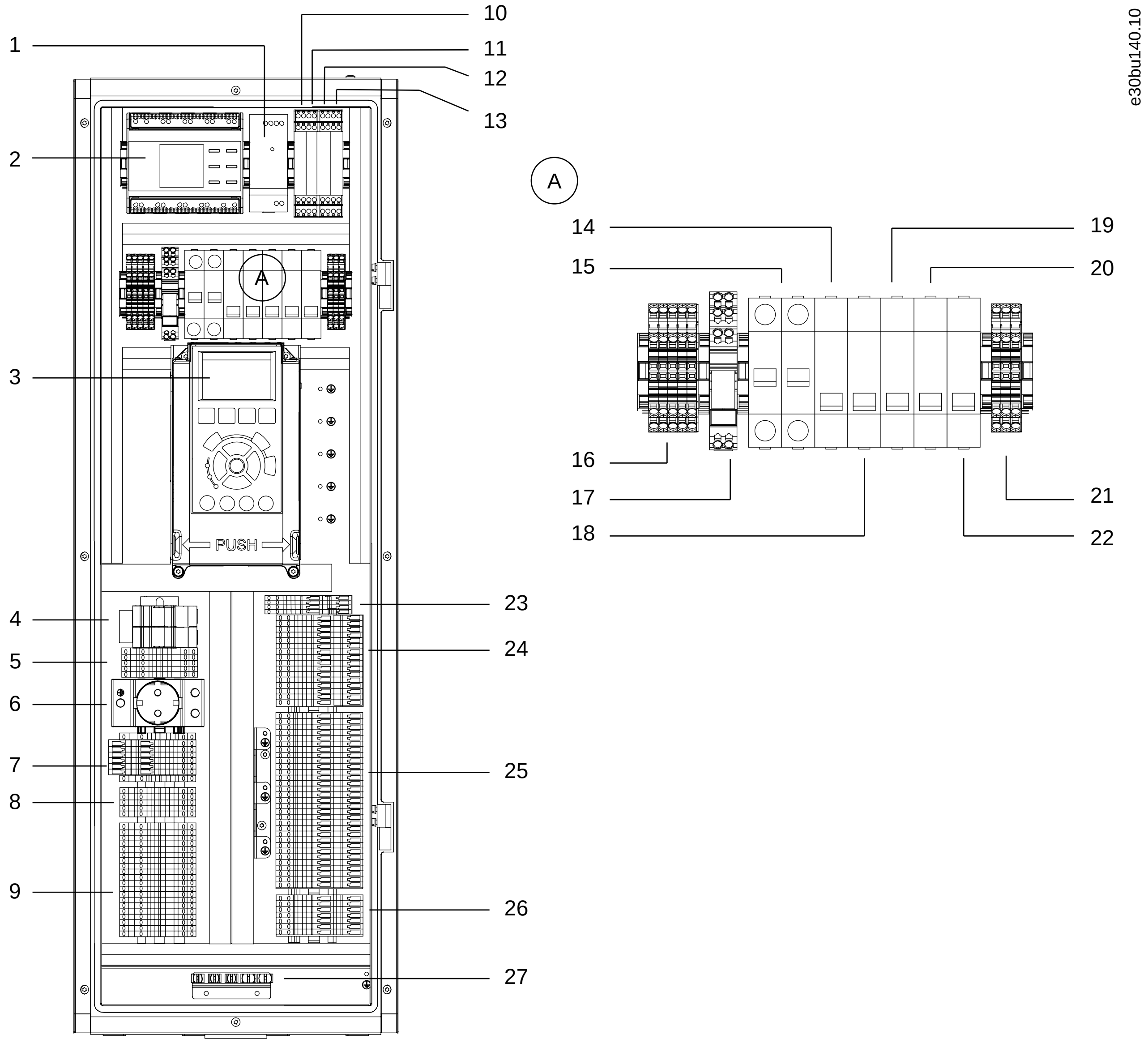
4.3 Control Compartment Door



1 Local control panel (LCP)	**2** Emergency push-button
3 Fault indicator light	**4** Run indicator light
5 Insulation fault indicator light	**6** USB slot
7 0–1 Start switch	**8** Reset button
9 Nameplate	

Illustration 19: Exterior Door of Control Compartment (Shown with All Options)

4.4 Control Compartment Interior View

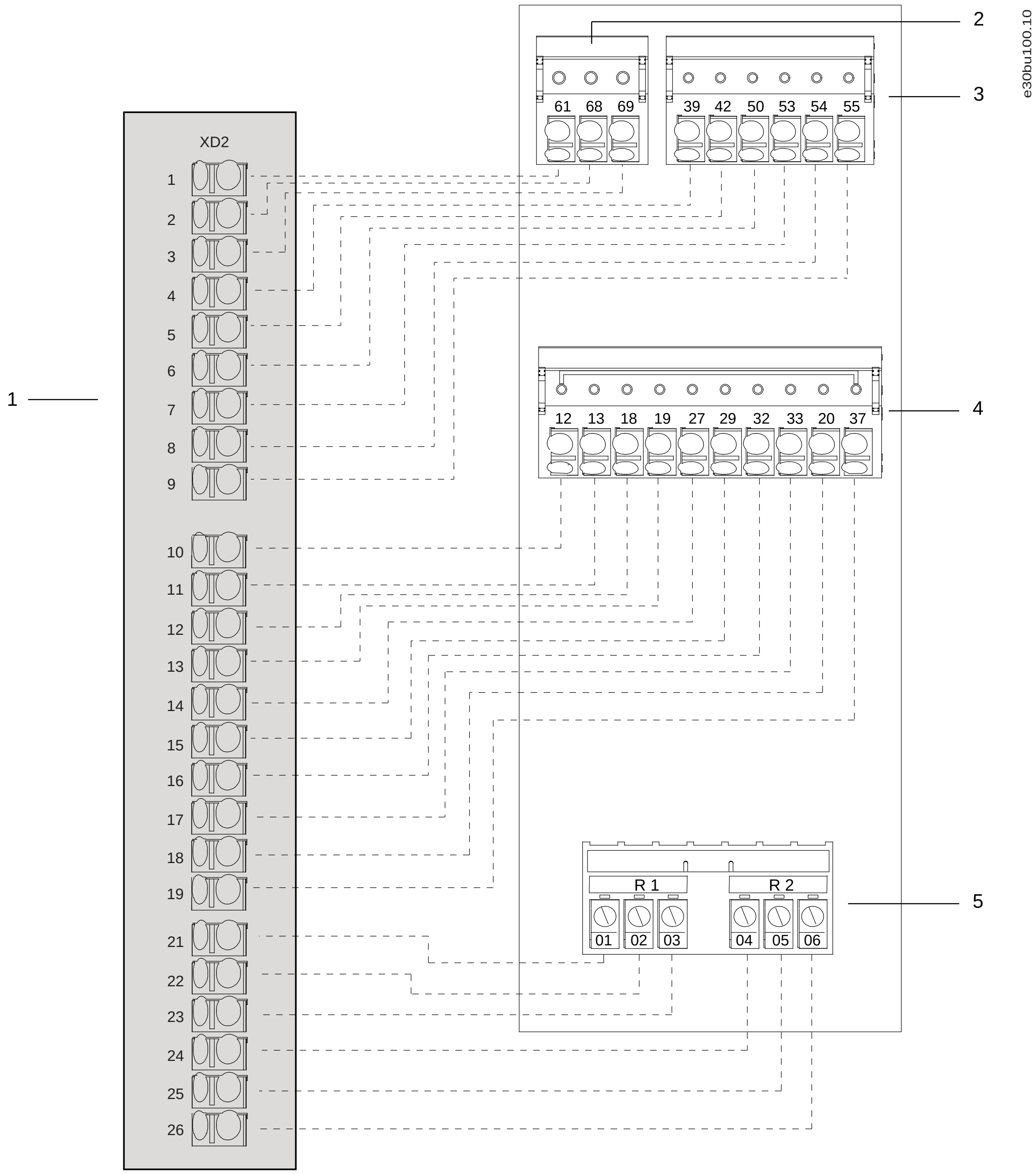


1 24 V DC supply (-TB7)	**2** Insulation monitor (-BE1)
3 Local control panel (LCP)	**4** RJ45 terminal blocks 1 and 2 (-RJ45_1 and RJ45_2)
5 Protection terminal block set (-XD11)	**6** Socket outlet (-XD10)
7 Contactor control circuit terminal block (-XD0)	**8** Cabinet heater terminal block (-XD4)
9 Customer terminal block/option C0 terminal block (-XDW)	**10** Thermal trip indicator relay, input power options cabinet (-KFJ.1)
11 Thermal trip indicator relay, output filter cabinet (-KFJ.2)	**12** Thermal trip indicator relay, input filter cabinet (-KFJ.3)
13 PHF capacitor connect/disconnect contactor relay (-QAF)	**14** +24 DC supply protection MCB (-FC7)
15 AC circuit protection MCB (-FC6)	**16** AC distribution circuit terminal block (-XD1)

17	Auxiliary relay for heater (-QAM)	**18**	Contactor control circuit protection MCB (-FC10)
19	Cabinet light/socket outlet protection MCB (-FCC)	**20**	Cabinet heater(s) circuit protection MCB (-FCE)
21	DC distribution circuit terminal block (-XD3)	**22**	Motor heater circuit protection MCB (-FCN)
23	AC fan supply terminal block set (-XDY)	**24**	Option C2 terminal block set (-XDF)
25	Basic I/O terminal block and option A, B, D card terminal block set (-XD2)	**26**	Door components terminal block set (-XDJ)
27	Grounding clamp for the shield termination of wires.		

Illustration 20: Layout of Control Compartment Interior with All Options

4.5 Control Terminal Wiring Diagram Cross-reference



1	User-accessible terminals (control compartment)	**2**	Serial communication terminals (drive module)
3	Analog input/output terminals (drive module)	**4**	Digital input/output terminals (drive module)

5 Relay terminals (drive module)	

Illustration 21: Serial Communication, Digital Input/Output, Analog Input/Output, and Relay Terminals Cross-reference

4.6 Control Terminals

Table 34: Serial Communication Terminals

XD2 terminal	Parameter	Default Setting	Description
1	–	–	Integrated RC-filter for cable shield. Used only for connecting the shield in case of EMC problems.
2	*Parameter group 8-3* FC Port Settings*	–	RS485 interface. A switch (BUS TER.) is provided on the control card for bus termination resistance. See *Illustration 5.22*.
3	*Parameter group 8-3* FC Port Settings*	–	

Table 35: Digital Input/Output Terminal Descriptions

XD2 terminal	Parameter	Default setting	Description
10, 11	–	+24 V DC	24 V DC supply voltage for digital inputs and external transducers. Maximum output current 200 mA for all 24 V loads.
12	*Parameter 5-10 Terminal 18 Digital Input*	*[8] Start*	Digital inputs.
13	*Parameter 5-11 Terminal 19 Digital Input*	*[10] Reversing*	
16	*Parameter 5-14 Terminal 32 Digital Input*	*[0] No operation*	
17	*Parameter 5-15 Terminal 33 Digital Input*	*[0] No operation*	
14	*Parameter 5-12 Terminal 27 Digital Input*	*[2] Coast inverse*	For digital input or output. Default setting is input.
15	*Parameter 5-13 Terminal 29 Digital Input*	*[14] JOG*	
18	–	–	Common for digital inputs and 0 V potential for 24 V supply.
19	–	STO	When not using the optional STO feature, a jumper wire is required between terminal 10 (or 11) and terminal 19. This setup allows the drive to operate with factory default programming values.

Table 36: Analog Input/Output Terminal Descriptions

XD2 terminal	Parameter	Default setting	Description
4	–	–	Common for analog output.

XD2 terminal	Parameter	Default setting	Description
5	*Parameter 6-50 Terminal 42 Output*	*[0] No operation*	Programmable analog output. 0–20 mA or 4–20 mA at a maximum of 500 Ω.
6	–	+10 V DC	10 V DC analog supply voltage for potentiometer or thermistor. 15 mA maximum.
7	*Parameter group 6-1* Analog Input 1*	Reference	Analog input. For voltage (V) or current (mA).
8	*Parameter group 6-2* Analog Input 2*	Feedback	
9	–	–	Common for analog input.

4.7 Relay Terminals

Table 37: Relay Terminal Descriptions

XD2 terminal	Parameter	Default setting	Description
21, 22, 23	*Parameter 5-40 Function Relay [0]*	*[0] No operation*	Form C relay outputs. For AC or DC voltage.
24, 25, 26	*Parameter 5-40 Function Relay [1]*	*[0] No operation*	

4.8 Option Card Terminals

The option cards extend the functionality of drives and provide a high variety of interfaces to automation systems. When the option cards are specified in the type code, they are mounted in slots A, B, C, and D of the control card within the drive module. The option card wiring is routed to a terminal block within the control compartment. For more details, refer to the installation/operating guide for the respective option card.

NOTICE

OPTION CARD INSTALLATION

If the option card is ordered along with the drive using the type code, the factory installs the option card and its wiring. If the option is ordered separately, the customer is responsible for installing the option card and the wiring extensions to the control compartment.

Table 38: Option A Terminal Connections for VLT® DeviceNet MCA 104, VLT® CANopen MCA 105, VLT® DeviceNet Converter MCA 194

Option card terminal	Corresponding terminal within the control compartment
1	XD2.40
2	XD2.41
3	XD2.42
4	XD2.43
5	XD2.44

Table 39: Option A Terminal Connections for VLT® PROFIBUS DP-V1 MCA 101, VLT® PROFIBUS Converter VLT 300 MCA 113, VLT® PROFIBUS Converter VLT 5000 MCA 114

Option card terminal	Corresponding terminal within the control compartment
67	XD2.40
66	XD2.41
63	XD2.42
62	XD2.43
CS	XD2.44

Table 40: Option A Terminal Connections for VLT® EtherNet/IP MCA 121, VLT® Modbus TCP MCA 122, VLT® POWERLINK MCA 123, VLT® Ether-CAT MCA 124

Option card terminal	Corresponding terminal within the control compartment
Port 1	RJ45_1
Port 2	RJ45_2

Table 41: Option B Terminal Connections

Option card terminal	Corresponding terminal within the control compartment
1	XD2.46
2	XD2.47
3	XD2.48
4	XD2.49
5	XD2.50
6	XD2.51
7	XD2.52
8	XD2.53
9	XD2.54
10	XD2.55
11	XD2.56
12	XD2.57

Table 42: Option C0 Terminal Connections for VLT® Synchronizing Controller MCO 350

Option card terminal	Corresponding terminal within the control compartment
X55.1	XDW.1
X55.2	XDW.2
X55.3	XDW.3
X55.4	XDW.4
X55.5	XDW.5

Option card terminal	Corresponding terminal within the control compartment
X55.6	XDW.6
X55.7	XDW.7
X55.8	XDW.8
X55.9	XDW.9
X55.10	XDW.10
X55.11	XDW.11
X55.12	XDW.12
X56.1	XDW.13
X56.2	XDW.14
X56.3	XDW.15
X56.4	XDW.16
X56.5	XDW.17
X56.6	XDW.18
X56.7	XDW.19
X56.8	XDW.20
X56.9	XDW.21
X56.10	XDW.22
X56.11	XDW.23
X56.12	XDW.24
X57.1	XDW.27
X57.2	XDW.28
X57.3	XDW.29
X57.4	XDW.30
X57.5	XDW.31
X57.6	XDW.32
X57.7	XDW.33
X57.8	XDW.34
X57.9	XDW.35
X57.10	XDW.36
X58.1	XDW.25
X58.2	XDW.26
X59.1	XDW.37
X59.2	XDW.38
X59.3	XDW.39
X59.4	XDW.40

Option card terminal	Corresponding terminal within the control compartment
X59.5	XDW.41
X59.6	XDW.42
X59.7	XDW.43
X59.8	XDW.44

Table 43: Option C0 Terminal Connections for VLT® Positioning Controller MCO 351

Option card terminal	Corresponding terminal within the control compartment
X55.1	XDW.1
X55.2	XDW.2
X55.3	XDW.3
X55.4	XDW.4
X55.5	XDW.5
X55.6	XDW.6
X55.7	XDW.7
X55.8	XDW.8
X55.9	XDW.9
X55.10	XDW.10
X55.11	XDW.11
X55.12	XDW.12
X56.1	XDW.13
X56.2	XDW.14
X56.3	XDW.15
X56.4	XDW.16
X56.5	XDW.17
X56.6	XDW.18
X56.7	XDW.19
X56.8	XDW.20
X56.9	XDW.21
X56.10	XDW.22
X56.11	XDW.23
X56.12	XDW.24
X58.1	XDW.25
X58.2	XDW.26
X57.1	XDW.27
X57.2	XDW.28

Option card terminal	Corresponding terminal within the control compartment
X57.3	XDW.29
X57.4	XDW.30
X57.5	XDW.31
X57.6	XDW.32
X57.7	XDW.33
X57.8	XDW.34
X57.9	XDW.35
X57.10	XDW.36
X59.1	XDW.37
X59.2	XDW.38
X59.3	XDW.39
X59.4	XDW.40
X59.5	XDW.41
X59.6	XDW.42
X59.7	XDW.43
X59.8	XDW.44
X60.1	XDW.45
X60.2	XDW.46
X60.3	XDW.47
X60.4	XDW.48
X60.5	XDW.49
X62.2	XDW.50
X62.3	XDW.51
X62.4	XDW.52

Table 44: Option C1 Terminal Connections for VLT® Extended Relay Card MCB 113

Option card terminal	Corresponding terminal within the control compartment
X45.1	XDF.17
X45.2	XDF.18
X45.3	XDF.19
X45.4	XDF.20
X46.1	XDF.1
X46.2	XDF.2
X46.3	XDF.3
X46.4	XDF.4

Option card terminal	Corresponding terminal within the control compartment
X46.5	XDF.5
X46.6	XDF.6
X46.7	XDF.7
X46.8	XDF.8
X46.9	XDF.9
X46.10	XDF.10
X46.11	XDF.11
X46.12	XDF.12
X46.13	XDF.13
X46.14	XDF.14
X47.1	XDF.21
X47.2	XDF.22
X47.3	XDF.23
X47.4	XDF.24
X47.5	XDF.25
X47.6	XDF.26
X47.7	XDF.27
X47.8	XDF.28
X47.9	XDF.29
X47.10	XDF.30
X47.11	XDF.31
X47.12	XDF.32
X58.1	XDF.15
X58.2	XDF.16

Table 45: Option C1 Terminal Connections for VLT® Advanced Cascade Controller MCO 102

Option card terminal	Corresponding terminal within the control compartment
X67.1	XDF.21
X67.2	XDF.22
X67.3	XDF.23
X67.4	XDF.24
X67.5	XDF.25
X67.6	XDF.26
X67.7	XDF.27
X67.8	XDF.28

Option card terminal	Corresponding terminal within the control compartment
X67.9	XDF.29
X67.10	XDF.30
X67.11	XDF.31
X67.12	XDF.32
X66.1	XDF.1
X66.2	XDF.2
X66.3	XDF.3
X66.4	XDF.4
X66.5	XDF.5
X66.6	XDF.6
X66.7	XDF.7
X66.8	XDF.8
X66.9	XDF.9
X66.10	XDF.10
X66.11	XDF.11
X66.12	XDF.12
X66.13	XDF.13
X66.14	XDF.14
X58.1	XDF.15
X58.2	XDF.16

Table 46: Option D Terminal Connections

Option card terminal	Corresponding terminal within the control compartment
35	XD2.28
36	XD2.29

4.9 Control Compartment Options

4.9.1 Auxiliary Supply Terminals

Table 47: Auxiliary Supply Type Codes

Character position	Code	Description
21	1	230 V AC external
	5	230 V AC external + 24 V DC internal
	6	120 V AC external
	9	120 V AC external + 24 V DC internal

The auxiliary supply terminal option provides an external voltage supply to the –XD1.1 terminal. The external supply must be short-circuit protected. The power of the external supply depends on other selected cabinet options.

Illustration 22: Auxiliary AC Supply Terminals

WARNING

HIGH VOLTAGE

The mains disconnect switch does not disconnect the external voltage supply. Failure to disconnect the external voltage supply before touching any components in the control compartment can result in death or serious injury.

- Disconnect the external voltage supply.
- Only qualified personnel must install, start up, and maintain the drive.

4.9.2 Auxiliary Voltage Transformer

Table 48: Auxiliary Supply Type Codes for Auxiliary Voltage Transformer

Character position	Code	Description
21	2	230 V AC internal
	4	230 V AC internal + 24 V DC internal
	7	120 V AC internal
	8	120 V AC internal + 24 V DC internal

The auxiliary voltage transformer is an option fitted internally that allows for the supply to be tapped from the mains. For example, if the enclosed drive is specified with a fused disconnect, the supply for the auxiliary voltage transformer is taken from between the drive and the fused disconnect. This configuration allows the control voltage to be disconnected with the main switch.

The transformer has multiple tappings on the primary side for the standard range of voltages on which the drive operates. The factory default wiring connects to the highest voltage tapping on the primary side, and the trip settings for the -FC4 terminal is set accordingly. The customer can change the tapping provided the correct voltage is applied and the thermal magnetic circuit breaker is set accordingly.

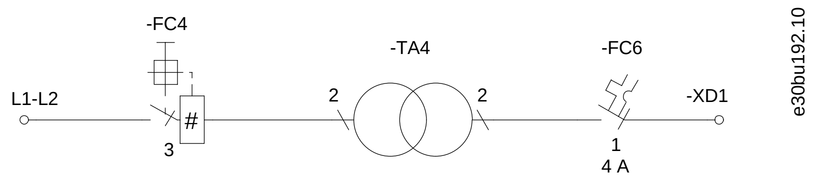


Illustration 23: Auxiliary Voltage Transformer Terminals

NOTICE

AUXILIARY COMPONENT FAILURE

Incorrect voltage or incorrect tapping installation will cause other auxiliary components in the control compartment to fail.

- When tapping the transformer, make sure to apply the correct voltage for the drive.
- Use the correct tapping and trip settings.

4.9.3 +24 V DC External Supply

Table 49: Auxiliary Supply Type Codes

Character position	Code	Description
21	4	230 V AC internal+24 V DC internal
	5	230 V AC external+24 V DC internal
	8	120 V AC internal+24 V DC internal
	9	120 V AC external+24 V DC internal

The 24 V DC external supply option enables other auxiliary options to be connected to a 24 V DC supply within the control compartment.

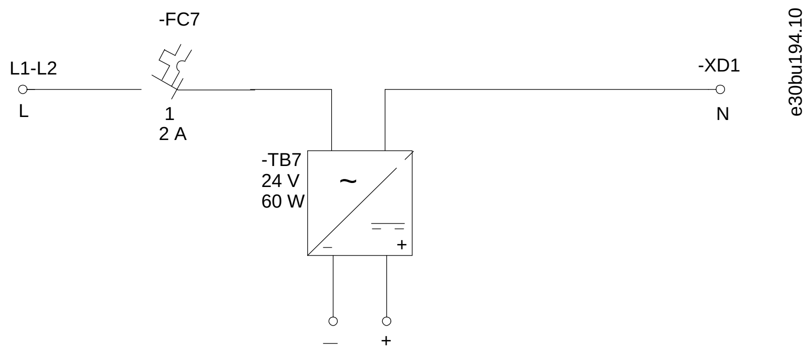


Illustration 24: 24 V DC External Supply Terminals

4.9.4 AC Customer Socket

Table 50: Auxiliary Function Type Codes

Character position	Code	Description
23–24	A1	AC socket + cabinet light
	AA	AC socket + cabinet light + extended I/O terminals
	AB	AC socket + cabinet light + cabinet heater
	AC	AC socket + cabinet light + motor heater control
	AD	AC socket + cabinet light + insulation monitor
	AE	AC socket + cabinet light + extended I/O terminals + cabinet heater
	AF	AC socket + cabinet light + extended I/O terminals + motor heater control
	AG	AC socket + cabinet light + extended I/O terminals + insulation monitor
	AH	AC socket + cabinet light + extended I/O terminals + cabinet heater + motor heater control
	AI	AC socket + cabinet light + extended I/O terminals + cabinet heater + insulation monitor
	AJ	AC socket + cabinet light + extended I/O terminals + motor heater control + insulation monitor
	AK	AC socket + cabinet light + extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AL	AC socket + cabinet light + cabinet heater + motor heater control
	AM	AC socket + cabinet light + cabinet heater + insulation monitor
	AN	AC socket + cabinet light + cabinet heater + motor heater control + insulation monitor
	AO	AC socket + cabinet light + motor heater control + insulation monitor

The customer socket provides a supply for measurement tools, equipment, or a computer. The socket type is CEE 7/3 ("Schuko", Type F) or NEMA 5-15 grounded (Type B). The default voltage is 230 V AC (IEC variant) and 115 V AC (UL variant). When using an external supply, the maximum output power is 450 VA (IEC variant) and 230 VA (UL variant). When using a transformer supply, the maximum output power is 200 VA for both variants.

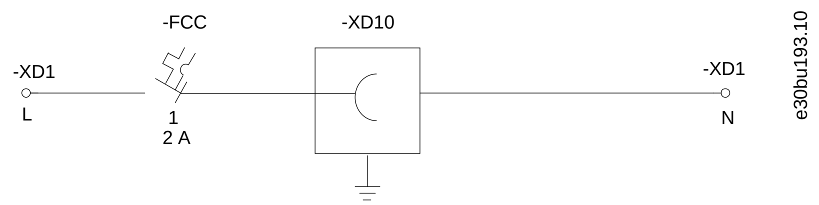


Illustration 25: AC Customer Socket Terminals

4.9.5 Extended I/O Terminals

Table 51: Auxiliary Function Type Codes

Character position	Code	Description
23–24	A2	Extended I/O terminals
	AA	AC socket+cabinet light + extended I/O terminals
	AE	AC socket+cabinet light + extended I/O terminals + cabinet heater
	AF	AC socket+cabinet light + extended I/O terminals + motor heater control
	AG	AC socket+cabinet light + extended I/O terminals + insulation monitor
	AH	AC socket+cabinet light + extended I/O terminals + cabinet heater + motor heater control
	AI	AC socket+cabinet light + extended I/O terminals + cabinet heater + insulation monitor
	AJ	AC socket+cabinet light + extended I/O terminals + motor heater control + insulation monitor
	AK	AC socket+cabinet light + extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AP	Extended I/O terminals + cabinet heater
	AQ	Extended I/O terminals + motor heater control
	AR	Extended I/O terminals + insulation monitor
	AS	Extended I/O terminals + cabinet heater + motor heater control
	AT	Extended I/O terminals + cabinet heater + insulation monitor
	AU	Extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AV	Extended I/O terminals + motor heater control + insulation monitor

The extended I/O terminal option includes 25 control terminals (-XDW) in the control compartment for use by the customer. If the enclosed drive is configured with any option C1 card, the -XDW terminal block is used for the option C1 card wiring.

4.9.6 Cabinet Heater

Table 52: Auxiliary Function Type Codes

Character position	Code	Description
23–24	A3	Cabinet heater
	AB	AC socket + cabinet light + cabinet heater
	AE	AC socket + cabinet light + extended I/O terminals + cabinet heater
	AH	AC socket + cabinet light + extended I/O terminals + cabinet heater + motor heater control
	AI	AC socket + cabinet light + extended I/O terminals + cabinet heater + insulation monitor
	AK	AC socket + cabinet light + extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AL	AC socket + cabinet light + cabinet heater + motor heater control
	AM	AC socket + cabinet light + cabinet heater + insulation monitor
	AN	AC socket + cabinet light + cabinet heater + motor heater control + insulation monitor
	AP	Extended I/O terminals + cabinet heater
	AS	Extended I/O terminals + cabinet heater + motor heater control
	AT	Extended I/O terminals + cabinet heater + insulation monitor
	AU	Extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AW	Cabinet heater + motor heater control
	A8	Cabinet heater + insulation monitor
	AY	Cabinet heater + motor heater control + insulation monitor

The cabinet heater option increases the inside temperature of the cabinet above the ambient temperature, preventing condensation in the cabinet. Each cabinet has 1 cabinet heater. The heater element is self regulating. The external supply is connected to terminal -XD1.1. When the drive is not in run state, the control relay -QAM changes the supply to the output terminals (-XD4). When the drive is in run state, the control relay disconnects the supply to the cabinet heater. The function is disabled when MCB –FCE is open.

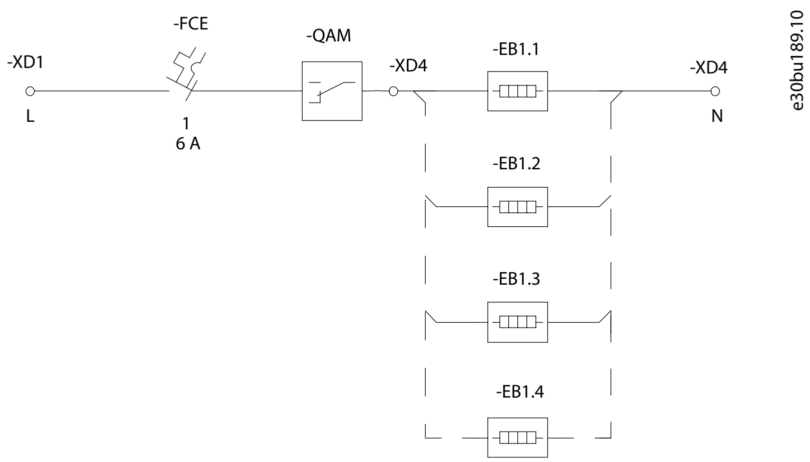


Illustration 26: Cabinet Heater Terminals

4.9.7 Motor Heater Control

Table 53: Auxiliary Function Type Codes

Character position	Code	Description
23–24	A4	Motor heater control
	AC	AC socket + cabinet light + motor heater control
	AF	AC socket + cabinet light + extended I/O terminals + motor heater control
	AH	AC socket + cabinet light + extended I/O terminals + cabinet heater + motor heater control
	AJ	AC socket + cabinet light + extended I/O terminals + motor heater control + insulation monitor
	AK	AC socket + cabinet light + extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AL	AC socket + cabinet light + cabinet heater + motor heater control
	AN	AC socket + cabinet light + cabinet heater + motor heater control + insulation monitor
	AO	AC socket + cabinet light + motor heater control + insulation monitor
	AQ	Extended I/O terminals + motor heater control
	AS	Extended I/O terminals + cabinet heater + motor heater control
	AU	Extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AV	Extended I/O terminals + motor heater control + insulation monitor
	AW	Cabinet heater + motor heater control
	AY	Cabinet heater + motor heater control + insulation monitor
	AZ	Motor heater control + insulation monitor

The motor heater option provides the ability to control the supply for the motor anti-condensation heater. The 24 V DC external supply is connected to terminal -XD1.1 in the lower part of the cabinet. When the drive is not in run state, the control relay -QAM changes the external supply to the -XDM output terminals. When the drive is in run state, the control relay disconnects the external supply to the motor heater. The function is disabled when MCB –FCN is open.

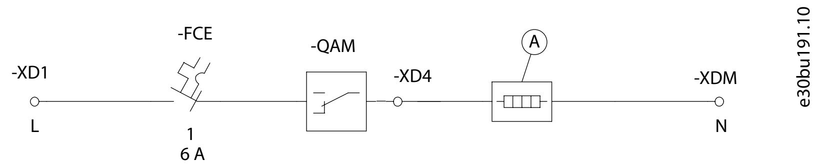


Illustration 27: Motor Heater Control (A = Heater element, not included.)

4.9.8 Insulation Monitor

Table 54: Auxiliary Function Type Codes

Character position	Code	Description
23–24	A5	Insulation monitor
	AD	AC socket+cabinet light + insulation monitor
	AG	AC socket+cabinet light + extended I/O terminals + insulation monitor
	AI	AC socket+cabinet light + extended I/O terminals + cabinet heater + insulation monitor
	AJ	AC socket+cabinet light + extended I/O terminals + motor heater control + insulation monitor
	AK	AC socket+cabinet light + extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AM	AC socket+cabinet light + cabinet heater + insulation monitor
	AN	AC socket+cabinet light + cabinet heater + motor heater control + insulation monitor
	AO	AC socket+cabinet light + motor heater control + insulation monitor
	AR	Extended I/O terminals + insulation monitor
	AT	Extended I/O terminals + cabinet heater + insulation monitor
	AU	Extended I/O terminals + cabinet heater + motor heater control + insulation monitor
	AV	Extended I/O terminals + motor heater control + insulation monitor
	A8	Cabinet heater + insulation monitor
	AY	Cabinet heater + motor heater control + insulation monitor
	AZ	Motor heater control + insulation monitor

The insulation monitor option monitors the supply and insulation faults within the insulation level in an IT supply network with an insulation monitor in the control compartment.

4.9.9 Signal Lights and Reset Buttons

Table 55: Door-mounted Option Type Codes

Character position	Code	Description
28–29	D1	Signal lights and reset button
	DA	Signal lights and reset button + emergency switch off and emergency push-button
	DB	Signal lights and reset button + STO w/ emergency push-button (no functional safety)
	DC	Signal lights and reset button + STO/SS1 w/ emergency push-button + safely limited speed (TTL encoder)
	DE	Signal lights and reset button + STO/SS1 w/ emergency push-button + safely limited speed (HTL encoder)

The signal light and reset button option includes signal lights on the control compartment door for run and fault states of the AC drive. The door also has a button for the reset function of the drive.

4.9.10 Emergency Switch Off

Table 56: Door-mounted Option Type Codes

Character position	Code	Description
28–29	D2	Emergency switch off + emergency push-button
	DA	Signal lights and reset button + emergency switch off and emergency push-button

The emergency switch off option uses an input contactor to disconnect the drive from mains. Pushing the emergency stop push-button on the control compartment door opens the control circuit of the input contactor.

4.9.11 STO with Emergency Push-button on Door

Table 57: Door-mounted Option Type Codes

Character position	Code	Description
28–29	D3	STO with emergency push-button (no functional safety)
	DB	Signal lights and reset button + STO with emergency push-button (no functional safety)

This option provides the STO (Safe Torque Off) function via an emergency push-button mounted on the door of the control compartment. The control terminals of the control card are extended from inside the drive module and routed out to the terminal block set -XD2 in the control compartment. The emergency push-button is wired between terminals -XD2.10 and -XD2.19.

Activating the emergency push-button prevents the unit from generating the voltage required to rotate the motor. The option provides:

- Safe Torque Off (STO), as defined by EN IEC 61800-5-2.
- Stop Category 0, as defined in EN 60204-1.

4.9.12 STO/SS1 with Emergency Push-button + Safely Limited Speed (TTL Encoder) on Door

Table 58: Door-mounted Option Type Codes

Character position	Code	Description
28–29	D4	STO/SS1 with emergency push-button+safely limited speed (TTL encoder)
	DC	Indicator lights and reset button + STO/SS1 with emergency push-button+safely limited speed (TTL encoder)

This option provides the SS1 (Safe Stop 1) function with the VLT® Safety Option MCB 150 along with STO function using an emergency stop push-button on the control compartment door. In case of SS1, pushing the emergency stop push-button activates the motor deceleration and makes the motor stop in the set deceleration ramp time. Basic wiring for the S37 terminal of the option card to terminal 37 of control card and the emergency push-button wiring are provided

MCB 150 is used when the standstill or the motor speed is measured using a TTL encoder. For detailed instructions, refer to the VLT® Safety Option MCB 150/151 Operating Guide. MCB 150 can be programmed using the VLT® Motion Control Tool MCT 10 software to take advantage of the following functional safety features:

- No power is being fed to the motor which can generate a rotation. Stop category 0 to EN IEC 60204-1.
- The motor decelerates. Monitoring of deceleration ramp and STO following zero speed, or STO at the end of a deceleration time. Stop category 1 to EN IEC 60204-1.
- This function prevents exceeding a defined speed value. See the OPT-B option board and safety relay user manuals for the regulations and the certified safety.

4.9.13 STO/SS1 with Emergency Push-button + Safely Limited Speed (HTL Encoder) on Door

Table 59: Door-mounted Option Type Codes

Character position	Code	Description
28–29	D5	STO/SS1 with emergency push-button + safely limited speed (HTL encoder)
	DE	Signal lights and reset button + STO/SS1 with emergency push-button + safely limited speed (HTL encoder)

This option provides the SS1 (Safe Stop 1) function with the VLT® Safety Option MCB 151 along with STO function using an emergency stop push-button on the control compartment door. The option is compatible with HTL encoders or PNP proximity switches. In case of SS1, pushing the emergency stop-push button activates the motor deceleration and makes the motor stop in the set deceleration ramp time. Basic wiring for the S37 terminal of the option card to terminal 37 of control card and the emergency push-button wiring are provided

MCB 151 is used when the standstill or the motor speed is measured using a TTL encoder. For detailed instructions, refer to the VLT® Safety Option MCB 150/151 Operating Guide. MCB 151 can be programmed using VLT® Motion Control Tool MCT 10 software to take advantage of the following functional safety features:

- No power is being fed to the motor which can generate a rotation. Stop category 0 to EN IEC 60204-1.
- The motor decelerates. Monitoring of deceleration ramp and STO following zero speed, or STO at the end of a deceleration time. Stop category 1 to EN IEC 60204-1.
- This function prevents exceeding a defined speed value. See the OPT-B option board and safety relay user manuals for the regulations and the certified safety.

4.10 Local Control Panel (LCP)

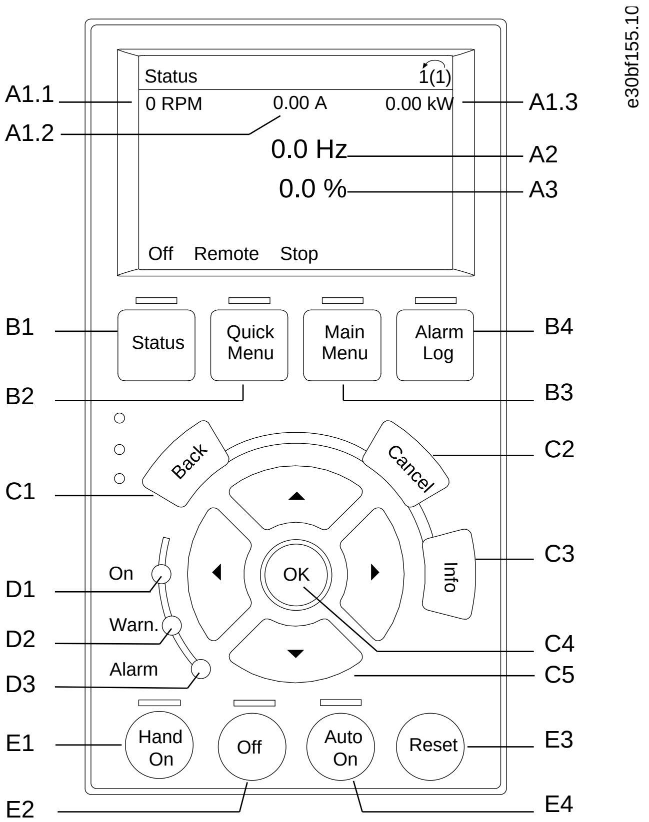


Illustration 28: Graphical Local Control Panel (LCP)

A. Display area

Each display readout has a parameter associated with it. See table 60. The information shown on the LCP can be customized for specific applications. Refer to My Personal Menu in the LCP Menu section.

Table 60: LCP Display Area

Callout	Parameter	FC 102/FC 103 Default setting	FC 202 Default setting	FC 302 Default setting
A1.1	*Parameter 0-20 Display Line 1.1 Small*	ReferenceSpeed [%]	Reference [Unit]	Speed [RPM]
A1.2	*Parameter 0-21 Display Line 1.2 Small*	Motor current [A]	Analog input 53 [V]	Motor current [A]
A1.3	*Parameter 0-22 Display Line 1.3 Small*	Power [kW]	Motor current [A]	Power [kW]
A2	*Parameter 0-23 Display Line 2 Large*	Frequency [Hz]	Frequency [Hz]	Frequency [Hz]
A3	*Parameter 0-24 Display Line 3 Large*	kWh counter	Feedback [Unit]	Reference [%]

B. Menu keys

Menu keys are used to access the menu for setting up parameters, toggling through status display modes during normal operation, and viewing fault log data.

Table 61: LCP Menu Keys

Callout	Key	Function
B1	Status	Shows operational information.
B2	Quick Menu	Allows access to parameters for initial set-up instructions. Also provides detailed application steps. Refer to Quick Menu Mode in the LCP Menu section.
B3	Main Menu	Allows access to all parameters. Refer to Main Menu Mode in the LCP Menu section.
B4	Alarm Log	Shows a list of current warnings and the last 10 alarms.

C. Navigation keys

Navigation keys are used for programming functions and moving the display cursor. The navigation keys also provide speed control in local (hand) operation. The display brightness can be adjusted by pressing [Status] and [▵]/[▿] keys.

Table 62: LCP Navigation Keys

Callout	Key	Function
C1	Back	Reverts to the previous step or list in the menu structure.
C2	Cancel	Cancels the last change or command as long as the display mode has not changed.
C3	Info	Shows a definition of the function being shown.
C4	OK	Accesses parameter groups or enables an option.
C5	[▵][▹] [▿] [◃]	Moves between items in the menu.

D. Indicator lights

Indicator lights identify the drive status and provide a visual notification of warning or fault conditions.

Table 63: LCP Indicator Lights

Callout	Indicator	Light	Function
D1	On	Green	Activates when the drive receives power from the mains voltage or a 24-V external supply.
D2	Warn.	Yellow	Activates when warning conditions are active. Text appears in the display area identifying the problem.
D3	Alarm	Red	Activates during a fault condition. Text appears in the display area identifying the problem.

E. Operation keys and reset

The operation keys are found toward the bottom of the local control panel.

Table 64: LCP Operation Keys and Reset

Callout	Key	Function
E1	[Hand On]	Starts the drive in local control. An external stop signal by control input or serial communication overrides the local [Hand On].
E2	Off	Stops the motor but does not remove power to the drive.
E3	Reset	Resets the drive manually after a fault has been cleared.

Callout	Key	Function
E4	Auto On	Puts the system in remote operational mode so it can respond to an external start command by control terminals or serial communication.

4.11 LCP Menu

Quick Menus

The *Quick Menus* mode provides a list of menus used to configure and operate the drive. Select the *Quick Menus* mode by pressing the [Quick Menus] key. The resulting readout appears on the LCP display.

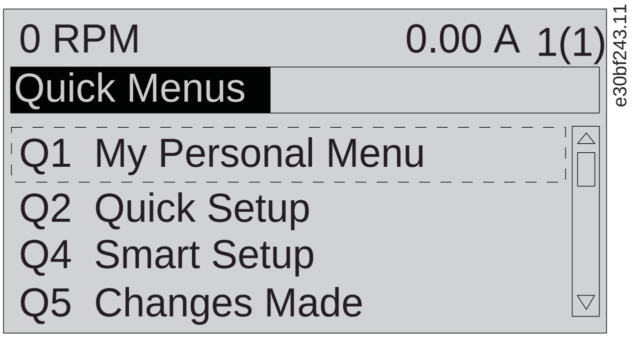


Illustration 29: Quick Menu View

Q1 My Personal Menu

The Personal Menu is used to determine what is shown in the display area of the LCP. Refer to the Local Control Panel (LCP) section. This menu can also show up to 50 pre-programmed parameters. These 50 parameters are manually entered using *parameter 0-25 My Personal Menu*.

Q2 Quick Setup

The parameters found in the Q2 Quick Setup contain basic system and motor data that are always necessary for configuring the drive. See the operating guide for set-up procedures.

Q4 Smart Setup

Q4 Smart Setup guides the user through typical parameter settings used to configure 1 of the following 3 applications:

- Mechanical brake.
- Conveyor.
- Pump/fan.

The [Info] key can be used to see help information for various selections, settings, and messages.

Q5 Changes Made

Select Q5 Changes Made for information about:

- The 10 most recent changes.
- Changes made from default setting.

Q6 Loggings

Use Q6 Loggings for fault finding. To get information about the display line readout, select Loggings. The information is shown as graphs. Only parameters selected in *parameter 0-20 Display Line 1.1 Small* through *parameter 0-24 Display Line 3 Large* can be viewed. It is possible to store up to 120 samples in memory for later reference.

Table 65: Logging Parameter Examples

Q6 Loggings	
Parameter 0-20 Display Line 1.1 Small	Speed [RPM]
Parameter 0-21 Display Line 1.2 Small	Motor Current
Parameter 0-22 Display Line 1.3 Small	Power [kW]
Parameter 0-23 Display Line 2 Large	Frequency
Parameter 0-24 Display Line 3 Large	Reference %

Q7 Motor Setup

The parameters found in the Q7 Motor Setup contain basic and advanced motor data that are always necessary for configuring the drive. This option also includes parameters for encoder setup.

Main Menu

The *Main Menu* mode is used to:

- List the parameter groups available to the drive and drive options.
- Change parameter values.

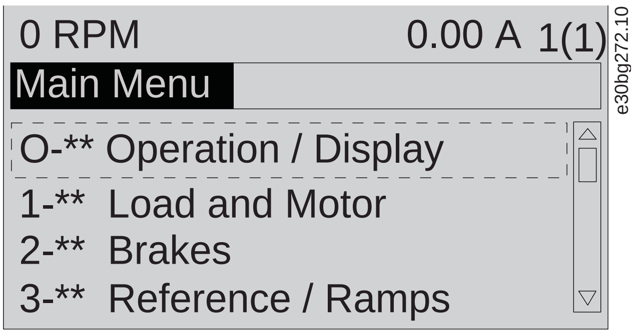


Illustration 30: Main Menu View

Related information

For more detailed information on the menus or parameters, refer to the product-specific programming guide.

5 Internal Drive Operation

5.1 Introduction

This section is intended to provide an operational overview of the main assemblies and circuitry of a drive. With this information, a repair technician can better understand the operation of the drive and the troubleshooting process.

5.2 Description of Operation

Overview

An enclosed drive is an electronic controller that supplies a regulated amount of AC power to a 3-phase induction motor. By supplying variable frequency and voltage to the motor, the drive controls the motor speed or torque. Also, it can maintain a constant speed as the load on the motor changes. The drive can stop and start a motor without the mechanical stress associated with a line start.

The enclosed drive offers extra functionality based on the selected options.

- If the sine-wave filter option is present, the system offers sinusoidal output current and reduced voltage spikes at the motor terminals.
- If the dU/dt filter option is present, the system offers reduced voltage spikes at the motor terminals due to long cables.
- If the passive harmonic filter (PHF) or line reactor is present, the system offers reduced input current harmonics.

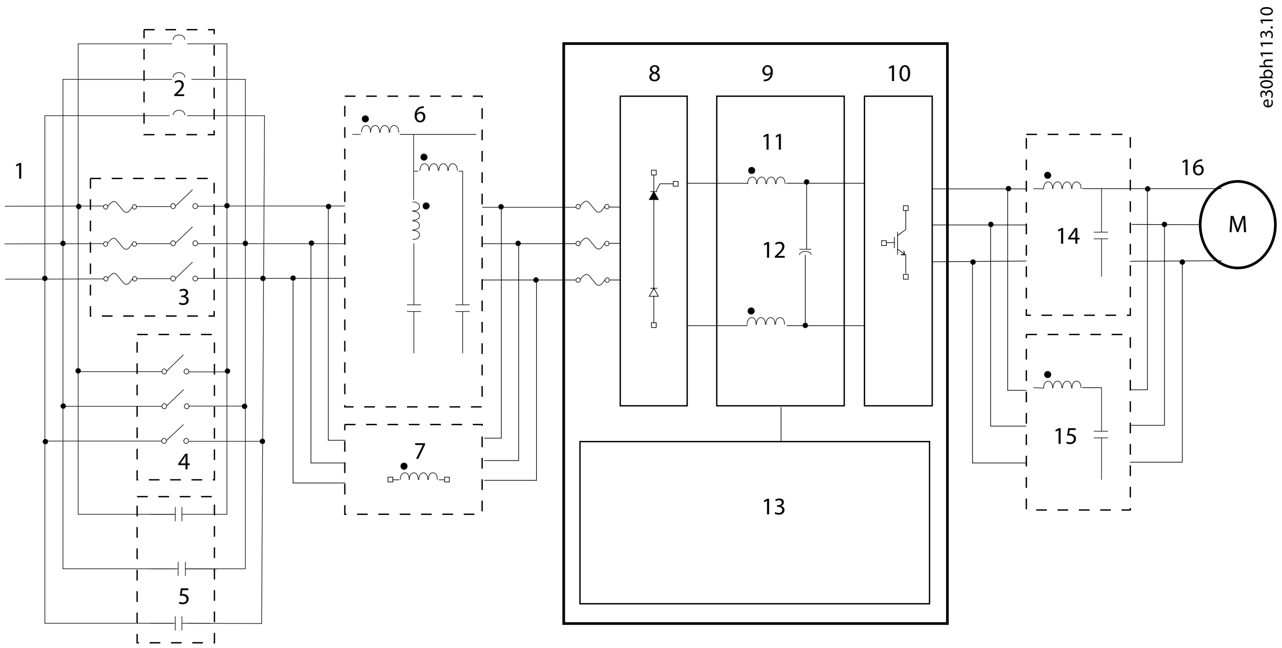


Illustration 31: Enclosed Drive Basic Block Diagram

Table 66: Enclosed Drive Block Diagram Definitions

Item	Title	Functions
1	Mains input	Provides 3-phase AC mains power input to the drive module.
2	Molded-case circuit breaker (MCCB)	Input power option. Allows switching of input voltage. Includes circuit breaker, which trips at fault current or short circuit.

Item	Title	Functions
3	Fusible disconnect	Input power option. Allows switching of input voltage. Contains fuses, which clear the fault current or short circuit.
4	Non-fusible disconnect	Input power option. Allows switching of input voltage. Contains circuit breaker, which trips at fault current or short circuit.
5	Mains contactor	Input power option. Allows switching of input voltage. Enables remote connection or disconnection of input voltage.
6	Passive harmonic filter	Reduces input current harmonics below 5% or below 8%, depending on the selected filter.
7	Line reactor	Reduces rectifier current harmonics and stress, when connected to grid that has active filters.
8	Input rectifier section	Converts mains input AC voltage into DC voltage.
9	Intermediate DC bus section	Acts as a filter and stores energy in the form of DC voltage.
10	Inverter section	Converts the DC voltage into a variable, controlled PWM AC output voltage to the motor.
11	DC reactors	Filters the DC-link voltage. Reduces RMS current. Raises the power factor reflected back to the line. Reduces harmonics on the AC input.
12	Capacitor bank	Stores the DC power and provides ride-through protection for short power losses.
13	Control	Monitors input and motor current to provide efficient operation and control. Monitors the user interface and performs external commands. Provides status output and control. Includes the power card, fan power card (in E-sized drives only), and inrush card.
14	Sine-wave filter	Delivers sine current and reduced voltage spikes and dU/dt at the motor terminals.
15	dU/dt filter	Delivers reduced voltage spikes and dU/dt at the motor terminals.
16	Motor output	Sends output to the motor being controlled.
Note: Dashed lines show customer-selected options.		

Input options

The enclosed drive system can include the following input options:

- Non-fusible disconnect
- Fusible disconnect
- Mains contactor
- Miniature circuit breaker (MCCB)
- Non-fusible disconnect + mains contactor
- Fusible disconnect + mains contactor

The fuses are a built-in feature of the fusible disconnect. The trip setting of the miniature circuit breakers is completed at the factory. For the correct trip setting, refer to the operating guide.

5.3 Input Filter Operation

Passive harmonic filter

The passive harmonic filter (PHF) consists of a main inductor L_0 and a 2-stage absorption circuit with inductors L_1 and L_2 and capacitors C_1 and C_2. When the current load reaches 10%, the PHF contactor is switched on. The PHF allows the absorption circuit to be tuned to eliminate harmonics starting with the 5^{th} harmonic, and is specific for the designed supply frequency. Therefore, the circuit for 50 Hz has different parameters than the circuit for 60 Hz.

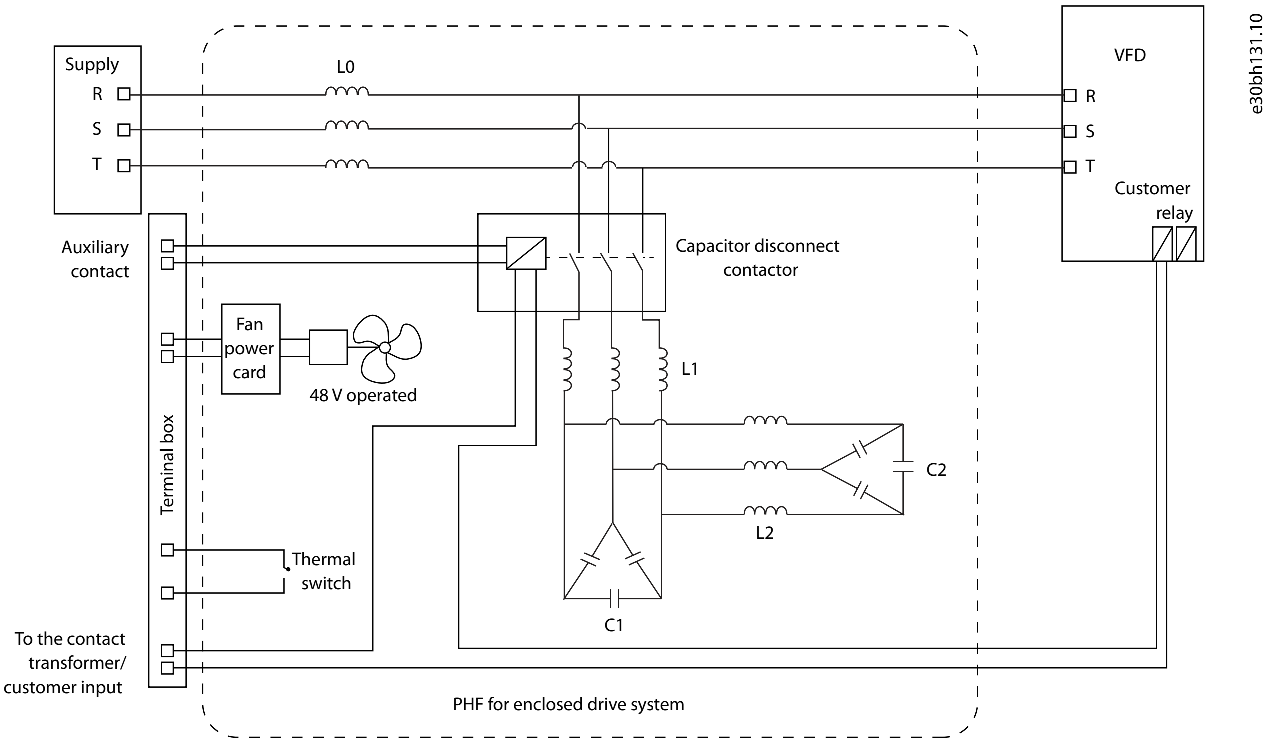


Illustration 32: Passive Harmonic Filter Diagram

Passive harmonic filters are available in 2 variants for 2 performance levels:

- PHF 005 with 5% THDi (total current harmonic distortion).
- PHF 008 with 8% THDi.

The filter performance (THDi) varies as a function of the load. At nominal load, the performance of the filter is equal to or lower than 8% THDi for PHF 008, and 5% THDi for PHF 005. At partial load, the THDi has higher values. However, the absolute value of the harmonic current is lower at partial loads, even if the THDi has a higher value. Therefore, the negative effect of the harmonics at partial loads is lower than at full load.

Line reactor

The line reactor is a 3-phase reactor available as an option with the enclosed drive. The purpose of the line reactor is to minimize the drive-side current harmonics and current stresses when the active filter is connected. The line reactor is housed in a separate cabinet. A single line reactor cabinet can accommodate a maximum of 3 reactors. The number of line reactors depend on the power size of the enclosed drive. If the line reactor option is present, the enclosed drive cannot include a passive harmonic filter.

5.4 Output Filter Operation

dU/dt filter

Output filters are used with enclosed drive systems for 4 main reasons:

- Protection of motor insulation.
- Reduction of motor acoustic noise.
- Reduction of high frequency electromagnetic noise in motor cabling.
- Reduction of bearing currents and shaft voltage.

The dU/dt filter is a factory-built option available with the enclosed drive.

NOTICE

FILTERS AND FAN SPEED

If a dU/dt filter, common-mode filter, or both are present in a D9h/D10h enclosed drive system, fan speed should be kept at 100%.

- Set *parameter 14-52 Fan Control* to *[3] 100%*.

Sine-wave filter

When the enclosed drive includes an optional sine-wave filter, the drive is derated for higher output frequency (more that 60 Hz). Refer to the Electrical Data section in the product-specific operating guide for derating information.

Sine-wave filters are LC filters designed to allow only low frequencies to pass. High frequencies are discarded, resulting in a sinusoidal phase-to-phase voltage waveform and sinusoidal current waveforms. With sinusoidal waveforms, the use of special drive motors with reinforced insulation is not necessary. Acoustic noise from the motor is damped with use of the sine-wave filter.

Sine-wave filters reduce insulation stress and bearing currents in the motor, prolonging motor life. Sine-wave filters enable use of longer motor cables in applications where the motor is installed farther away from the drive. Because the filter does not act between motor phases and ground, it does not reduce leakage currents in the cables. The filter accommodates applications with motor cables from 150–300 m (492–984 ft) (with both shielded and unshielded cable). The use of motor cables longer than 300 m (984 ft) depends on the specific application.

5.5 Control Logic Section

Microprocessor

The control card contains most of the logic section. The primary logic element of the control card is a microprocessor, which supervises and controls all functions of operation of the drive. In addition, separate PROMs contain the parameters to provide programmable options. These parameters are programmed to enable the drive to meet specific application requirements. This data is then stored in an EEPROM which provides security during power-down and allows for changing the operational characteristics of the drive.

PWM Waveforms

A custom-integrated circuit generates a pulse width modulation (PWM) waveform which is then sent to the interface circuitry on the power card.

The PWM waveform is created using an improved control scheme called VVC$^+$, a further development of the earlier VVC (voltage vector control) system. VVC$^+$ provides a variable frequency and voltage to the motor which matches the requirements of the motor.

Local control panel (LCP)

Another part of the logic section is the local control panel (LCP). The LCP is a removable keypad/display mounted on the front of the drive. The LCP provides the interface between the internal digital logic and the operator.

All the programmable parameter settings can be uploaded into the EEPROM of the LCP. This function is useful for maintaining a back-up drive profile and parameter set. It can be used, through its download function, in programming other drives or to restore a program to a repaired unit. The LCP is removable during operation to prevent undesired program changes. With the addition of a remote mounting kit, the LCP can be mounted in a remote location of up to 3 m (10 ft) away.

Control terminals

Control terminals, with programmable functions, are provided for input commands such as run, stop, forward, reverse, and speed reference. Extra output terminals are provided to supply signals to run peripheral devices or for monitoring and reporting status.

The control card logic can communicate via serial link with outside devices such as personal computers or programmable logic controllers (PLC).

The control card also provides 2 voltage supplies for use from the control terminals. The 24 V DC is used for switching functions such as start, stop, and forward/reverse. The 24-V DC supply can supply 200 mA of power, part of which can be used to power external encoders or other devices. A 10-V DC supply on terminal 50 is rated at 17 mA is also available for use with speed reference circuitry.

The analog and digital output signals are powered through an internal drive supply.

Two relays for monitoring the status of the drive are on the power card. They are programmable through *parameter group 5-4* Relays*. The relays have different ratings. See the corresponding operating guide or design guide for more information on ratings.

The control card logic circuitry allows for the addition of option modules for synchronizing the following types of software:

- Control
- Serial communications
- Extra relays
- Cascade pump controller
- Custom operating

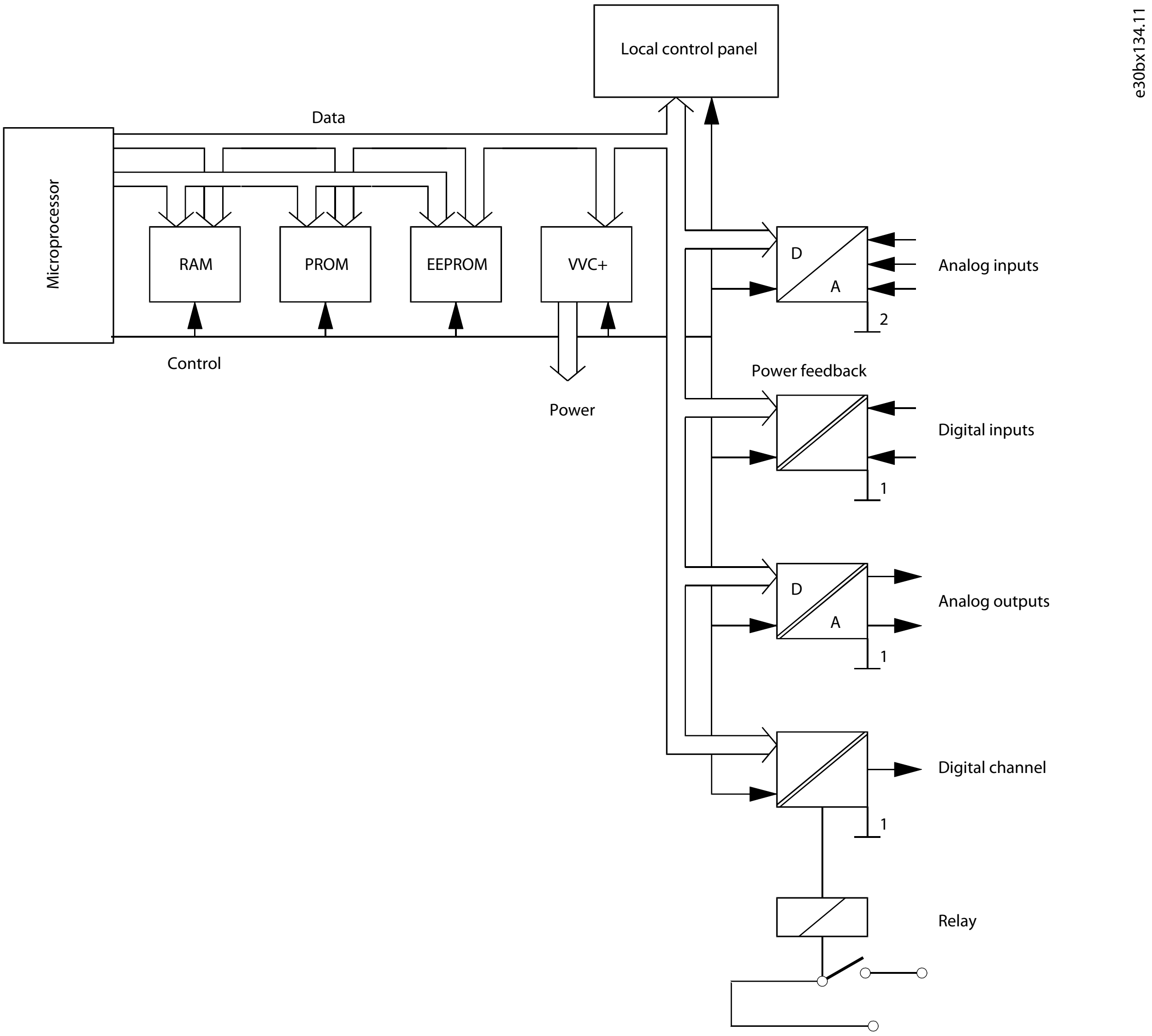


Illustration 33: Logic Section

5.6 Logic-to-power Interface

The logic-to-power interface isolates the high voltage components of the power section from the low voltage signals of the logic section. The interface section consists of the power card and gate drive card.

Control card

The control card handles much of the fault processing for output short circuit and ground fault conditions. The power card provides conditioning of these signals. The control card also handles scaling of current and voltage feedback.

Power card

The power card contains a switch mode power supply (SMPS), which provides the unit with 24 V DC, (+)18 V DC, (–)18 V DC, and 5 V DC operating voltage. The SMPS powers the logic and interface circuitry. The SMPS is supplied by the DC bus voltage. The drives can be purchased with an optional secondary SMPS, which is powered from a customer supplied 24 V DC source. This secondary SMPS provides power to the logic circuitry with mains input disconnected. It can keep units with communication options live on a network when the drive is not powered from the mains.

The power card also supplies circuitry for controlling the speed of the cooling.

Gate drive card

The gate drive signals from the control card to the output transistors (IGBTs) are isolated and buffered on the gate drive card. In units that have the dynamic brake option, the driver circuits for the brake transistors are also found on this card.

5.7 Power Section

Power components

The high voltage power section consists of the following components:

- AC mains input and motor terminals.
- AC and DC busbars.
- Fuses.
- Wiring harness.
- Circuitry.
  - Soft charge and SCR/diode modules in the rectifier.
  - DC link filter circuitry containing the DC coils.
  - Output IGBT modules that make up the inverter section.
- Optional components.

The inrush circuit controls the firing of the SCRs in the rectifier. When power is applied, the SCRs limit the charging rate of the DC capacitors. Once the capacitors are charged, the inrush circuit sequences the firing of the SCRs to maintain the proper charge on the DC capacitors.

The DC bus circuitry regulates the pulsating DC voltage created by the input AC supply.

The DC coil is a single unit with 2 coils wound on a common core. One coil resides in the positive side of the DC bus and the other in the negative. The coil aids in the reduction of mains harmonics.

The DC bus capacitors are arranged into a capacitor bank along with bleeder and balancing circuitry.

The inverter section is made up of insulated-gate bipolar transistors, commonly referred to as IGBTs or switches. In D-sized drives, there are 3 IGBT modules. In E-sized drives, there are 6 IGBT modules. Each IGBT module contains multiple IGBTs.

A Hall effect type current sensor is used on each phase of the output to measure motor current. With Hall sensors, the drive can monitor:

- Average current.
- Peak current.
- Ground leakage current.

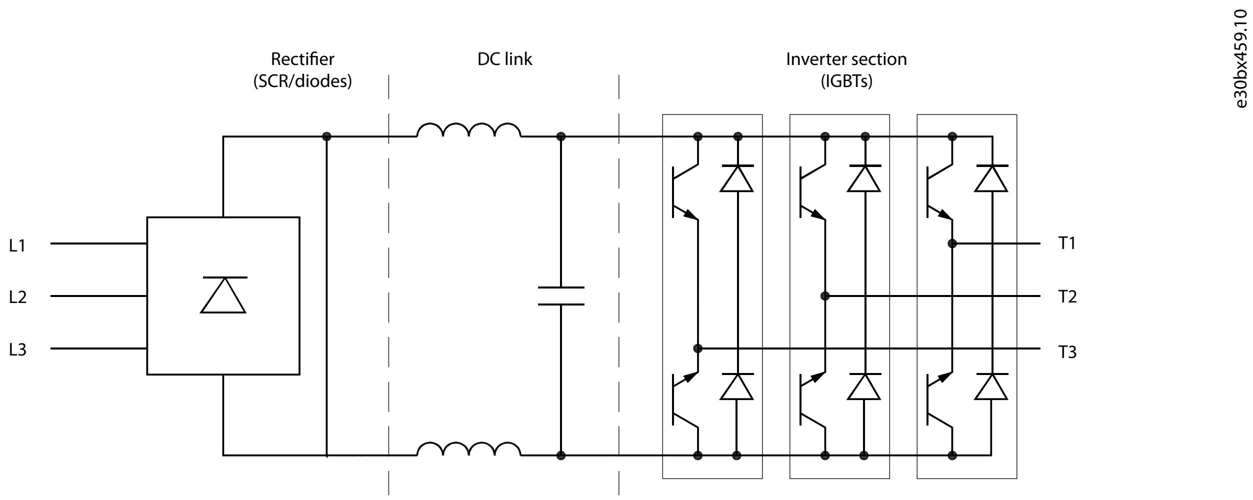


Illustration 34: Typical Power Section of an Individual Drive

5.8 Sequence of Operation

Rectifier section

When power is first applied to the drive, it enters through the input terminals (L1, L2, and L3). Then, power moves to the disconnect/mains contactor/MCCB/RFI filter option, depending on the configuration. If equipped with optional fuses, these fuses limit damage caused by a short circuit in the power section. The input power is also connected to the inrush circuit. This circuit supplies gate signals to the SCRs, with a high firing angle (near 180°) at first. The firing angle decreases with every successive AC cycle until it reaches 0°. This process increases the DC voltage slowly over a period of several line cycles, thus greatly reducing the current for charging the DC capacitors. See illustration 35.

The low-voltage supplies are activated when the DC bus reaches approximately 50 V DC less than the alarm voltage low for the DC bus. After a short delay, an inrush enable signal is sent from the control card to the inrush card SCR gating circuit. The SCRs are automatically gated when forward biased, acting similar to an uncontrolled rectifier as a result.

When the DC bus capacitors are fully charged, the voltage on the DC bus equals the peak voltage of the input AC line. Theoretically, this figure can be calculated by multiplying the AC line value by 1.414 (V AC x 1.414). However, since AC ripple voltage is present on the DC bus, the actual DC value is closer to V AC x 1.38 under unloaded conditions. It can drop to V AC x 1.32 while running under load. For example, a drive connected to a nominal 460-V line, while sitting idle, the DC bus voltage is approximately 635 V DC (460 x 1.38).

As long as power is applied to the drive, this voltage is present in the DC-link and inverter circuits. It is also fed to the switch mode power supply on the power card and is used for generating all other low voltage supplies.

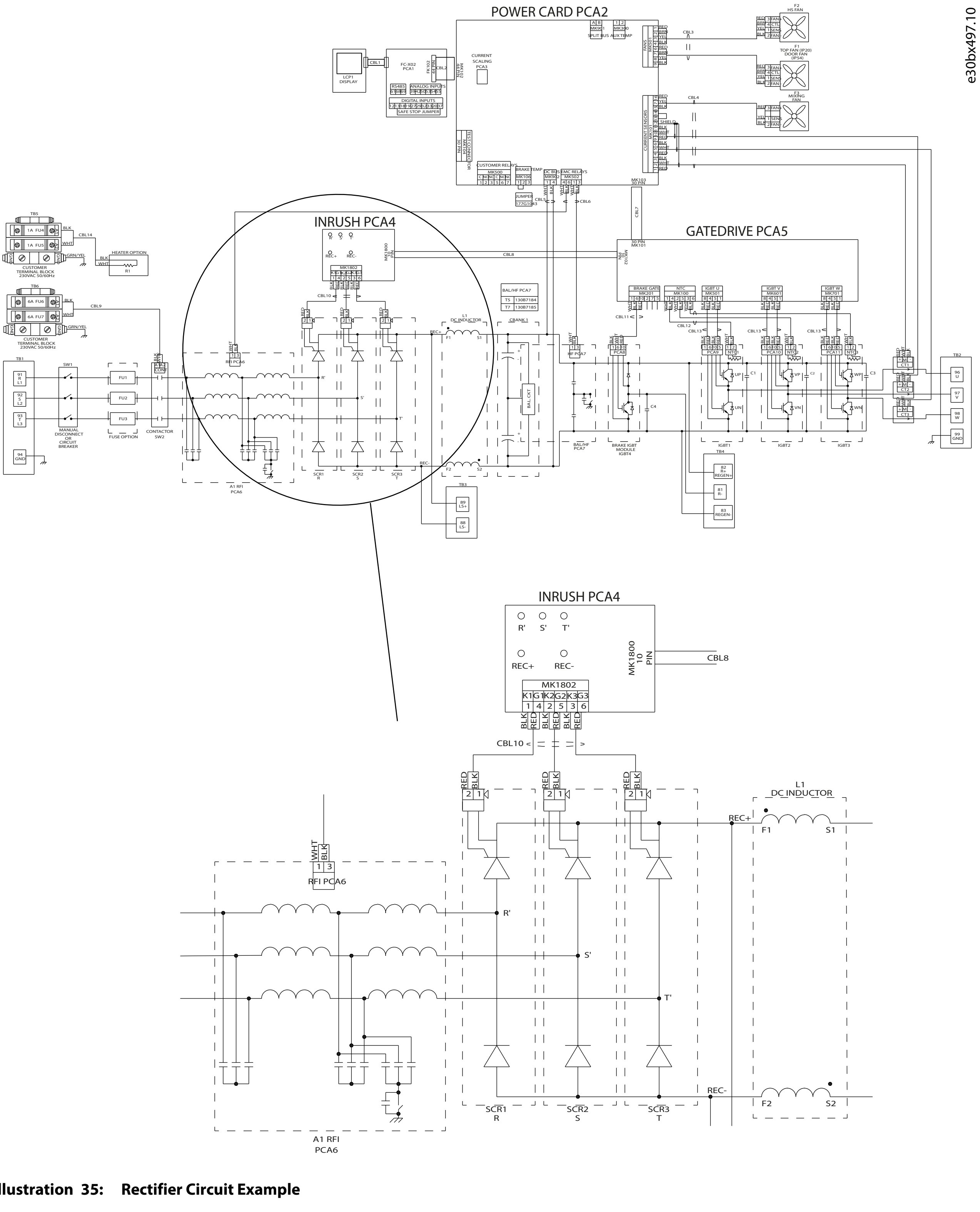


Illustration 35: Rectifier Circuit Example

Intermediate section

Following the rectifier section, voltage passes to the intermediate section (see illustration 36). An LC filter circuit consisting of the DC bus inductor and the DC bus capacitor bank smooths the rectified voltage.

The DC bus inductor provides series impedance to changing current. It aids the filtering process while reducing harmonic distortion to the input AC current waveform normally present in rectifier circuits.

The DC capacitor bank assembly consists of up to 21 capacitors arranged in series/parallel configuration. The assembly also contains the bleeder/balance circuitry. This circuitry maintains equal voltage drops across each capacitor, and provides a current path for discharging the capacitors when the drive is powered down.

The intermediate section also includes the high frequency (HF) filter card. This card contains a high frequency filter circuit to reduce naturally occurring currents in the HF range to prevent interference with sensitive equipment nearby. The circuit, as with other RFI filter circuitry, can be sensitive to unbalanced phase-to-ground voltages in the 3-phase AC input line. This sensitivity occasionally results in nuisance overvoltage alarms. For this reason, the high frequency filter card contains a set of relay contacts in the ground connection of the filter capacitors. The relay is tied to the RFI/HF switch, which can be switched on or off in *parameter 14-50 RFI Filter*. This setting disconnects the ground references to all filters in case unbalanced phase-to-ground voltages create nuisance overvoltage conditions.

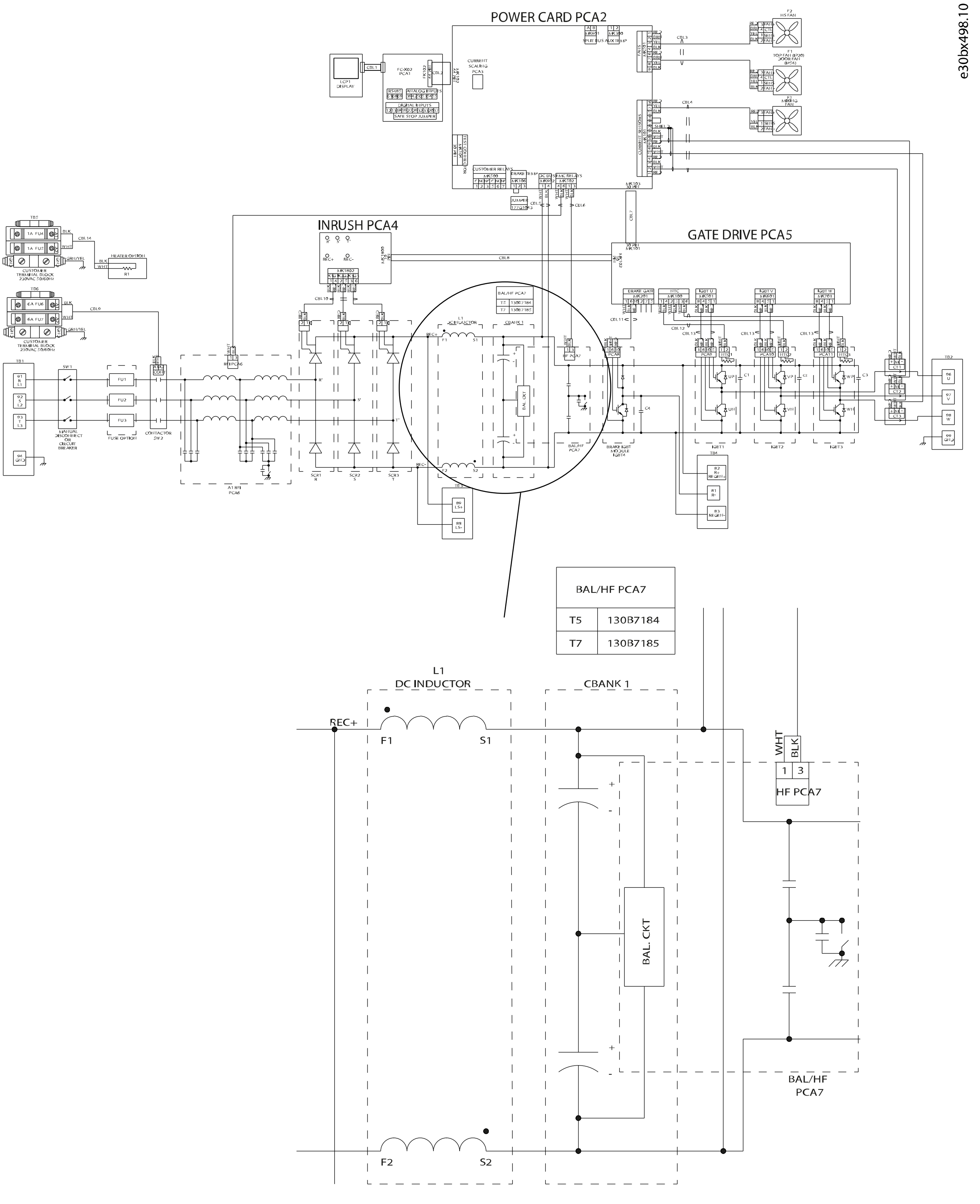


Illustration 36: Intermediate Section Example

Inverter section

In the inverter section (see illustration 38), gate signals are delivered from the control card, through the power card and gatedrive card to the gates of the IGBTs. The series connection of each set of IGBTs is delivered to the output, first passing through the current sensors.

Once a run command and speed reference are present, the IGBTs begin switching to create the output waveform, as shown in illustration 37. Looking at the phase-to-phase voltage waveform with an oscilloscope, the pulse width modulation (PWM) principal creates a series of pulses which vary in width.

Basically, the pulses narrow as they approach 0 crossing and grow wider when further away from 0 crossing. The pulse duration of applied DC voltage controls the width. Although the voltage waveform is a consistent amplitude, the inductance within the motor windings averages the voltage delivered. As the pulse width of the waveform varies, the average voltage that the motor detects also varies. The resulting current waveform takes on the sine-wave shape common to an AC system. The rate at which the pulses occur determines the frequency of the waveform. By employing a sophisticated control scheme, the drive delivers a current waveform that nearly replicates a true AC sine-wave.

Hall effect current sensors monitor the output current and deliver proportional signals to the power card where they are buffered and delivered to the control card. The control card logic uses these current signals to determine proper waveform compensations based on load conditions. They further serve to detect overcurrent conditions, including ground faults and phase-to-phase shorts on the output.

During normal use, the power card and control card are monitoring various functions within the drive. The current sensors provide current feedback information. The DC bus voltage is monitored along with the voltage delivered to the motor. A thermal sensor mounted inside each IGBT module provides heat sink temperature feedback.

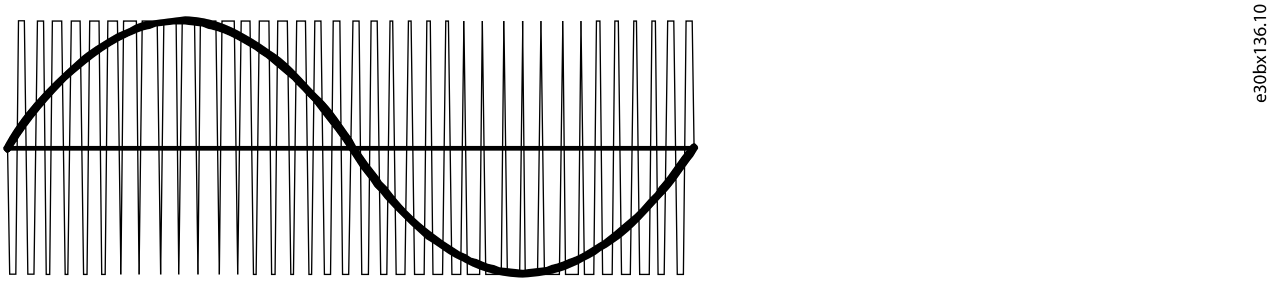


Illustration 37: Output Voltage and Current Waveforms

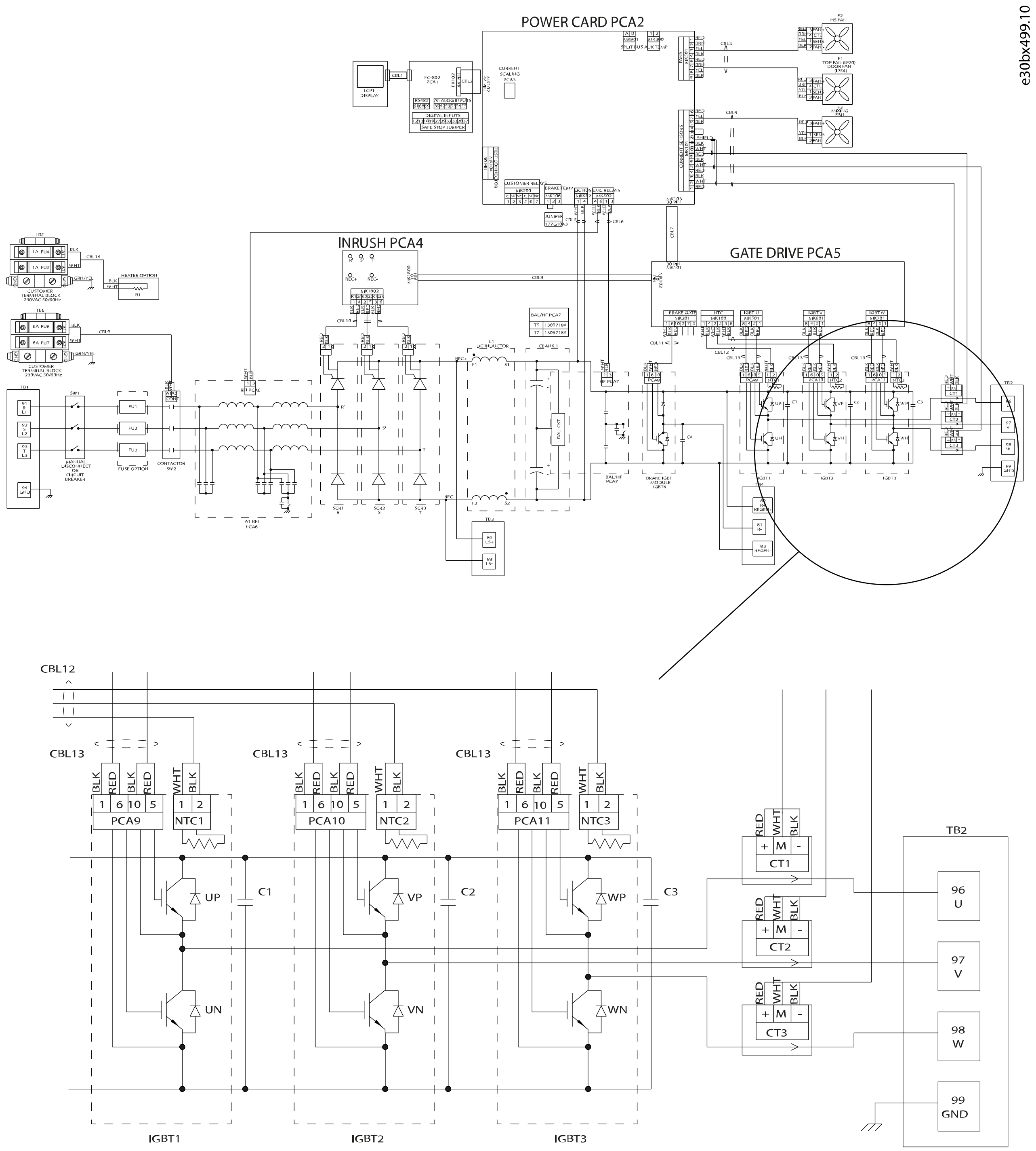


Illustration 38: Inverter Section Example

Brake option

Drives equipped with the dynamic brake option (see illustration 39) can connect to an external brake resistor using the brake IGBT and terminals 81(R-) and 82(R+).

The function of the brake IGBT is to limit the voltage in the DC link, whenever the maximum voltage limit is exceeded. To limit the DC-link voltage, the brake IGBT switches the externally mounted resistor across the DC bus to remove excess DC voltage from the bus capacitors. Typically, excess DC bus voltage is a result of an overhauling load causing regenerative energy to be returned to the DC bus. This excess occurs, for example, when the load drives the motor causing the voltage to return to the DC bus circuit.

External placement of the brake resistor offers multiple advantages:

- Selecting the resistor based on application need.
- Dissipating the energy outside of the control panel.
- Protecting the drive from overheating when the brake resistor is overloaded.

The brake IGBT gate signal originates on the control card and is delivered to the brake IGBT via the power card and gatedrive card. The power and control cards also monitor the brake IGBT and brake resistor connection for short circuits and overloads.

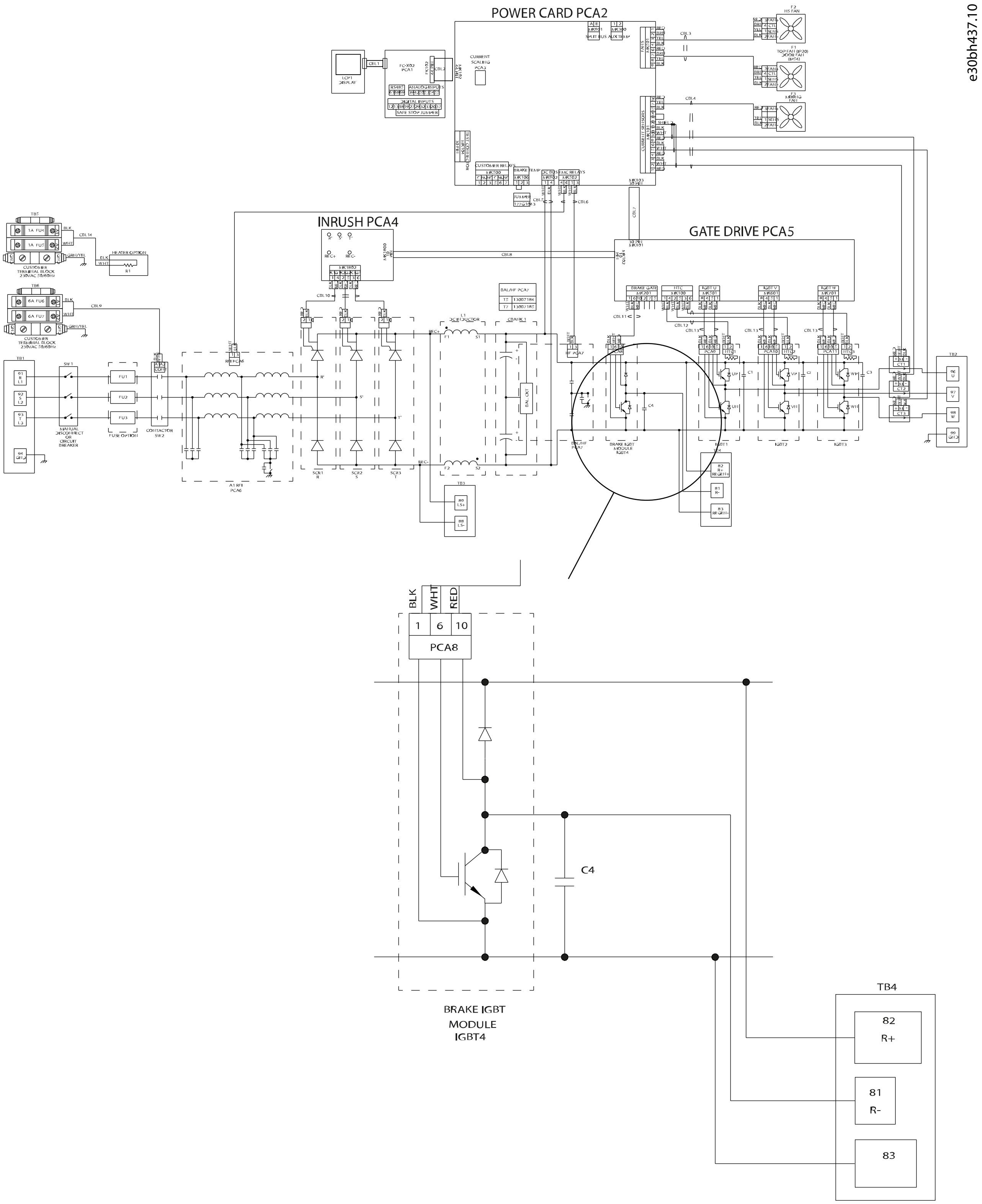


Illustration 39: Brake Option Example

5.9 Fan Operation

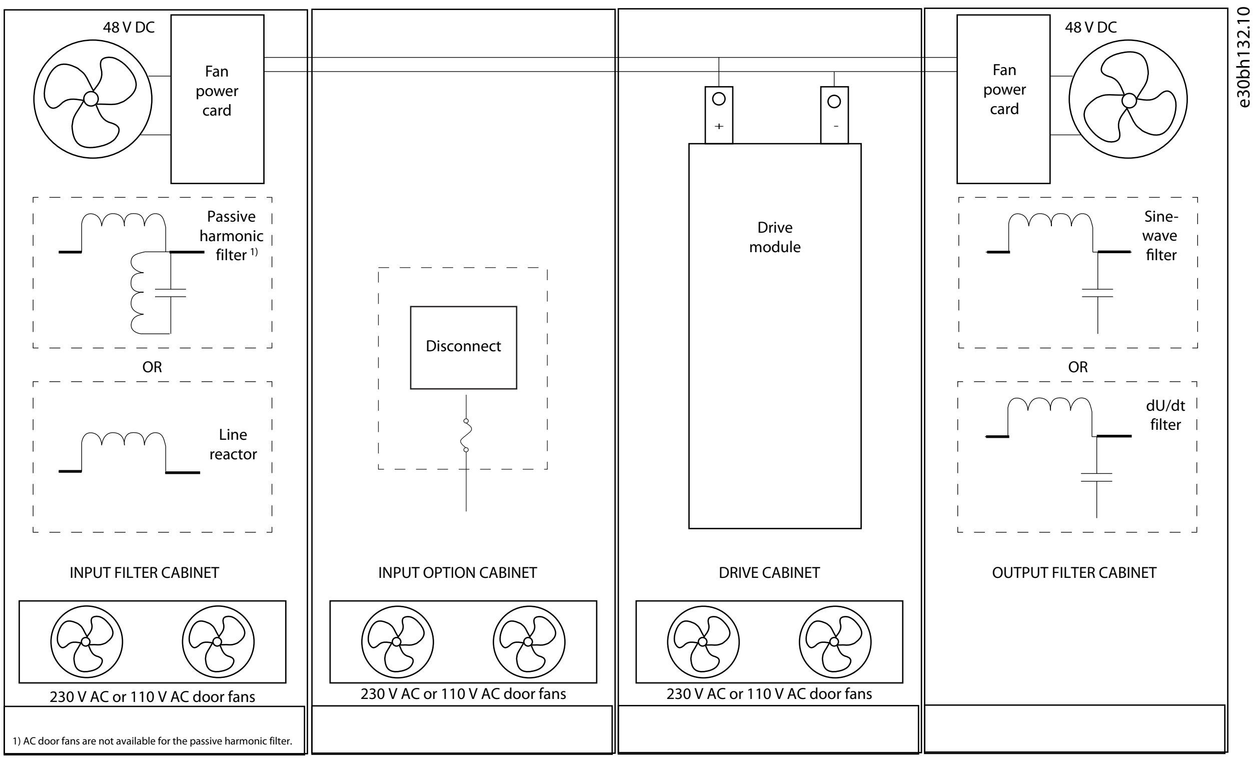


Illustration 40: Fan Concept for Enclosed Drives

Door fans

Enclosed drive systems include cabinet door fans of either 110 V AC (for UL variants) or 230-V AC fans (for IEC variants). The door fans are powered by the internal auxiliary transformers or by external power provided by the customer.

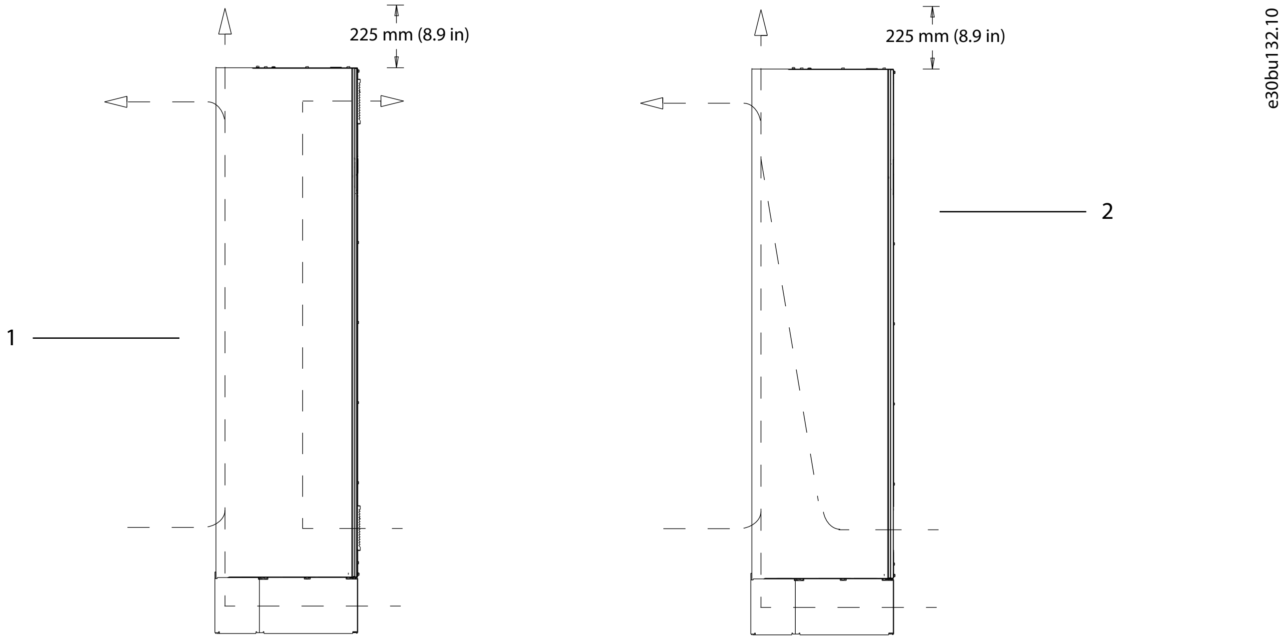
Back-channel fans

The DC fans are the cooling fans found in the enclosure back channel. The DC fan is powered by 48 volts. The associated fan power card acts as a DC-DC converter to provide 48 volts from the DC bus of the drive. Different fan power card variants are listed in table 67.

Table 67: Back-channel Fan Connection Specifications

Part	Electrical specification	Part number
Fan power card	Fan power card 200–500 V	181n0453
	Fan power card 525–690 V	181n0438
Internal (back-channel) fan	175 mm 48-V DC fan	181n0220

5.10 Enclosure Airflow



1 Drive module cabinet	**2** PHF and sine-wave cabinets

Illustration 41: Enclosure Airflow in Sine-wave Filter, Passive Harmonic Filter, and Drive Cabinets

5.11 Airflow Rates

Table 68: Airflow Rates for D9h Enclosure

Cabinet	Back-channel fan [m^3/hr (cfm)]	Drive module top fan [m^3/hr (cfm)]	Cabinet door fan [m^3/hr (cfm)]
PHF/line reactor	450 (265)	–	–
Drive	420 (250)	102 (60)	150 (90)
dU/dt	–	–	–
Sine-wave	900 (530)	–	–
Top entry/top exit	–	–	–

Table 69: Airflow Rates for D10h Enclosure

Cabinet	Back-channel fan [m^3/hr (cfm)]	Drive module top fan [m^3/hr (cfm)]	Cabinet door fan [m^3/hr (cfm)]
PHF/line reactor	450 (265)	–	–
Input options	–	–	510 (310)
Drive	840 (500)	204 (120)	315 (185)
dU/dt	–	–	–
Sine-wave	900 (530)	–	–
Top entry/top exit	–	–	–

Table 70: Airflow Rates for E5h Enclosure

Cabinet	Back-channel fan [m^3/hr (cfm)]	Drive module top fan [m^3/hr (cfm)]	Cabinet door fan [m^3/hr (cfm)]
PHF/line reactor	765 (450)	–	–
Input options	–	–	510 (310)
Drive	994 (585)	595 (350)	335 (200)
dU/dt	665 (392)	–	–
Sine-wave	2x900 (530)	–	–
Top entry/top exit	–	–	–

Table 71: Airflow Rates for E6h Enclosure

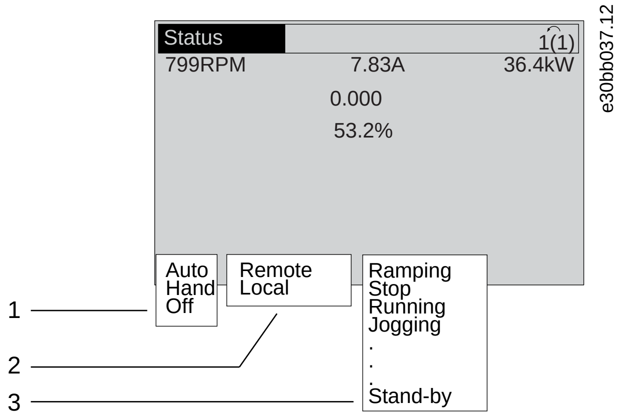
Cabinet	Back-channel fan [m^3/hr (cfm)]	Drive module top fan [m^3/hr (cfm)]	Cabinet door fan [m^3/hr (cfm)]
PHF/line reactor	1285 (755)	–	–
Input options	–	–	510 (310)
Drive	1053–1206 (620–710)	629 (370)	430 (255)
dU/dt	665 (392)	–	–
Sine-wave	2x900 (530)	–	–
Top entry/top exit	–	–	–

6 Troubleshooting

6.1 Status Messages

6.1.1 Status Message Overview

When the drive is in status mode, status messages automatically appear in the bottom line of the LCP display. See illustration 42.



1 Operating mode. Refer to 6.1.2 Status Messages - Operating Mode.	**2** Reference site. Refer to 6.1.3 Status Messages - Reference Site.
3 Operation status. Refer to 6.1.4 Status Messages - Operation Status.	

Illustration 42: Status Display

6.1.2 Status Messages - Operating Mode

Table 72: Operating Mode

Operating mode	Description
Off	The drive does not react to any control signal until [Auto On] or [Hand On] is pressed.
Auto	The drive requires external commands to execute functions. The start/stop commands are sent via the control terminals and/or the serial communication.
Hand	The navigation keys on the LCP can be used to control the drive. Stop commands, reset, reversing, DC brake, and other signals applied to the control terminals override local control.

6.1.3 Status Messages - Reference Site

Table 73: Reference Site

Reference site	Description
Remote	The speed reference is given from • External signals. • Serial communication. • Internal preset references.
Local	The drive uses reference values from the LCP.

6.1.4 Status Messages - Operation Status

Table 74: Operation Status

Operation status	Description
AC brake	AC brake was selected in *parameter 2-10 Brake Function*. The AC brake overmagnetizes the motor to achieve a controlled slow down.
AMA finish OK	Automatic motor adaptation (AMA) was carried out successfully.
AMA ready	AMA is ready to start. To start, press [Hand On].
AMA running	AMA process is in progress.
Braking	The brake chopper is in operation. The brake resistor absorbs the generative energy.
Braking max.	The brake chopper is in operation. The power limit for the brake resistor defined in *parameter 2-12 Brake Power Limit (kW)* has been reached.
Coast	• *[2] Coast inverse* was selected as a function for a digital input (*parameter group 5–1* Digital Inputs*). The corresponding terminal is not connected. • Coast activated by serial communication.
Ctrl. ramp-down	*[1] Ctrl. ramp-down* was selected in *parameter 14-10 Mains Failure*. • The mains voltage is below the value set in *parameter 14-11 Mains Voltage at Mains Fault*. • The drive ramps down the motor in a controlled manner.
Current high	The drive output current is above the limit set in *parameter 4-51 Warning Current High*.
Current low	The drive output current is below the limit set in *parameter 4-52 Warning Speed Low*.
DC hold	DC hold is selected in *parameter 1-80 Function at Stop* and a stop command is active. The motor is held by a DC current set in *parameter 2-00 DC Hold Current*.
DC stop	The motor is held with a DC current (*parameter 2-01 DC Brake Current*) for a specified time (*parameter 2-02 DC Braking Time*). • DC brake is activated in *parameter 2-03 DC Brake Cut In Speed [RPM]* and a stop command is active. • DC brake (inverse) is selected as a function for a digital input (*parameter group 5–1* Digital Inputs*). The corresponding terminal is not active. • The DC brake is activated via serial communication.

Operation status	Description
Feedback high	The sum of all active feedbacks is above the feedback limit set in *parameter 4-57 Warning Feedback High*.
Feedback low	The sum of all active feedbacks is below the feedback limit set in *parameter 4-56 Warning Feedback Low*.
Freeze output	The remote reference is active, which holds the present speed. • *[20] Freeze Output* was selected as a function for a digital input (*parameter group 5–1* Digital Inputs*). The corresponding terminal is active. Speed control is only possible via the terminal functions speed up and speed down. • Hold ramp is activated via serial communication.
Freeze output request	A freeze output command has been given, but the motor remains stopped until a run permissive signal is received.
Freeze ref.	*[19] Freeze Reference* was selected as a function for a digital input (*parameter group 5–1* Digital Inputs*). The corresponding terminal is active. The drive saves the actual reference. Changing the reference is now only possible via terminal functions speed up and speed down.
Jog request	A jog command has been given, but the motor is stopped until a run permissive signal is received via a digital input.
Jogging	The motor is running as programmed in *parameter 3-19 Jog Speed [RPM]*. • *[14] Jog* was selected as function for a digital input (*parameter group 5–1* Digital Inputs*). The corresponding terminal (for example, terminal 29) is active. • The jog function is activated via the serial communication. • The jog function was selected as a reaction for a monitoring function (for example, No signal). The monitoring function is active.
Motor check	In *parameter 1-80 Function at Stop, [2] Motor Check* was selected. A stop command is active. To ensure that a motor is connected to the drive, a permanent test current is applied to the motor.
OVC control	Overvoltage control was activated by *[2] Enabled* in *parameter 2-17 Over-voltage Control*. The connected motor is supplying the drive with generative energy. The overvoltage control adjusts the V/Hz ratio to run the motor in controlled mode and to prevent the drive from tripping.
Power unit off	(For drives with a 24 V external supply installed only.) Mains supply to the drive is removed, but the control card is supplied by the external 24 V.
Protection md	Protection mode is active. The unit has detected a critical status (an overcurrent or overvoltage). • To avoid tripping, the switching frequency is reduced to 1.5 kHz if *parameter 14-55 Output Filter* is set to *[2] Sine-Wave Filter Fixed*. Otherwise, the switching frequency is reduced to 1.0 kHz. • If possible, protection mode ends after approximately 10 s. • Protection mode can be restricted in *parameter 14-26 Trip Delay at Inverter Fault*.
QStop	The motor is decelerating using *parameter 3-81 Quick Stop Ramp Time*. • *[4] Quick stop inverse* was selected as a function for a digital input (*parameter group 5–1* Digital Inputs*). The corresponding terminal is not active. • The quick stop function was activated via serial communication.
Ramping	The motor is accelerating/decelerating using the active ramp up/down. The reference, a limit value, or a standstill is not yet reached.
Ref. high	The sum of all active references is above the reference limit set in *parameter 4-55 Warning Reference High*.
Ref. low	The sum of all active references is below the reference limit set in *parameter 4-54 Warning Reference Low*.
Run on ref.	The drive is running in the reference range. The feedback value matches the setpoint value.
Run request	A start command has been given, but the motor is stopped until a run permissive signal is received via digital input.

Operation status	Description
Running	The drive is driving the motor.
Sleep mode	The energy-saving function is enabled. This function being enabled means that now the motor has stopped, but that it restarts automatically when required.
Speed high	The motor speed is above the value set in *parameter 4-53 Warning Speed High*.
Speed low	The motor speed is below the value set in *parameter 4-52 Warning Speed Low*.
Standby	In auto-on mode, the drive starts the motor with a start signal from a digital input or serial communication.
Start delay	In *parameter 1-71 Start Delay*, a delay starting time was set. A start command is activated and the motor starts after the start delay time expires.
Start fwd/rev	*[12] Enable Start Forward* and *[13] Enable Start Reverse* were selected as functions for 2 different digital inputs (*parameter group 5–1* Digital Inputs*). The motor starts in forward or reverse depending on which corresponding terminal is activated.
Stop	The drive has received a stop command from 1 of the following: • LCP. • Digital input. • Serial communication.
Trip	An alarm occurred and the motor is stopped. Once the cause of the alarm is cleared, reset the drive using 1 of the following: • Pressing [Reset]. • Remotely by control terminals. • Via serial communication.
Trip lock	An alarm occurred and the motor is stopped. Once the cause of the alarm is cleared, cycle power to the drive. Reset the drive manually by 1 of the following: • Pressing [Reset]. • Remotely by control terminals. • Via serial communication.

6.2 Warnings and Alarms

6.2.1 Warning and Alarm Types

Alarm

An alarm indicates a fault that requires immediate attention. The fault always triggers a trip or trip lock. Reset the drive after an alarm using 1 of the following methods:

- Press [Reset]/[Off/Reset].
- Digital reset input command.
- Serial communication reset input command.
- Auto reset.

Warning

A state entered in fault situations, for example if the drive is subject to an overtemperature or when the drive is protecting the motor, process, or mechanism. The drive prevents a restart until the cause of the fault has disappeared. To cancel the trip state, restart the drive. Do not use the trip state for personal safety.

Trip lock

The drive enters this state in fault situations to protect itself. The drive requires physical intervention, for example when there is a short circuit on the output. A trip lock can only be canceled by disconnecting mains, removing the cause of the fault, and reconnecting the drive. Restart is prevented until the trip state is canceled by activating reset or, sometimes, by being programmed to reset automatically. Do not use the trip lock state for personal safety.

LCP notification

When a fault is triggered, the LCP indicates the type of fault (alarm, warning, or trip lock) and shows the alarm or warning number in the display.

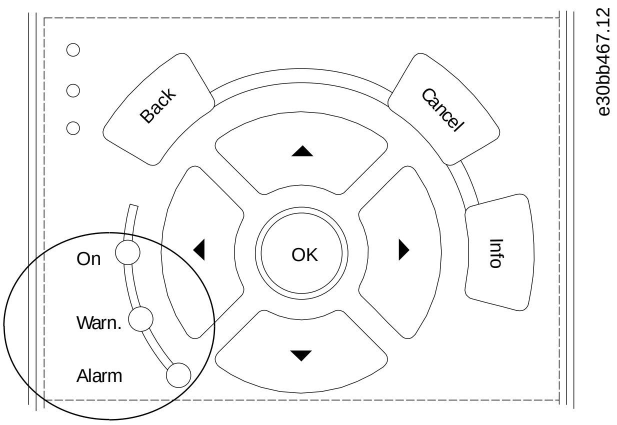


Illustration 43: Status Indicator Lights

Table 75:

Type of fault	Warning indicator light	Alarm indicator light
Warning	On	Off
Alarm	Off	On (flashing)
Trip lock	On	On (flashing)

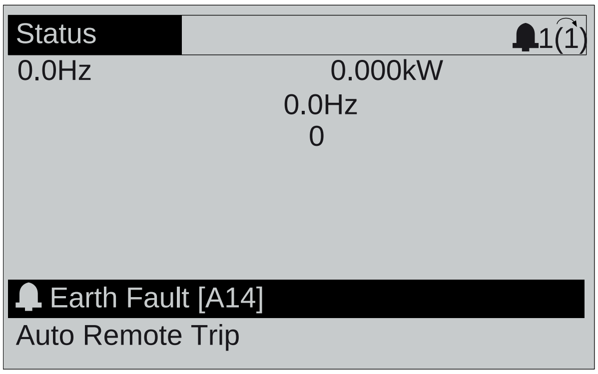


Illustration 44: Alarm Example

6.2.2 WARNING 1, 10 Volts Low

Cause

The control card voltage is less than 10 V from terminal 50. Remove some of the load from terminal 50, as the 10 V supply is overloaded. Maximum 15 mA or minimum 590 Ω.

A short circuit in a connected potentiometer or incorrect wiring of the potentiometer can cause this condition.

Troubleshooting

- Remove the wiring from terminal 50. If the warning clears, the problem is with the wiring. If the warning does not clear, replace the control card.

6.2.3 WARNING/ALARM 2, Live Zero Error

Cause

This warning or alarm only appears if programmed in *parameter 6-01 Live Zero Timeout Function*. The signal on 1 of the analog inputs is less than 50% of the minimum value programmed for that input. Broken wiring or a faulty device sending the signal can cause this condition.

Troubleshooting

- Check connections on all analog mains terminals.
  - Control card terminals 53 and 54 for signals, terminal 55 common.
  - VLT® General Purpose I/O MCB 101 terminals 11 and 12 for signals, terminal 10 common.
  - VLT® Analog I/O Option MCB 109 terminals 1, 3, and 5 for signals, terminals 2, 4, and 6 common.
- Check that the drive programming and switch settings match the analog signal type.
- Perform an input terminal signal test.

6.2.4 WARNING/ALARM 3, No Motor

Cause

No motor is connected to the output of the drive.

6.2.5 WARNING/ALARM 4, Mains Phase Loss

Cause

A phase is missing on the supply side, or the mains voltage imbalance is too high. This message also appears for a fault in the input rectifier. Options are programmed in *parameter 14-12 Function at Mains Imbalance*.

Troubleshooting

- Check the supply voltage and supply currents to the drive.

6.2.6 WARNING 5, DC Link Voltage High

Cause

The DC-link voltage (DC) is higher than the high-voltage warning limit. The limit depends on the drive voltage rating. The unit is still active.

6.2.7 WARNING 6, DC Link Voltage Low

Cause

The DC-link voltage (DC) is lower than the low voltage warning limit. The limit depends on the drive voltage rating. The unit is still active.

6.2.8 WARNING/ALARM 7, DC Overvoltage

Cause

If the DC-link voltage exceeds the limit, the drive trips after a certain time.

Troubleshooting

- Connect a brake resistor.
- Extend the ramp time.
- Change the ramp type.
- Activate the functions in *parameter 2-10 Brake Function*.
- Increase *parameter 14-26 Trip Delay at Inverter Fault*.
- If the alarm/warning occurs during a power sag, use kinetic back-up (*parameter 14-10 Mains Failure*).

6.2.9 WARNING/ALARM 8, DC Undervoltage

Cause

If the DC-link voltage drops below the undervoltage limit, the drive checks for 24 V DC back-up supply. If no 24 V DC back-up supply is connected, the drive trips after a fixed time delay. The time delay varies with unit size.

Troubleshooting

- Check that the supply voltage matches the drive voltage.
- Perform an input voltage test.
- Perform a soft-charge circuit test.

6.2.10 WARNING/ALARM 9, Inverter Overload

Cause

The drive has run with more than 100% overload for too long and is about to cut out. The counter for electronic thermal inverter protection issues a warning at 98% and trips at 100% with an alarm. The drive cannot be reset until the counter is below 90%.

Troubleshooting

- Compare the output current shown on the LCP with the drive rated current.
- Compare the output current shown on the LCP with the measured motor current.
- Show the thermal drive load on the LCP and monitor the value. When running above the drive continuous current rating, the counter increases. When running below the drive continuos current rating, the counter decreases.

6.2.11 WARNING/ALARM 10, Motor Overload Temperature

Cause

According to the electronic thermal protection (ETR), the motor is too hot.

Select 1 of these options:

- The drive issues a warning or an alarm when the counter is >90% if *parameter 1-90 Motor Thermal Protection* is set to warning options.
- The drive trips when the counter reaches 100% if *parameter 1-90 Motor Thermal Protection* is set to trip options.

The fault occurs when the motor runs with more than 100% overload for too long.

Troubleshooting

- Check for motor overheating.
- Check if the motor is mechanically overloaded.
- Check that the motor current set in *parameter 1-24 Motor Current* is correct.
- Ensure that the motor data in *parameters 1-20* to *1-25* is set correctly.
- If an external fan is in use, check that it is selected in *parameter 1-91 Motor External Fan*.
- Running AMA in *parameter 1-29 Automatic Motor Adaptation (AMA)* tunes the drive to the motor more accurately and reduces thermal loading.

6.2.12 WARNING/ALARM 11, Motor Thermistor Overtemp

The motor thermistor indicates that the motor temperature is too high.

Troubleshooting

- Check for motor overheating.
- Check that the thermistor is securely connected.
- Check if the motor is mechanically overloaded.
- When using terminal 53 or 54, check that the thermistor is connected correctly between either terminal 53 or 54 (analog voltage input) and terminal 50 (+10 V supply). Also check that the terminal switch for 53 and 54 is set for voltage. Check that *parameter 1-93 Thermistor Resource* selects 53 or 54.
- When using terminal 18, 19, 31, 32, or 33 (digital inputs), check that the thermistor is connected correctly between the digital input terminal used (digital input PNP only) and terminal 50. Select the terminal to use in *parameter 1-93 Thermistor Resource*.

6.2.13 WARNING/ALARM 12, Torque Limit

Cause

The torque has exceeded the value in *parameter 4-16 Torque Limit Motor Mode* or the value in *parameter 4-17 Torque Limit Generator Mode*. *Parameter 14-25 Trip Delay at Torque Limit* can change this warning from a warning-only condition to a warning followed by an alarm.

Troubleshooting

- If the motor torque limit is exceeded during ramp-up, extend the ramp-up time.
- If the generator torque limit is exceeded during ramp-down time, extend the ramp-down time.
- If torque limit occurs while running, increase the torque limit. Make sure that the system can operate safely at a higher torque.
- Check the application for excessive current draw on the motor.

6.2.14 WARNING/ALARM 13, Overcurrent

Cause

The inverter peak current limit (approximately 200% of the rated current) is exceeded. The warning lasts approximately 1.5 s, then the drive trips and issues an alarm. Shock loading or quick acceleration with high-inertia loads can cause this fault. If the acceleration during ramp-up is quick, the fault can also appear after kinetic back-up. If extended mechanical brake control is selected, a trip can be reset externally.

The inverter peak current limit (approximately 200% of the rated current) is exceeded. The warning lasts approximately 1.5 s, then the drive trips and issues an alarm. Shock loading or quick acceleration with high-inertia loads can cause this fault.

Troubleshooting

- Remove power and check if the motor shaft can be turned.
- Check that the motor size matches the drive.
- Check that the motor data is correct in *parameters 1-20* to *1-25*.

6.2.15 ALARM 14, Earth (Ground) Fault

Cause

There is current from the output phase to ground, either in the cable between the drive and the motor, or in the motor itself. The current transducers detect the ground fault by measuring current going out from the drive and current going into the drive from the motor. Ground fault is issued if the deviation of the 2 currents is too large. The current going out of the drive must be the same as the current going into the drive.

Troubleshooting

- Remove power to the drive and repair the ground fault.
- Check for ground faults in the motor by measuring the resistance to ground of the motor cables and the motor with a megohmmeter.
- Reset any potential individual offset in the 3 current transducers in the drive. Perform a manual initialization or perform a complete AMA. This method is most relevant after changing the power card.

6.2.16 ALARM 15, Hardware Mismatch

Cause

A fitted option is not operational with the present control card hardware or software.

Troubleshooting

Record the value of the following parameters and contact Danfoss.

- *Parameter 15-40 FC Type*.
- *Parameter 15-41 Power Section*.
- *Parameter 15-42 Voltage*.
- *Parameter 15-43 Software Version*.
- *Parameter 15-45 Actual Typecode String*.
- *Parameter 15-49 SW ID Control Card*.
- *Parameter 15-50 SW ID Power Card*.
- *Parameter 15-60 Option Mounted*.
- *Parameter 15-61 Option SW Version* (for each option slot).

6.2.17 ALARM 16, Short Circuit

Cause

There is short-circuiting in the motor or motor wiring.

Troubleshooting

⚠ WARNING ⚠

HIGH VOLTAGE

AC drives contain high voltage when connected to AC mains input , DC supply , or load sharing. Failure to perform installation , start-up, and maintenance by qualified personnel can result in death or serious injury.

- Only qualified personnel must perform installation, start-up, and maintenance.

- Disconnect power before proceeding.
- Remove the power to the drive and repair the short circuit.

6.2.18 WARNING/ALARM 17, Control Word Timeout

Cause

There is no communication to the drive. The warning is only active when *parameter 8-04 Control Word Timeout Function* is NOT set to *[0] Off*.

If *parameter 8-04 Control Word Timeout Function* is set to *[5] Stop and trip*, a warning appears, and the drive ramps down to a stop and shows an alarm.

Troubleshooting

- Check the connections on the serial communication cable.
- Increase *parameter 8-03 Control Word Timeout Time*.
- Check the operation of the communication equipment.
- Verify that proper EMC installation was performed.

6.2.19 WARNING/ALARM 20, Temp. Input Error

Cause

The temperature sensor is not connected.

6.2.20 WARNING/ALARM 21, Parameter Error

Cause

The parameter is out of range. The parameter number is shown in the display.

Troubleshooting

- Set the affected parameter to a valid value.

6.2.21 WARNING/ALARM 22, Hoist Mechanical Brake

Cause

The value of this warning/alarm shows the type of warning/alarm.

0 = The torque reference was not reached before timeout (*parameter 2-27 Torque Ramp Up Time*).

1 = Expected brake feedback was not received before timeout (*parameter 2-23 Activate Brake Delay*, *parameter 2-25 Brake Release Time*).

6.2.22 WARNING 23, Internal Fan Fault

Cause

The fan warning function is a protective function that checks if the fan is running/mounted. The fan warning can be disabled in *parameter 14-53 Fan Monitor* (*[0] Disabled*).

For drives with DC fans, a feedback sensor is mounted in the fan. If the fan is commanded to run and there is no feedback from the sensor, this alarm appears. For drives with AC fans, the voltage to the fan is monitored.

Troubleshooting

- Check for proper fan operation.
- Cycle power to the drive and check that the fan operates briefly at start-up.
- Check the sensors on the control card.

6.2.23 WARNING 24, External Fan Fault

Cause

The fan warning function is a protective function that checks if the fan is running/mounted. The fan warning can be disabled in *parameter 14-53 Fan Monitor* (*[0] Disabled*).

For drives with DC fans, a feedback sensor is mounted in the fan. If the fan is commanded to run and there is no feedback from the sensor, this warning appears. For drives with AC fans, the voltage to the fan is monitored.

Troubleshooting

- Check for proper fan operation.
- Cycle power to the drive and check that the fan operates briefly at start-up.
- Check the sensors on the heat sink.

6.2.24 WARNING 25, Brake Resistor Short Circuit

Cause

The brake resistor is monitored during operation. If a short circuit occurs, the brake function is disabled and the warning appears. The drive is still operational, but without the brake function.

Troubleshooting

- Remove the power to the drive and replace the brake resistor (refer to *parameter 2-15 Brake Check*).

6.2.25 WARNING/ALARM 26, Brake Resistor Power Limit

Cause

The power transmitted to the brake resistor is calculated as a mean value over the last 120 s of run time. The calculation is based on the DC-link voltage and the brake resistor value set in *parameter 2-16 AC Brake Max. Current*. The warning is active when the dissipated braking power is higher than 90% of the brake resistor power. If option *[2] Trip* is selected in *parameter 2-13 Brake Power Monitoring*, the drive trips when the dissipated braking power reaches 100%.

6.2.26 WARNING/ALARM 27, Brake Chopper Fault

Cause

The brake transistor is monitored during operation, and if a short circuit occurs, the brake function is disabled, and a warning is issued. The drive is still operational, but since the brake transistor has short-circuited, substantial power is transmitted to the brake resistor, even if it is inactive.

Troubleshooting

- Remove the power to the drive and remove the brake resistor.

6.2.27 WARNING/ALARM 28, Brake Check Failed

Cause

The brake resistor is not connected or not working.

Troubleshooting

- Check *parameter 2-15 Brake Check*.

6.2.28 ALARM 29, Heat Sink Temp

Cause

The maximum temperature of the heat sink is exceeded. The temperature fault is not reset until the temperature drops below a defined heat sink temperature. The trip and reset points are different based on the drive power size.

Troubleshooting

- The ambient temperature is too high.
- The motor cables are too long.
- Incorrect airflow clearance above and below the drive.
- Blocked airflow around the drive.
- Damaged heat sink fan.
- Dirty heat sink.

6.2.29 ALARM 30 Motor Phase U Missing

Cause

Motor phase U between the drive and the motor is missing.

Troubleshooting

⚠ WARNING ⚠

HIGH VOLTAGE

AC drives contain high voltage when connected to AC mains input , DC supply , or load sharing. Failure to perform installation , start-up, and maintenance by qualified personnel can result in death or serious injury.

- Only qualified personnel must perform installation, start-up, and maintenance.

- Disconnect power before proceeding.
- Remove the power from the drive and check motor phase U.

6.2.30 ALARM 31 Motor Phase V Missing

Cause

Motor phase V between the drive and the motor is missing.

Troubleshooting

⚠ WARNING ⚠

HIGH VOLTAGE

AC drives contain high voltage when connected to AC mains input , DC supply , or load sharing. Failure to perform installation , start-up, and maintenance by qualified personnel can result in death or serious injury.

- Only qualified personnel must perform installation, start-up, and maintenance.

- Disconnect power before proceeding.
- Remove the power from the drive and check motor phase V.

6.2.31 ALARM 32 Motor Phase W Missing

Cause

Motor phase W between the drive and the motor is missing.

Troubleshooting

⚠ WARNING ⚠

HIGH VOLTAGE

AC drives contain high voltage when connected to AC mains input , DC supply , or load sharing. Failure to perform installation , start-up, and maintenance by qualified personnel can result in death or serious injury.

- Only qualified personnel must perform installation, start-up, and maintenance.

- Disconnect power before proceeding.
- Remove the power from the drive and check motor phase W.

6.2.32 ALARM 33, Inrush Fault

Cause

Too many power-ups have occurred within a short time period.

Troubleshooting

- Let the unit cool to operating temperature.
- Check potential DC-link fault to ground.

6.2.33 WARNING/ALARM 34, Fieldbus Communication Fault

Cause

The fieldbus on the communication option card is not working.

6.2.34 WARNING/ALARM 35, Option Fault

Cause

An option alarm is received. The alarm is option-specific. The most likely cause is a power-up or a communication fault.

6.2.35 WARNING/ALARM 36, Mains Failure

Cause

This warning/alarm is only active if the supply voltage to the drive is lost and *parameter 14-10 Mains Failure* is not set to *[0] No Function*.

Troubleshooting

- Check the fuses to the drive and mains supply to the unit.

6.2.36 ALARM 37, Phase Imbalance

Cause

There is a current imbalance between the power units.

6.2.37 ALARM 38, Internal Fault

Cause

When an internal fault occurs, a code number defined in table 76 is shown.

Troubleshooting

- Cycle power.
- Check that the option is properly installed.
- Check for loose or missing wiring.

It may be necessary to contact the Danfoss supplier or service department. Note the code number for further troubleshooting directions.

Table 76: Internal Fault Codes

Number	Text
0	The serial port cannot be initialized. Contact the Danfoss supplier or Danfoss service department.
256-258	The power EEPROM data is defective or too old. Replace the power card.
512-519	Internal fault. Contact the Danfoss supplier or Danfoss service department.
783	Parameter value outside of minimum/maximum limits.

Number	Text
1024-1284	Internal fault. Contact the Danfoss supplier or Danfoss service department.
1299	The option software in slot A is too old.
1300	The option software in slot B is too old.
1302	The option software in slot C1 is too old.
1315	The option software in slot A is not supported/allowed.
1316	The option software in slot B is not supported/ allowed.
1318	The option software in slot C1 is not supported/ allowed.
1379-2819	Internal fault. Contact the Danfoss supplier or Danfoss service department.
1792	Hardware reset of digital signal processor.
1793	Motor-derived parameters not transferred correctly to the digital signal processor.
1794	Power data not transferred correctly at power-up to the digital signal processor.
1795	The digital signal processor has received too many unknown SPI telegrams. The AC drive also uses this fault code if the MCO does not power up correctly. This situation can occur due to poor EMC protection or improper grounding.
1796	RAM copy error.
2561	Replace the control card.
2820	LCP stack overflow.
2821	Serial port overflow.
2822	USB port overflow.
3072-5122	Parameter value is outside its limits.
5123	Option in slot A: Hardware incompatible with the control board hardware.
5124	Option in slot B: Hardware incompatible with the control board hardware.
5125	Option in slot C0: Hardware incompatible with the control board hardware.
5126	Option in slot C1: Hardware incompatible with the control board hardware.
5376-6231	Internal fault. Contact the Danfoss supplier or Danfoss service department.

6.2.38 ALARM 39, Heat Sink Sensor

Cause

No feedback from the heat sink temperature sensor.

The signal from the IGBT thermal sensor is not available on the power card. The problem could be on the power card, on the gatedrive card, or on the ribboncable between the power card and the gatedrive card.

6.2.39 WARNING 40, Overload of Digital Output Terminal 27

Troubleshooting

- Check the load connected to terminal 27 or remove the short-circuit connection.
- Check *parameter 5-00 Digital I/O Mode* and *parameter 5-01 Terminal 27 Mode*.

6.2.40 WARNING 41, Overload of Digital Output Terminal 29

Troubleshooting

- Check the load connected to terminal 29 or remove the short-circuit connection.
- Check *parameter 5-00 Digital I/O Mode* and *parameter 5-02 Terminal 29 Mode*.

6.2.41 WARNING 42, Ovrld X30/6-7

Troubleshooting

For terminal X30/6:

- Check the load connected to the terminal, or remove the short-circuit connection.
- Check *parameter 5-32 Term X30/6 Digi out (MCB 101)* (VLT® General Purpose I/O MCB 101).

For terminal X30/7:

- Check the load connected to the terminal, or remove the short-circuit connection.
- Check *parameter 5-33 Term X30/7 Digi Out (MCB 101)* (VLT® General Purpose I/O MCB 101).

6.2.42 ALARM 43, Ext. Supply

Either connect a 24 V DC external supply or specify that no external supply is used via *parameter 14-80 Option Supplied by External 24VDC*, *[0] No*. A change in *parameter 14-80 Option Supplied by External 24VDC* requires a power cycle.

Cause

VLT® Extended Relay Option MCB 113 is mounted without 24 V DC.

Troubleshooting

Choose 1 of the following:

- Connect a 24 V DC external supply.
- Specify that no external supply is used via *parameter 14-80 Option Supplied by External 24VDC*, *[0] No*. A change in *parameter 14-80 Option Supplied by External 24VDC* requires a power cycle.

6.2.43 ALARM 45, Earth Fault 2

Cause

Ground fault.

Troubleshooting

- Check for proper grounding and loose connections.
- Check for proper wire size.
- Check the motor cables for short circuits or leakage currents.

6.2.44 ALARM 46, Power Card Supply

Cause

The supply on the power card is out of range. Another reason can be a defective heat sink fan.

There are 3 supplies generated by the switch mode supply (SMPS) on the power card:

- 24 V.
- 5 V.
- ±18 V.

When powered with VLT® 24 V DC Supply MCB 107, only 24 V and 5 V supplies are monitored. When powered with 3-phase mains voltage, all 3 supplies are monitored.

Troubleshooting

- Check for a defective power card.
- Check for a defective control card.
- Check for a defective option card.
- If a 24 V DC supply is used, verify proper supply power.
- Check for a defective heat sink fan.

6.2.45 WARNING 47, 24 V Supply Low

Cause

The supply on the power card is out of range.

There are 3 supplies generated by the switch mode supply (SMPS) on the power card:

- 24 V
- 5 V
- ±18 V

Troubleshooting

- Check for a defective power card.

6.2.46 WARNING 48, 1.8 V Supply Low

Cause

The 1.8 V DC supply used on the control card is outside of the allowed limits. The supply is measured on the control card.

Troubleshooting

- Check for a defective control card.
- If an option card is present, check for overvoltage.

6.2.47 WARNING 49, Speed Limit

Cause

The warning is shown when the speed outside of the specified range in *parameter 4-11 Motor Speed Low Limit [RPM]* and *parameter 4-13 Motor Speed High Limit [RPM]*. When the speed is below the specified limit in *parameter 1-86 Trip Speed Low [RPM]* (except when starting or stopping), the drive trips.

6.2.48 ALARM 50, AMA Calibration Failed

Troubleshooting

- Contact the Danfoss supplier or service department.

6.2.49 ALARM 51, AMA Check Unom and Inom

Cause

The settings for motor voltage, motor current, and motor power are wrong.

Troubleshooting

- Check settings in *parameters 1-20* to *1-25*.

6.2.50 ALARM 52, AMA Low Inom

Cause

The motor current is too low.

Troubleshooting

- Check the settings in *parameter 1-24 Motor Current*.

6.2.51 ALARM 53, AMA Motor Too Big

Cause

The motor is too big for the AMA to operate.

6.2.52 ALARM 54, AMA Motor Too Small

Cause

The motor is too small for the AMA to operate.

6.2.53 ALARM 55, AMA Parameter Out of Range

Cause

The AMA cannot run because the paramenter values of the motor are out of the acceptable range.

6.2.54 ALARM 56, AMA Interrupted by User

Cause

The AMA is manually interrupted.

6.2.55 ALARM 57, AMA Internal Fault

Cause

Try to restart the AMA. Repeated restarts can overheat the motor.

6.2.56 ALARM 58, AMA Internal Fault

Troubleshooting

Contact the Danfoss supplier.

6.2.57 WARNING 59, Current Limit

Cause

The current is higher than the value in *parameter 4-18 Current Limit*.

Troubleshooting

- Ensure that the motor data in *parameters 1-20* to *1-25* is set correctly.
- Increase the current limit if necessary. Ensure that the system can operate safely at a higher limit.

6.2.58 ALARM 60, External Interlock

Cause

A digital input signal indicates a fault condition external to the drive. Within the control compartment, the following 3 relay contacts are connected in series to 1 digit input that is used as a thermal overload relay:

- KFJ.1 monitors the heat within the input power options cabinet.
- KFJ.2 monitors the heat within the output filter cabinet.
- KFJ.3 monitors the heat within the input filter cabinet.

When the thermal switches in any of these cabinets open due to overtemperature, the drive trips on External Interlock [A60].

Troubleshooting

- Open the control compartment and check for any lights in relays KFJ.1, KFJ.2, and KFJ.3. If no lights are present, check for other external interlocks.
- Clear the external fault condition.
- To resume normal operation, apply 24 V DC to the terminal programmed for external interlock.
- Reset the drive.

6.2.59 WARNING/ALARM 61, Feedback Error

Cause

An error between calculated speed and speed measurement from feedback device.

Troubleshooting

- Check the settings for warning/alarm/disabling in *parameter 4-30 Motor Feedback Loss Function*.
- Set the tolerable error in *parameter 4-31 Motor Feedback Speed Error*.
- Set the tolerable feedback loss time in *parameter 4-32 Motor Feedback Loss Timeout*.

6.2.60 WARNING 62, Output Frequency at Maximum Limit

Cause

The output frequency has reached the value set in *parameter 4-19 Max Output Frequency*.

Troubleshooting

- Check the application for possible causes.
- Increase the output frequency limit. Be sure that the system can operate safely at a higher output frequency.

The warning clears when the output drops below the maximum limit.

6.2.61 ALARM 63, Mechanical Brake Low

Cause

The actual motor current has not exceeded the release brake current within the start delay time window.

6.2.62 WARNING 64, Voltage Limit

Cause

The load and speed combination demands a motor voltage higher than the actual DC-link voltage.

6.2.63 WARNING/ALARM 65, Control Card Overtemperature

Cause

The cutout temperature of the control card is 85 °C (185 °F).

The cutout temperature of the control card has exceeded the upper limit.

Troubleshooting

- Check that the ambient operating temperature is within the limits.
- Check for clogged filters.
- Check the fan operation.
- Check the control card.

6.2.64 WARNING 66, Heat Sink Temperature Low

Cause

The drive is too cold to operate. This warning is based on the temperature sensor in the IGBT module.

Troubleshooting

- Increase the ambient temperature of the unit.
- Supply a trickle amount of current to the drive whenever the motor is stopped by setting *parameter 2-00 DC Hold/Preheat Current* to 5% and *parameter 1-80 Function at Stop*.

6.2.65 ALARM 67, Option Module Configuration has Changed

Cause

One or more options have either been added or removed since the last power-down.

Troubleshooting

- Check that the configuration change is intentional and reset the unit.

6.2.66 ALARM 68, Safe Stop Activated

Cause

Safe Torque Off (STO) has been activated.

Troubleshooting

- To resume normal operation, apply 24 V DC to terminal 37, then send a reset signal (via bus, digital, or by pressing [Reset]).

6.2.67 ALARM 69, Power Card Temperature

Cause

The temperature sensor on the power card is either too hot or too cold.

Troubleshooting

- Check that the ambient operating temperature is within the limits.
- Check for clogged filters.
- Check fan operation.
- Check the power card.

6.2.68 ALARM 70, Illegal FC Configuration

Cause

The control card and power card are incompatible.

Troubleshooting

- To check compatibility, contact the Danfoss supplier with the type code from the unit nameplate and the part numbers on the cards.

6.2.69 ALARM 71, PTC 1 Safe Stop

Cause

Because the motor is too warm, the VLT® PTC Thermistor Card MCB 112 activated the Safe Torque Off (STO).

Troubleshooting

- Once the motor temperature reaches an acceptable level and the digital input from MCB 112 is deactivated,send a reset signal via bus or digital I/O, or press [Reset].

6.2.70 ALARM 72, Dangerous Failure

Cause

Safe Torque Off (STO) with trip lock.

Troubleshooting

An unexpected combination of STO commands has occurred:

- VLT® PTC Thermistor Card MCB 112 enables X44/10, but STO is not enabled.
- MCB 112 is the only device using STO (specified through selection *[4] PTC 1 alarm* or *[5] PTC 12 warning* in *parameter 5-19 Terminal 37 Safe Stop*). STO is activated, but X44/10 is not activated.

6.2.71 WARNING 73, Safe Stop Auto Restart

Cause

STO activated.

Troubleshooting

- With automatic restart enabled, the motor can start when the fault is cleared.

6.2.72 ALARM 74, PTC Thermistor

Cause

The PTC is not working. Alarm is related to VLT® PTC Thermistor Card MCB 112.

6.2.73 ALARM 75, Illegal Profile Sel.

Cause

Do not write the parameter value while the motor is running.

Troubleshooting

- Stop the motor before writing the MCO profile to *parameter 8-10 Control Word Profile*.

6.2.74 Warning 76, Power Unit Setup

Cause

The required number of power units do not match the detected number of active power units.

Troubleshooting

- When replacing an F-frame module, this will occur if the power specific data in the module power card does not match the rest of the drive. Confirm the spare part and its power card are the correct part number.

6.2.75 WARNING 77, Reduced Power Mode

Cause

The drive is operating in reduced power mode (less than allowed number of inverter sections). The warning is generated on power cycle when the drive is set to run with fewer inverters and remains on.

6.2.76 ALARM 78, Tracking Error

Cause

The difference between setpoint value and actual value exceeds the value in *parameter 4-35 Tracking Error*.

Troubleshooting

- Disable the function or select an alarm/warning in *parameter 4-34 Tracking Error Function*.
- Investigate the mechanics around the load and motor. Check feedback connections from motor encoder to drive.
- Select motor feedback function in *parameter 4-30 Motor Feedback Loss Function*.
- Adjust the tracking error band in *parameter 4-35 Tracking Error* and *parameter 4-37 Tracking Error Ramping*.

6.2.77 ALARM 79, Illegal Power Section Configuration

Cause

The scaling card has an incorrect part number or is not installed. The MK102 connector on the power card could not be installed.

6.2.78 ALARM 80, Drive Initialized to Default Value

Cause

Parameter settings are initialized to default settings after a manual reset. To clear the alarm, reset the unit.

6.2.79 ALARM 81, CSIV Corrupt

Cause

The CSIV file has syntax errors.

6.2.80 ALARM 82, CSIV Parameter Error

Cause

CSIV failed to initialize a parameter.

6.2.81 ALARM 83, Illegal Option Combination

Cause

The mounted options are incompatible.

6.2.82 ALARM 84, No Safety Option

Cause

The safety option was removed without applying a general reset.

Troubleshooting

Reconnect the safety option.

6.2.83 ALARM 85, Dang Fail PB

Cause

PROFIBUS/PROFIsafe error.

6.2.84 ALARM 88, Option Detection

Cause

A change in the option layout is detected. *Parameter 14-89 Option Detection* is set to *[0] Frozen configuration* and the option layout has been changed.

Troubleshooting

- To apply the change, enable option layout changes in *parameter 14-89 Option Detection*.
- Alternatively, restore the correct option configuration.

6.2.85 WARNING 89, Mechanical Brake Sliding

Cause

The hoist brake monitor detects a motor speed exceeding 10 RPM.

6.2.86 ALARM 90, Feedback Monitor

Troubleshooting

- Check the connection to the encoder/resolver option and, if necessary, replace the VLT® Encoder Input MCB 102 or VLT® Resolver Input MCB 103.

6.2.87 ALARM 91, Analog Input 54 Wrong Settings

Troubleshooting

- Set switch S202 in position OFF (voltage input) when a KTY sensor is connected to analog input terminal 54.

6.2.88 ALARM 99, Locked Rotor

Cause

The rotor is blocked.

The rotor is blocked. It is only enabled for PM motor control.

Troubleshooting

- Check if the motor shaft is locked.
- Check if the start current triggers the current limit set in *parameter 4-18 Current Limit*.
- Check if it increases the value in *parameter 30-23 Locked Rotor Detection Time [s]*.

6.2.89 WARNING/ALARM 104, Mixing Fan Fault

Cause

The fan is not operating. The fan monitor checks that the fan is spinning at power-up or whenever the mixing fan is turned on. The mixing fan fault can be configured as a warning or an alarm in *parameter 14-53 Fan Monitor*.

Troubleshooting

- Cycle power to the drive to determine if the warning/alarm returns.

6.2.90 WARNING/ALARM 122, Mot. Rotat. Unexp.

Cause

The drive performs a function that requires the motor to be at standstill, for example DC hold for PM motors.

6.2.91 WARNING 163, ATEX ETR Cur.Lim.Warning

Cause

The drive has run above the characteristic curve for more than 50 s. The warning is activated at 83% and deactivated at 85% of the allowed thermal overload.

6.2.92 ALARM 164, ATEX ETR Cur.Lim.Alarm

Cause

Running above the characteristic curve for more than 60 s within a period of 600 s activates the alarm, and the drive trips.

6.2.93 WARNING 165, ATEX ETR Freq.Lim.Warning

Cause

The drive has run for more than 50 s below the allowed minimum frequency (*parameter 1-98 ATEX ETR Interpol. Points Freq.*).

6.2.94 ALARM 166, ATEX ETR Freq.Lim.Alarm

The drive has run for more than 60 s (in a period of 600 s) below the allowed minimum frequency (*parameter 1-98 ATEX ETR Interpol. Points. Freq.*).

6.2.95 ALARM 244, Heat Sink Temperature

Cause

The maximum temperature of the heat sink has been exceeded. The temperature fault cannot reset until the temperature drops below the defined heat sink temperature. The trip and reset points are different based on the power size. This alarm is equivalent to *Alarm 29, Heat Sink Temp*.

Troubleshooting

Check for the following:

- Ambient temperature too high.
- Motor cables too long.
- Incorrect airflow clearance above or below the AC drive.
- Blocked airflow around the unit.
- Damaged heat sink fan.
- Dirty heat sink.

6.2.96 WARNING 251, New Typecode

Cause

The power card or other components have been replaced, and the typecode has changed.

6.2.97 ALARM 421, Temperature Fault

Cause

A fault caused by the on-board temperature sensor is detected on the fan power card.

Troubleshooting

- Check wiring.
- Check the on-board temperture sensor.
- Replace fan power card.

6.2.98 ALARM 423, FPC Updating

Cause

The alarm is generated when the fan power card reports it has an invalid PUD. The control card attempts to update the PUD. A subsequent alarm can result depending on the update. See *Alarm 424, FPC Update Successful* and *Alarm 425 FPC Update Failure*.

6.2.99 ALARM 424, FPC Update Successful

Cause

This alarm is generated when the control card has successfully updated the fan power card PUD.

Troubleshooting

- Press [Reset] to stop the alarm.

6.2.100 ALARM 425, FPC Update Failure

Cause

This alarm is generated after the control card failed to update the fan power card PUD.

Troubleshooting

- Check the fan power card wiring.
- Replace fan power card.
- Contact supplier.

6.2.101 ALARM 426, FPC Config

Cause

The number of found fan power cards does not match the number of configured fan power cards. See *parameter group 15-6* Option Ident* for the number of configured fan power cards.

Troubleshooting

- Check fan power card wiring.
- Replace fan power card.

6.2.102 ALARM 427, FPC Supply

Cause

Supply voltage fault (5 V, 24 V, or 48 V) on fan power card is detected.

Troubleshooting

- Check fan power card wiring.
- Replace fan power card.

6.3 Troubleshooting

Table 77: Troubleshooting

Symptom	Possible cause	Test	Solution
Display dark/No function	Missing input power.	Check for loose connections.	Check the input power source.
	Missing or open fuses.	See *Open power fuses* in this table for possible causes.	Follow the recommendations provided.
	No power to the LCP.	Check the LCP cable for proper connection or damage.	Replace the faulty LCP or connection cable.
	Short-circuit on control voltage (terminal 12 or 50) or at control terminals.	Check the 24-V control voltage supply for terminal 12/13 to 20–39, or 10-V supply for terminals 50–55.	Wire the terminals properly.
	Incompatible LCP (LCP from VLT® 2800 or 5000/6000/8000/ FCD or FCM).	–	Use only LCP 101 (P/N 130B1124) or LCP 102 (P/N. 130B1107).
	Wrong contrast setting.	–	Press [Status] + [▲]/[▼] to adjust the contrast.
	Display (LCP) is defective.	Test using a different LCP.	Replace the faulty LCP or connection cable.
	Internal voltage supply fault or SMPS is defective.	–	Contact supplier.

Symptom	Possible cause	Test	Solution
Intermittent display	Overloaded supply (SMPS) due to improper control wiring or a fault within the AC drive.	To rule out a problem in the control wiring, disconnect all control wiring by removing the terminal blocks.	If the display stays lit, the problem is in the control wiring. Check the wiring for shorts or incorrect connections. If the display continues to cut out, follow the procedure for *Display dark\No function*.
Motor not running	Service switch open or missing motor connection.		Connect the motor and check the service switch.
	No mains power with 24-V DC option card.		Apply mains power.
	LCP stop.		Depending on the operating mode, press [Auto On] or [Hand On].
	Missing start signal (Standby).		Apply a valid start signal.
	Motor coast signal active (Coasting).		Apply 24 V on terminal 27 or program this terminal to *[0] No operation*.
	Wrong reference signal source.	Check reference signal: • Local • Remote or bus reference? • Preset reference active? • Terminal connection correct? • Scaling of terminals correct? • Reference signal available?	Program correct settings. Check *parameter 3-13 Reference Site*. Set preset reference active in *parameter group 3-1* References*. Check for correct wiring. Check scaling of terminals. Check reference signal.
Motor running in wrong direction	Motor rotation limit.	Check that *parameter 4-10 Motor Speed Direction* is programmed correctly.	Program correct settings.
	Active reversing signal.	Check if a reversing command is programmed for the terminal in *parameter group 5-1* Digital inputs*.	Deactivate reversing signal.
	Wrong motor phase connection.	-	Correct motor phase connection, or set *parameter 1-06 Clockwise Direction* to *[1] Inverse*.
Motor is not reaching maximum speed	Frequency limits set wrong.	Check output limits in *parameter 4-13 Motor Speed High Limit [RPM]*, *parameter 4-14 Motor Speed High Limit [Hz]*, and *parameter 4-19 Max Output Frequency*.	Program correct limits.
	Reference input signal not scaled correctly.	Check reference input signal scaling in *parameter group 6-0* Analog I/O mode* and *parameter group 3-1* References*.	Program correct settings.
Motor speed unstable	Possible incorrect parameter settings.	Check the settings of all motor parameters, including all motor compensation settings. For closed-loop operation, check PID settings.	Check settings in *parameter group 1-6* Load Depen. Setting*. For closed-loop operation, check settings in *parameter group 20-0* Feedback*.
Motor runs rough	Possible overmagnetization.	Check for incorrect motor settings in all motor parameters.	Check motor settings in *parameter groups 1-2* Motor data*, *1-3* Adv Motor Data*, and *1-5* Load Indep. Setting*.

Symptom	Possible cause	Test	Solution
Motor does not brake	Possible incorrect settings in the brake parameters. Ramp-down times may be too short.	Check brake parameters. Check ramp time settings.	Check *parameter groups 2-0* DC Brake* and *3-0* Reference Limits*.
Open power fuses	Phase-to-phase short.	Motor or panel has a short phase-to-phase. Check motor and panel phases for shorts.	Eliminate any shorts detected.
	Motor overload.	Motor is overloaded for the application.	Perform start-up test and verify that motor current is within specifications. If motor current is exceeding the name-plate full load current, the motor can run only with reduced load. Review the specifications for the application.
	Loose connections.	Perform pre-start-up check for loose connections.	Tighten loose connections.
Mains current imbalance greater than 3%	Problem with mains power (see *Alarm 4, Mains phase loss* description).	Rotate input power leads into the 1 position: A to B, B to C, C to A.	If imbalanced leg follows the wire, it is a power problem. Check the mains supply.
	Problem with the AC drive.	Rotate input power leads into the AC drive 1 position: A to B, B to C, C to A.	If the imbalanced leg stays on same input terminal, it is a problem with the AC drive. Contact the supplier.
Motor current imbalance greater than 3%	Problem with motor or motor wiring.	Rotate output motor cables 1 position: U to V, V to W, W to U.	If the imbalanced leg follows the wire, the problem is in the motor or motor wiring. Check motor and motor wiring.
	Problem with AC drive.	Rotate output motor cables 1 position: U to V, V to W, W to U.	If the imbalanced leg stays on same output terminal, it is a problem with the unit. Contact the supplier.
AC drive acceleration problems	Motor data are entered incorrectly.	If warnings or alarms occur, refer to the Warnings and Alarms section. Check that motor data are entered correctly.	Increase the ramp-up time in *parameter 3-41 Ramp 1 Ramp Up Time*. Increase current limit in *parameter 4-18 Current Limit*. Increase torque limit in *parameter 4-16 Torque Limit Motor Mode*.
AC drive deceleration problems	Motor data are entered incorrectly.	If warnings or alarms occur, refer to the Warnings and Alarms section. Check that motor data are entered correctly.	Increase the ramp-down time in *parameter 3-42 Ramp 1 Ramp Down Time*. Enable overvoltage control in *parameter 2-17 Over-voltage Control*.

7 Drive and Motor Applications

7.1 Torque Limit, Current Limit, and Unstable Motor Operation

Excessive
loading of the drive may result in warning or tripping on torque limit, overcurrent, or inverter time. This situation is not a concern if the drive is properly sized for the application and intermittent load conditions cause anticipated operation in torque limit or an occasional trip. However, nuisance or unexplained occurrences can be the result of improperly setting specific parameters. The following parameters are important in matching the drive to the motor for optimum operation, and their settings need careful attention.

- *Parameter 1-00 Configuration Mode* sets the drive for open or closed-loop operation, or torque mode operation.
- *Parameter 1-03 Torque Characteristics* sets the operating mode of the drive.
- *Parameter 1-20 Motor Power [kW]* to *parameter 1-29 Automatic Motor Adaptation (AMA)* match the drive to the motor and adapt to the motor characteristics.
- *Parameter 4-16 Torque Limit Generator Mode,Parameter 4-17 Torque Limit Motor Mode,* and *parameter 14-25 Trip Delay at Torque Limit* set the torque control features of the drive for the application.

Parameter functions

- *Parameter 1-00 Configuration Mode* sets the drive for open or closed-loop operation or torque mode operation. In a closed-loop configuration, a feedback signal controls the drive speed. The settings for the PID controller play a key role for stable operation in closed loop, as described in the VLT® Decentral Drive FCD 302 Operating Guide. In open loop, the drive calculates the torque requirement based on current measurements of the motor.
- *Parameter 1-03 Torque Characteristics* sets the drive for constant or variable torque operation. It is imperative that the correct torque characteristic is selected, based on the application. For example, if the load type is constant torque, such as a conveyor, and variable torque is selected, the drive can have great difficulty starting the load, if started at all. Consult the factory if uncertain about the torque characteristics of an application.
- *Parameter 1-20 Motor Power [kW]* to *parameter 1-25 Motor Nominal Speed* configure the drive for the connected motor. These are motor power, voltage, frequency, current, and rated motor speed. Accurate setting of these parameters is important. Enter the motor data required as listed on the motor nameplate. For effective and efficient load control, the drive relies on this information for calculating the output waveform in response to the changing demands of the application.
- Never adjust these parameters to random values even though it may seem to improve operation. Such adjustments can result in unpredictable operation under changing conditions.
- *Parameter 4-16 Torque Limit Generator Mode* and *Parameter 4-17 Torque Limit Generator Mode* set the limit for drive torque. The factory setting is 160% for VLT® AutomationDrive FC 302, and 110% for VLT® HVAC Drive FC 102/VLT® AQUA Drive FC 202, and varies with motor power setting. For example, a drive programmed to operate a smaller motor yields a higher torque limit value than when programmed for a larger motor. It is important that this value is not set too low for the requirements of the application. Sometimes, it can be desirable to have a torque limit set at a lower value. This offers protection for the application as the drive limits the torque. It can, however, require higher torque at initial start-up, which can cause nuisance tripping.
- *Parameter 14-25 Trip Delay at Torque Limit* works with torque limit. This parameter selects how long the drive operates in torque limit before a trip. The factory default value is Off. This means that the drive does not trip on torque limit. However, it does not mean it never trips from an overload condition. Built into the drive is an internal inverter thermal protection circuit. This circuit monitors the output load on the inverter. If the load exceeds 100% of the continuous rating of the drive, a timer is activated. If the load remains excessive long enough, the drive trips on inverter time. Adjustments cannot be made to alter this circuit. Improper parameter settings affecting load current can result in premature trips of this type. The timer can be shown.

7.1.1 Overvoltage Trips

This trip occurs when the DC bus voltage reaches its DC bus alarm voltage high. Before tripping, the drive shows a high-voltage warning. Usually, the cause of an overvoltage condition is fast deceleration ramps relative to the inertia of the load. During deceleration of the load, inertia of the system acts to sustain the running speed. Once the motor frequency drops below the running speed, the load begins overtaking the motor. The motor becomes a generator and starts returning energy to the drive. This process is called regenerative energy. Regeneration occurs when the speed of the load is greater than the commanded speed. The diodes in the IGBT modules rectify this return voltage, which raises the DC bus. If the amount of returned voltage is too high, the drive trips.

Less often, the load causes an overvoltage condition while running at speed. When this condition occurs, the dynamic brake option or the overvoltage control circuit can be used. For example, if the speed of the load is greater than the commanded speed, the overvoltage circuit increases the frequency to match. The same restriction on the amount of influence applies.

The drive adds about 10% to the base speed before a trip occurs. Otherwise, the speed could continue to rise to potentially unsafe levels.

The enclosed drive configured with a passive harmonic filter will trip on overvoltage during the start up of the drive, if the PHF capacitor disconnect feature is not functioning properly.

How to avoid overvoltage trips

- Reduce the deceleration rate. The drive can only decelerate the load slightly faster than it would take for the load to naturally coast to a stop.
- Allow the overvoltage control circuit to take care of the deceleration ramp. When enabled, the overvoltage control circuit regulates deceleration at a rate that maintains the DC bus voltage at a level that keeps the unit from tripping. Overvoltage control corrects minor, but not major discrepancies between ramp rates. For example, if a deceleration ramp of 100 s is required, and the ramp rate is set at 70 s, the overvoltage control corrects it. However, with the same inertia, if the ramp is set at a larger difference, such as 3 s, overvoltage control engages initially, and then disengages, allowing the drive to trip. This trip is done deliberately to avoid confusion about the operation of the drive.
- Control regenerated energy with a dynamic brake. If the DC bus level becomes too high, the drive switches the resistor across the DC bus. The unwanted energy is dissipated into the external resistor bank mounted outside of the drive. This process increases deceleration rate.
- The capacitor disconnecting function should be enabled for the passive harmonic filter to avoid overvoltage trips. For achieving this, set the parameter *5-31 Terminal 29 Digital Output* to *[188]AHF CapacitorConnect*. The parameter settng is preconfigured, but it will be erased when factory reset is performed. After reset, reprogram the parameter for proper operation.

7.1.2 Mains Phase Loss Trips

The drive actually monitors phase loss by monitoring the amount of ripple voltage on the DC bus. Ripple voltage on the DC bus is a product of a phase loss. The main concern is that ripple voltage causes overheating in the DC bus capacitors and the DC coil. If the ripple voltage on the DC bus is left unchecked, the lifetime of the capacitors and DC coil would be drastically reduced.

When the input voltage becomes unbalanced or a phase disappears completely, the ripple voltage increases. The ripple voltage causes the drive to trip and issue *alarm 4, Mains phase loss*. In addition to missing phase voltage, a line disturbance or imbalance can cause increased bus ripple. Line disturbances can be caused by line notching, defective transformers or other loads that can affect the form factor of the AC waveform. Mains imbalances which exceed 3% cause sufficient DC bus ripple to initiate a trip.

Output disturbances can have the same effect of increased ripple voltage on the DC bus. A missing or lower than normal output voltage on 1 phase can cause increased ripple on the DC bus. When a mains imbalance trip occurs, it is necessary to check both the input and output voltage of the drive.

Severe imbalance of supply voltage or phase loss can easily be detected with a voltmeter. View disturbances through an oscilloscope. Conduct tests for input imbalance of supply voltage, input waveform, and output imbalance of supply voltage as described in the *Dynamic Test Procedures* section.

Mains phase loss trips in D-sized drives

D-sized drives monitor phase loss by monitoring the amount of ripple voltage on the DC bus. Ripple voltage on the DC bus is a product of a phase loss, and can cause overheating in the DC bus capacitors and DC coil. If the ripple voltage on the DC bus is unchecked, the lifetime of the capacitors is reduced significantly.

When the input voltage becomes unbalanced or a phase disappears completely, the ripple voltage increases. This increase causes the drive to trip and issue **alarm 4, Mains Phase Loss**. In addition to missing phase voltage, a line disturbance or imbalance can increase bus ripple.

Mains phase loss trips in E-sized drives

In E-sized drives, mains imbalance is directly measured by the inrush card. If the voltage imbalance is greater than 10%, then the drive is considered to be in single-phase mode. Once a predetermined motor power is exceeded, the drive trips. If communication with the inrush card is lost, the drive reverts to the phase loss monitoring of the D-sized drive.

The following parameters show the input voltage:

- *Parameter 18-70 Mains Voltage*.
  - *[0]* shows the average of the 3 input phases.
  - *[1]* shows the voltage between R and S phases.
  - *[2]* shows the voltage between S and T phases.
  - *[3]* shows the voltage between T and U phases.
- *Parameter 18-72 Mains Imbalance*.

Possible sources of disturbance

Loads affecting the form factor of the AC waveform cause line disturbances. For example, notching or defective transformers can cause disturbances.

Mains imbalances that exceed 3% cause sufficient DC bus ripple to initiate a trip. In 12-pulse systems, the allowed DC ripple is smaller than the ripple allowed in 6-pulse systems. Other causes of increased ripple voltage on the DC bus include:

- Output disturbance.
- Missing or lower than normal output voltage on 1 phase.

Checks

When a mains imbalance trip occurs, check both the input and output voltage of the drive. Significant imbalance of supply voltage or phase loss is detectable with a voltmeter. View line disturbances through an oscilloscope.

Conduct tests for:

- Input imbalance of supply voltage.
- Input waveform.
- Output imbalance of supply voltage.

In 12-pulse systems, check the input imbalance between the 2 secondary winding voltages.

7.1.3 Control Logic Problems

Problems with control logic can often be difficult to diagnose, since there is usually no associated fault indication. The typical complaint is simply that the drive does not respond to a given command. There are 2 basic commands that must be given to any drive in order to obtain an output:

- The drive must be told to run (start command).
- The drive must be told how fast to run (reference or speed command).

The drives are designed to accept various signals. First determine which of these signals the drive is receiving:

- Digital inputs (18, 19, 27, 29, 32, 33)
- Analog outputs (42)
- 10 V output
- Analog inputs (53, 54)
- Serial communication bus (68, 69)

The presence of a correct reading indicates that the microprocessor of the drive has detected the signal. Refer to the topics Grounding Shielded Cables and Input Terminal Signal Tests.

This data can also be read in *parameter group 16-6* Inputs & Outputs*. If there is no correct indication, check that the signal is present at the input terminals of the drive. Refer to the Input Terminal Signal Tests.

If the signal is present at the terminal, the control card is defective and must be replaced. If the signal is not present, the problem is external to the drive. Check the circuitry providing the signal along with its associated wiring.

7.1.4 Programming Problems

Difficulty with operation of the drive can be a result of improper programming of the drive parameters. The 3 areas where programming errors can affect drive and motor operation are:

- Motor settings.
- References and limits.
- I/O configuration.

Refer to the topic Drive Inputs and Outputs.

Set up the drive correctly for the motor or motors connected to it. *Parameter 1-20 Motor Power [kW] – parameter 1-25 Motor Nominal Speed* must have data from the motor nameplate entered into the drive. This data enables the drive processor to match the drive to the power characteristics of the motor. The most common result of inaccurate motor data is that the motor draws higher than normal amounts of current to perform the task. In such cases, setting the correct values to these parameters and performing the AMA function usually solves the problem.

Any references or limits set incorrectly result in poor drive performance. For instance, if maximum reference is set too low, the motor is unable to reach full speed. Set these parameters according to the requirements of the particular installation. References are set in *parameter group 3-0* Reference/Ramps*.

Incorrectly set I/O configuration usually results in the drive not responding to the function as commanded. Remember that for every control terminal input or output, there are corresponding parameter settings. These settings determine how the drive responds to an input signal or the type of signal present at that output. Utilizing an I/O function involves a 2-step process. First, wire the I/O terminal properly, and then set the corresponding parameter. Control terminals are programmed in *parameter groups 5-0* Digital I/O Mode* and *6-0* Analog I/O Mode*.

7.1.5 Motor/Load Problems

Problems with the motor, motor wiring, or mechanical load on the motor can develop in a number of ways. The motor or motor wiring can develop a phase-to-phase or phase-to-ground short resulting in an alarm indication. Check to determine whether the problem is in the motor wiring or the motor itself.

A motor with unbalanced, or non-symmetrical, impedances on all 3 phases can result in uneven or rough operation, or unbalanced output currents. Measurements must be made with a clamp-on style ammeter to determine if the current is balanced on the 3 output phases.

An incorrect mechanical load usually is indicated by a torque limit alarm or warning. Disconnecting the motor from the load, if possible, can determine if this is the case.

Often, the indications of motor problems are similar to those problems of a defect in the drive itself. To determine whether the problem is internal or external to the drive, disconnect the motor from the drive output terminals. If the 3 voltage measurements are balanced, the drive is functioning correctly. The problem therefore is external to the drive.

If the voltage measurements are not balanced, the drive is malfunctioning. This issue typically means that 1 or more output IGBTs are not switching on and off correctly, which can be the result of a defective IGBT or gate signal from the gatedrive card.

7.2 Internal Drive Problems

Most issues related to failed drive power components can be identified by performing a visual inspection and the static tests. However, there are various possible problems that must be diagnosed in a different manner.

7.2.1 Overtemperature Faults

When an overtemperature indication occurs, determine whether this condition exists within the drive or whether the thermal sensor is defective. If an overtemperature condition is present in the drive, the outside of the unit is warm. If the exterior is not warm, check the temperature sensor with an ohmmeter.

Overtemperature faults within the drive are typically caused by blocked airflow or a faulty cooling fan. The overtemperature alarm message shown indicates where the fault is.

Alarm 244, Heat Sink Overtemperature. This alarm normally indicates a heat sink fan not functioning. While an overtemperature alarm message is shown, all cooling fans should be operating at full speed. Check the fans before resetting the drive to determine the fault location.

Alarm 247, Power Card Overtemperature. This alarm normally indicates that the ambient temperature inside the drive enclosure is too high. To ensure that nothing is obstructing the airflow, check all air passages.

With either of these alarms, the report value in the alarm log shows which module experienced the overtemperature condition.

In enclosed drive systems an overtemperature protection circuit is provided for conditions outside the drive module as well. The heat sink overtemp protection sets a trip lock on overtemperature conditions for the drive module; the thermal circuit sets an external interlock trip for overtemperature conditions in the input option cabinet or in the filter cabinets.

Within the control compartment, the following 3 relay contacts are connected in series to digital input 18, which is used as a thermal overload relay:

- KFJ.1 monitors the heat within the input power options cabinet.
- KFJ.2 monitors the heat within the output filter cabinet.
- KFJ.3 monitors the heat within the input filter cabinet.

When the thermal switches in any of these cabinets open due to overtemperature, the drive trips on *alarm 60, External Interlock*.

For this alarm, open the control compartment and check whether the indicator lights in relays KFJ.1, KFJ.2, and KFJ.3 are glowing. If not, clear the external fault condition in the corresponding cabinet. To resume normal operation, apply 24 V DC to the terminal programmed for external interlock, and reset the drive.

For enclosed drives with a dU/dt filter as an output filter option, program the fan speed to run at 100% to avoid overtemperature faults. Set *parameter 14-52 Fan Control* to *[3] On 100%*. The parameter is preconfigured, but it is erased when factory reset is performed. After reset, reprogram the parameter for proper operation.

7.2.2 Current Sensor Faults

An overcurrent alarm that cannot be reset, even with the motor cables disconnected, sometimes indicates current sensor failure. The drive experiences frequent false ground fault trips due to the DC offset failure mode of the sensors.

An explanation of the internal composition of a Hall-effect type current sensor helps to explain these faults. Included inside the device is an op-amp to amplify the signal to usable levels in the receiving circuitry. The output at 0 input level (0 A flow being measured) is 0 V, exactly halfway between the plus and minus supply voltages. A tolerance of ±15 mV is acceptable. In a 3-phase system that operates correctly, the sum of the 3 output currents is always 0.

When the sensor becomes defective, the output voltage level varies by more than the 15 mV. The defective current sensor in that phase indicates current flow when there is none. This condition results in the sum of the 3 output currents being a value other than 0, which is an indication of leakage current flowing. If the deviation from 0 (current amplitude) approaches a specific level, the drive assumes a ground fault and issues an alarm.

To determine whether a current sensor is defective, disconnect the motor from the drive and observe the current in the drive display. With the motor disconnected, the current must be 0. A drive with a defective current sensor indicates some current flow. An indication of a fraction of 1 A is tolerable. However, that value should be considerably less than 1 A. If the display shows more than 1 A of current, there is a defective current sensor.

To determine which current sensor is defective, measure the voltage offset at 0 current for each current sensor. Refer to the Current Sensors Test.

7.3 Electromagnetic Compatibility (EMC) Considerations

The following is an overview of general signal and power wiring considerations related to electromagnetic compatibility (EMC) for typical commercial and industrial equipment. Only certain high frequency phenomena (such as RF emissions, RF immunity) are discussed. Low frequency phenomena (such as harmonics, mains voltage imbalance, notching) are not covered. Special installations or compliance to the European CE EMC directives requires strict adherence to relevant standards and are not discussed here.

7.3.1 Effects of EMI

While EMI-related disturbances to enclosed drive systems are uncommon, the following detrimental EMI effects can be seen:

- Motor speed fluctuations.
- Serial communication transmission errors.
- Drive CPU exception faults.
- Unexplained filter trips.

A disturbance resulting from nearby equipment is more common. Generally, industrial control equipment has a high level of EMI immunity. However, non-industrial, commercial, and consumer equipment is often susceptible to lower levels of EMI.

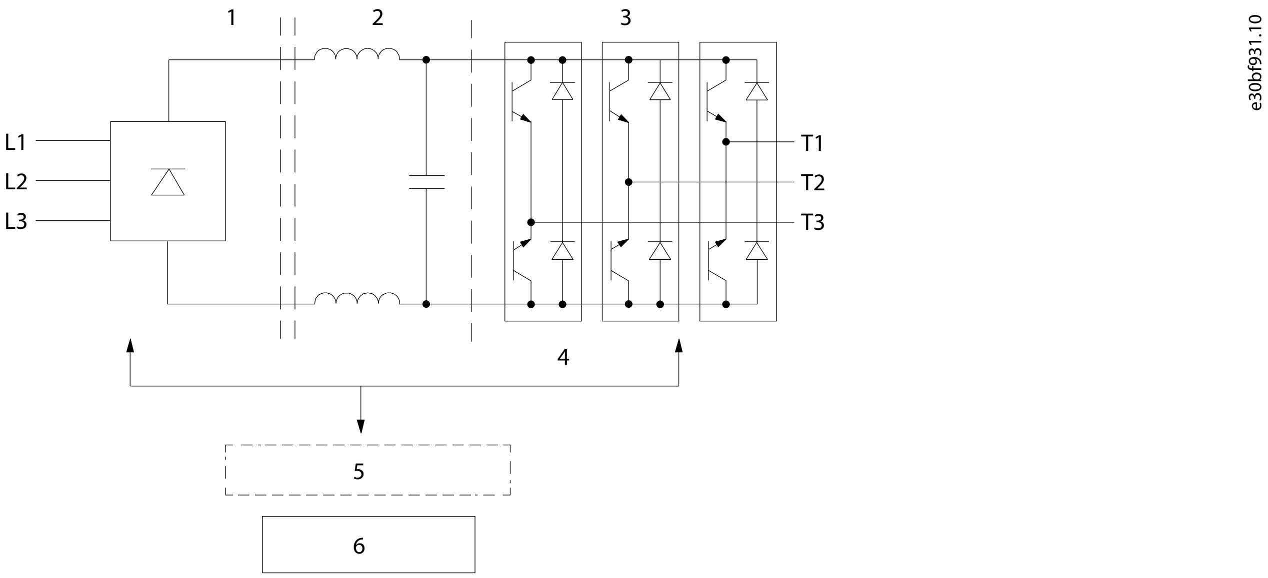
Detrimental effects to these systems can include the following:

- Pressure/flow/temperature signal transmitter signal distortion or aberrant behavior.
- Radio and TV interference.
- Telephone interference.
- Computer network data loss.
- Digital control system faults.

7.3.2 Sources of EMI

D-sized and E-sized drives (see illustration 45) use IGBTs to create the pulse-width modulated (PWM) output waveform necessary for accurate motor control. These IGBTs rapidly switch the fixed DC bus voltage creating a variable frequency and a variable voltage PWM waveform. This high rate of voltage change [dU/dt] is the primary source of generated EMI of the drives.

The high rate of voltage change caused by the IGBT switching creates high frequency EMI.



1 Rectifier	**2** DC link (DC bus)
3 Inverter (IGBTs)	**4** Power section
5 Logic-to-power interface	**6** Control logic

Illustration 45: 6-pulse Functionality Diagram

7.3.3 EMI Propagation

Drive-generated EMI is both conducted to the mains and radiated to nearby conductors. Refer to illustration 46. Stray capacitance between the motor conductors, equipment ground, and other nearby conductors results in induced high-frequency currents.

High ground circuit impedance at high frequencies results in an instant voltage at points reputed to be at ground potential. This voltage appears throughout a system as a common-mode signal that interferes with control signals. Theoretically, these currents return to the DC bus via the ground circuit and a high-frequency (HF) bypass network within the drive itself. However, imperfections in the drive grounding or the equipment ground system can cause some of the currents to travel out to the power network.

Unprotected or poorly routed signal conductors located close to or in parallel to motor and mains conductors are susceptible to EMI. Signal conductors are especially vulnerable when they are run parallel to the power conductors for any distance. EMI coupled into these conductors can affect either the drive or the interconnected control device. Refer to illustration 48.

These currents tend to travel back to the drive. However, imperfections in the system cause some current to flow in undesirable paths and expose other locations to EMI. When the mains conductors are close to the motor cables, high-frequency currents can be coupled into the mains supply.

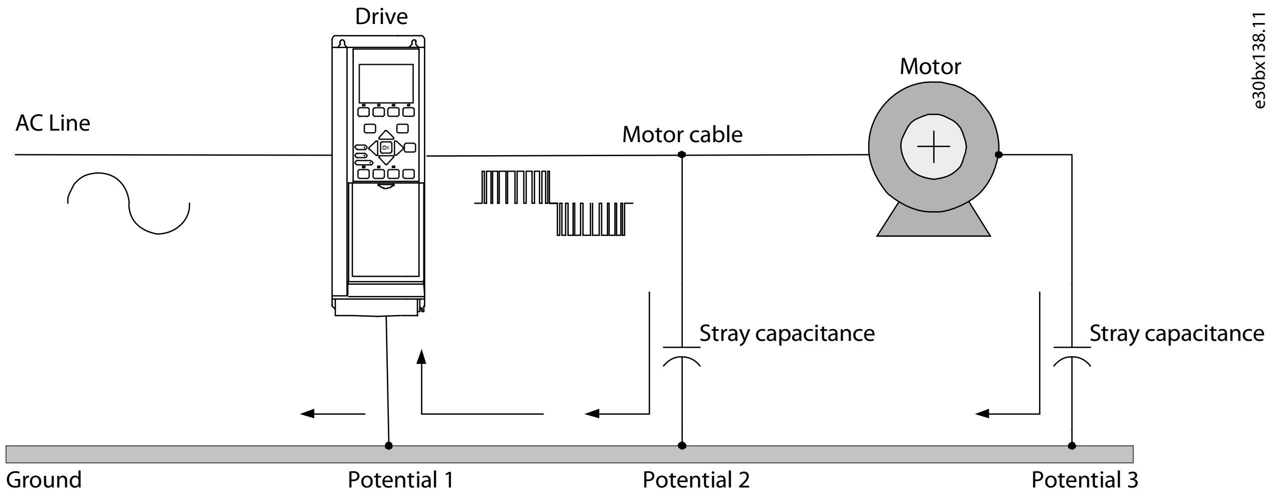


Illustration 46: Ground Currents

High ground circuit impedance at high frequencies results in an instant voltage at points reputed to be at ground potential. This voltage appears throughout a system as a common-mode signal that can interfere with control signals.

Theoretically, these currents return to the filter DC bus via the ground circuit and a high frequency (HF) bypass network within the filter itself. However, imperfections in the filter grounding or the equipment ground system can cause some of the currents to travel out to the power network.

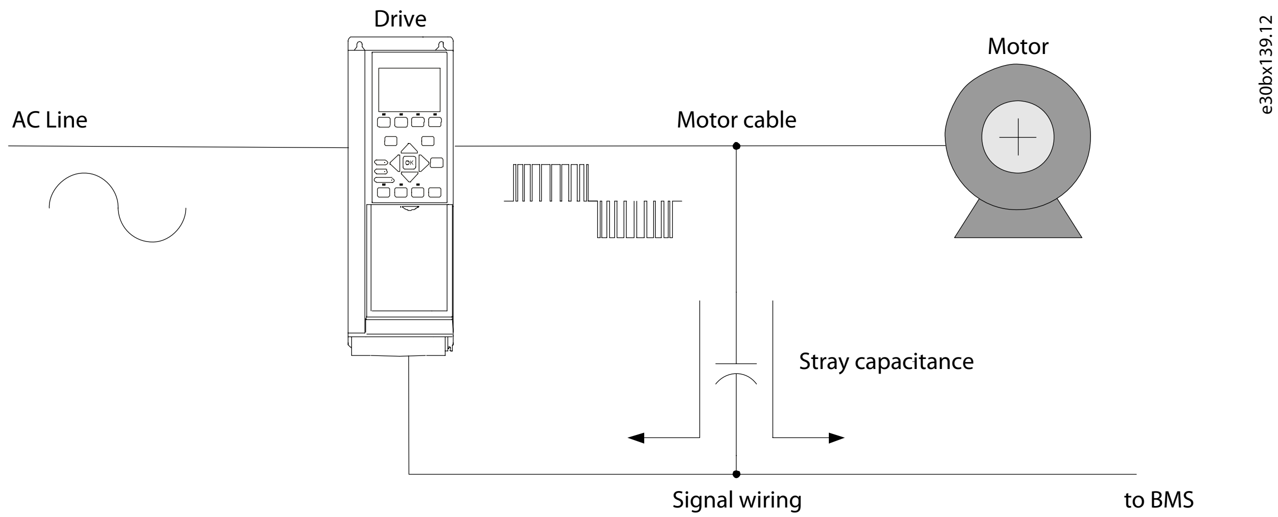


Illustration 47: Signal Conductor Currents

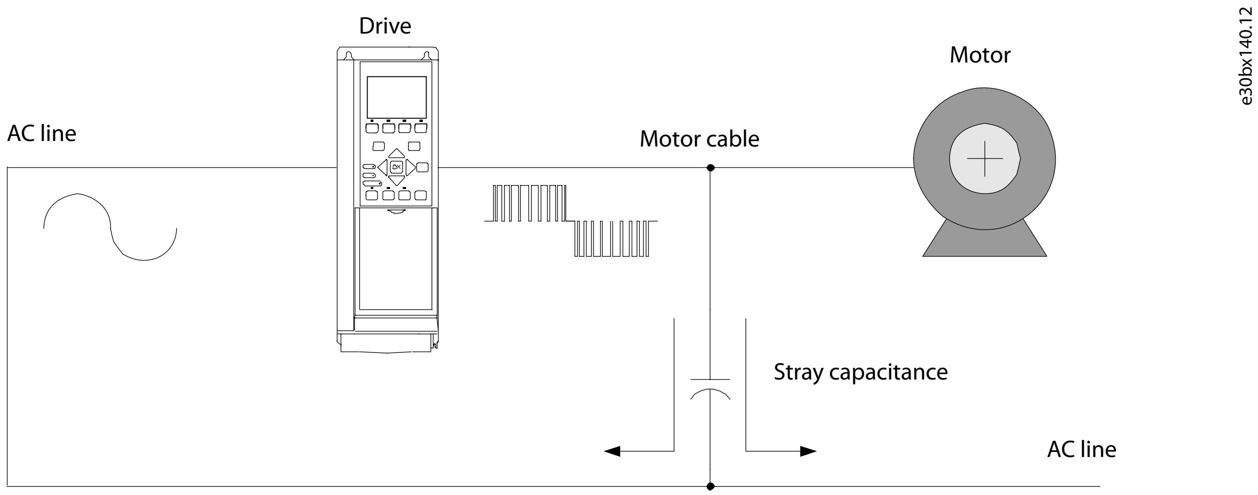


Illustration 48: Alternate Signal Conductor Currents

7.3.4 Preventive Measures

EMI-related problems are more effectively alleviated during the design and installation phases rather than during service.

Grounding

The drive and motor must be solidly grounded to the equipment enclosure. A good high-frequency connection is necessary to allow the high-frequency currents to return back to the drive rather than to travel through the power network. The ground connection is ineffective if it has high impedance to high-frequency currents. Therefore it must be as short and direct as practical. Flat-braided cable has lower high-frequency impedance than round cable. Simply mounting the drive or motor onto a painted surface does not create an effective ground connection. In addition, running a separate ground conductor directly between the drive and the running motor is recommended.

Cable routing

Avoid routing the following in parallel:

- Motor wiring.
- Mains wiring.
- Signal wiring.

If parallel routing is unavoidable, try to maintain a separation of 200 mm (6–8 in) between the cables, or separate them with a grounded conductive partition. Avoid routing cables through free air.

Signal cable selection

Single conductor 600-V rated wires provide the least protection from EMI. Twisted-pair cables and shielded twisted-pair cables are available and are designed to minimize the effects of EMI. While unshielded twisted-pair cables are often adequate, shielded twisted-pair cables provide another degree of protection. Terminate the signal cable shield in a manner that is appropriate for the connected equipment. Avoid terminating the shield through a pigtail connection as this method increases the high-frequency impedance and reduces the effectiveness of the shield. Refer to the topic *Grounding Shielded Cables*.

A simple alternative is to twist the existing single conductors to provide a balanced capacitive and inductive coupling. This method cancels differential mode interference. While not as effective as true twisted-pair cable, it can be implemented in the field using the available materials.

Motor cable selection

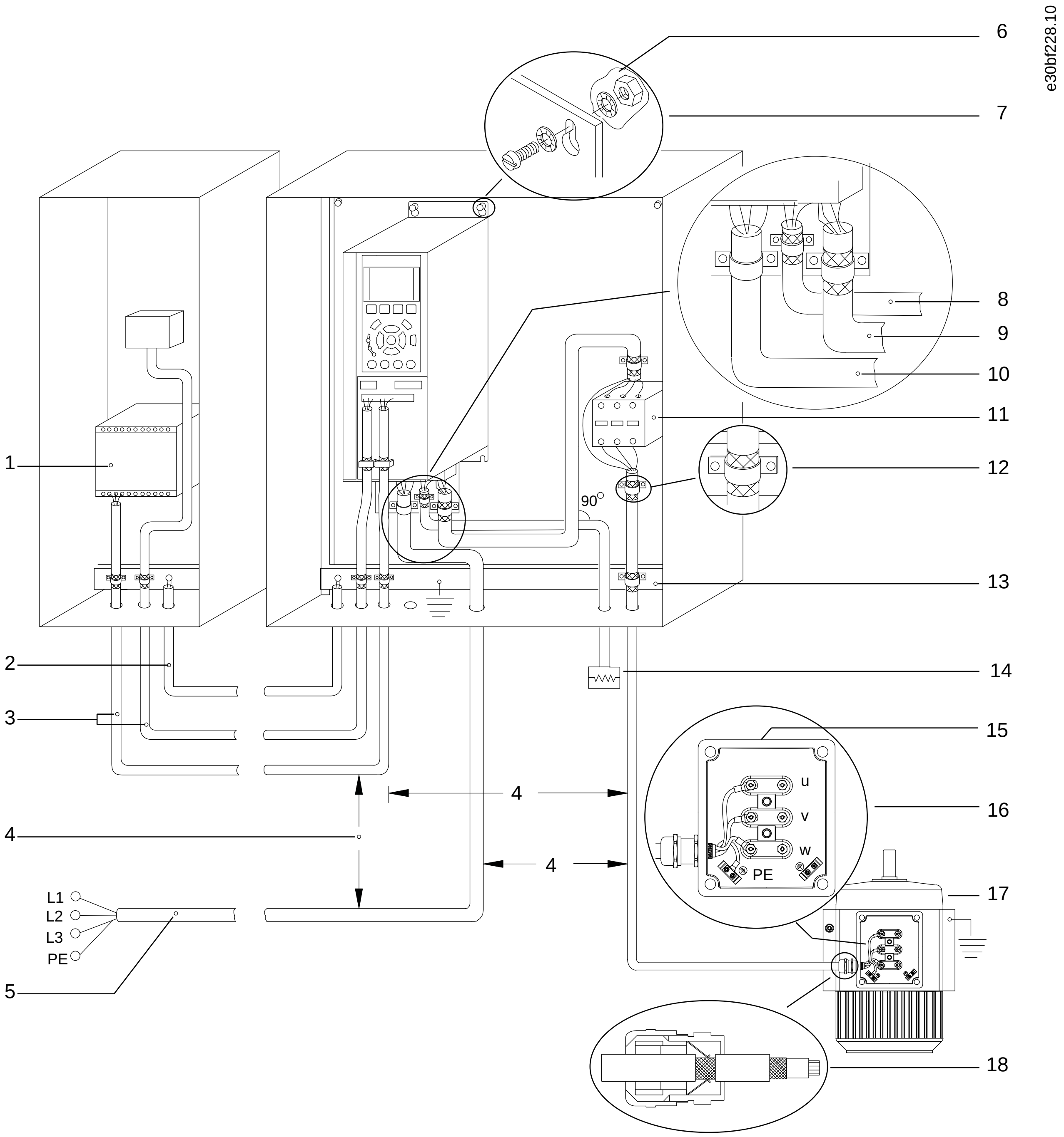
The management of the motor conductors has the greatest influence on the EMI characteristics of the system. These conductors must receive the highest attention whenever EMI is a problem. Single conductor wires provide the least protection from EMI emissions. Often, if these conductors are routed separately from the signal and mains wiring, then no further consideration is needed. If the conductors are routed close to other susceptible conductors, or if the system is suspected to cause EMI problems, consider alternate motor wiring methods.

Installing shielded power cable is the most effective methods to alleviate EMI problems. The shield forces the noise current to flow directly back to the drive. This prevents it from flowing back into the power network or other undesirable high-frequency paths. Unlike most signal wiring, the shielding on the motor cable must be terminated at both ends.

If a shielded motor cable is not available, then 3-phase conductors plus ground in a conduit provides some protection. This technique is not as effective as shielded cable due to the unavoidable contact of the conduit with various points within the equipment.

Serial communications cable selection

There are various serial communication interfaces and protocols in the market. Each interface/protocol recommends 1 or more specific types of cables. Refer to the manufacturer documentation when selecting these cables. Similar recommendations apply to serial communication cables as to other signal cables. Using twisted-pair cables and routing them away from power conductors is encouraged. While shielded cable provides extra EMI protection, the shield capacitance can reduce the maximum allowable cable length at high data rates.



1	PLC	2	Minimum 16 mm² (6 AWG) equalizing cable
3	Control cables	4	Minimum 200 mm (7.9 in) between control cables, motor cables, and mains cables.
5	Mains supply	6	Bare (unpainted) surface
7	Star washers	8	Brake cable (shielded)
9	Motor cable (shielded)	10	Mains cable (unshielded)

11	Output contactor, and so on	**12**	Cable insulation stripped
13	Common ground busbar. Follow local and national requirements for cabinet grounding.	**14**	Brake resistor
15	Metal box	**16**	Connection to motor
17	Motor	**18**	EMC cable gland

Illustration 49: Example of Proper EMC Installation

8 Test Procedures

8.1 Introduction

⚠ WARNING ⚠

DISCHARGE TIME

The drive contains DC-link capacitors and, if input filter options are present, extra capacitors and inductors. These components can remain charged even when the drive is not powered. High voltage can be present even when the warning indicator lights are off.

Failure to wait the specified time after power has been removed before performing service or repair work could result in death or serious injury.

- Stop the motor.
- Disconnect AC mains, permanent magnet type motors, and remote DC-link supplies, including battery back-ups, UPS, and DC-link connections to other drives.
- Wait for the capacitors to discharge fully. The minimum waiting time is specified both in the Discharge Time table and on the nameplate on top of the drive.
- Before performing any service or repair work, use an appropriate voltage measuring device to make sure that the capacitors are fully discharged.

Table 78: Discharge Time

Drive model	Minimum waiting time
D9h/D10h enclosed drive	20 minutes
E5h/E6h enclosed drive	40 minutes

This section contains detailed procedures for testing D9h–D10/E5h–E6h enclosed drives and related options. The results of these tests indicate the appropriate repair actions. The source of fault conditions is not always internal to the drive. For example, the drive monitors:

- I/O signals.
- Motor conditions.
- AC and DC power.
- Other functions.

Testing described in this chapter isolates many of these conditions.

Static tests

Static tests are conducted without power applied to the drive. Most drive problems can be diagnosed with these tests. Static tests are performed with little or no disassembly. The purpose of static testing is to check for shorted power components. Perform these tests on any unit suspected of containing faulty power components before applying power.

Dynamic tests

Dynamic tests are performed with power applied to the drive. Dynamic testing traces signal circuitry to isolate faulty components.

After-repair tests

After-repair tests are performed following service work or parts replacement. The after-repair procedures retest the drive with the new component before power is applied.

8.2 Testing Tools

8.2.1 Overview of Testing Tools

Table 79: Instruments for Testing D9h/D10h and E5h/E6h Enclosed Drives

Item	Description
Digital Volt-Ohm Meter (PWM-compatible)	Rated for true RMS.
	Rated for the mains AC voltage and DC-link voltage of the drive. (DC-link voltage = 1.414 x mains voltage).
	Supports the diode mode.
Analog voltmeter	With safety probe tip extenders.
Oscilloscope	–
Clamp-on ammeter	Rated for true RMS.
Split bus supply	Part number 130B3146
Signal test board	Part number 176F8437

NOTICE

SPECIAL TEST EQUIPMENT

For additional information on special test equipment such as the split bus supply, see the *VLT® FC Series Service Guide for D1h–D8h, Da2/Db2/Da4/Db4, E1h–E4h, J8/J9* (130R0296).

8.2.2 Signal Test Board

The signal test board is used to test circuitry within the drive and provides easy access to test points. Its use is described in the relevant procedures.

The connector for the signal test board is on the drive module power card. To access the power card, remove the control card mounting plate from the drive and plug the signal test board into power card connector MK104.

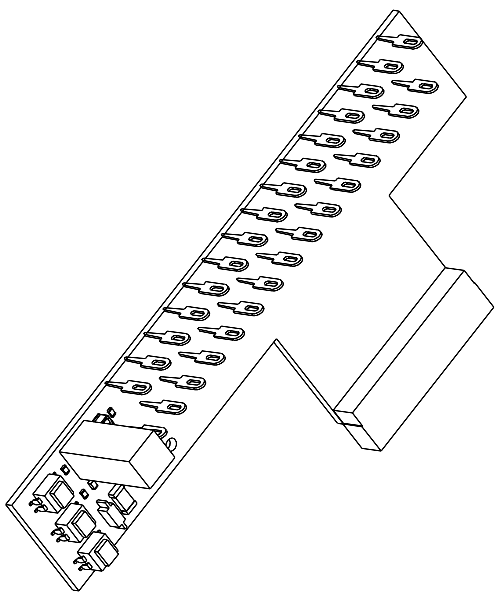


Illustration 50: Signal Test Board

8.2.3 Metering Tools

For best troubleshooting results, perform the static test procedures described in this section in the order presented.

Perform all tests with a meter capable of testing diodes. Use a digital Volt-Ohm Meter (VOM) set on the diode scale or an analog ohmmeter set on Rx100 scale. Before making any checks, disconnect all input, motor, and brake resistor connections.

Diode drop

A diode drop reading varies depending on the model of ohmmeter. Whatever the ohmmeter shows as a typical forward bias diode is defined as a diode drop in these procedures. With a typical DVM, the voltage drop across most components is around 0.300 to 0.500. The opposite reading is referred to as infinity, and most show the value OL for overload.

8.3 Test Preparations

8.3.1 Testing Safety

⚠ WARNING ⚠

HAZARDOUS SERVICE PROCEDURES

The maintenance and troubleshooting procedures recommended in this section of the manual could result in exposure to electrical, mechanical, or other potential safety hazards. Failure to follow all of the recommended safety warnings provided, could result in death or serious injury.

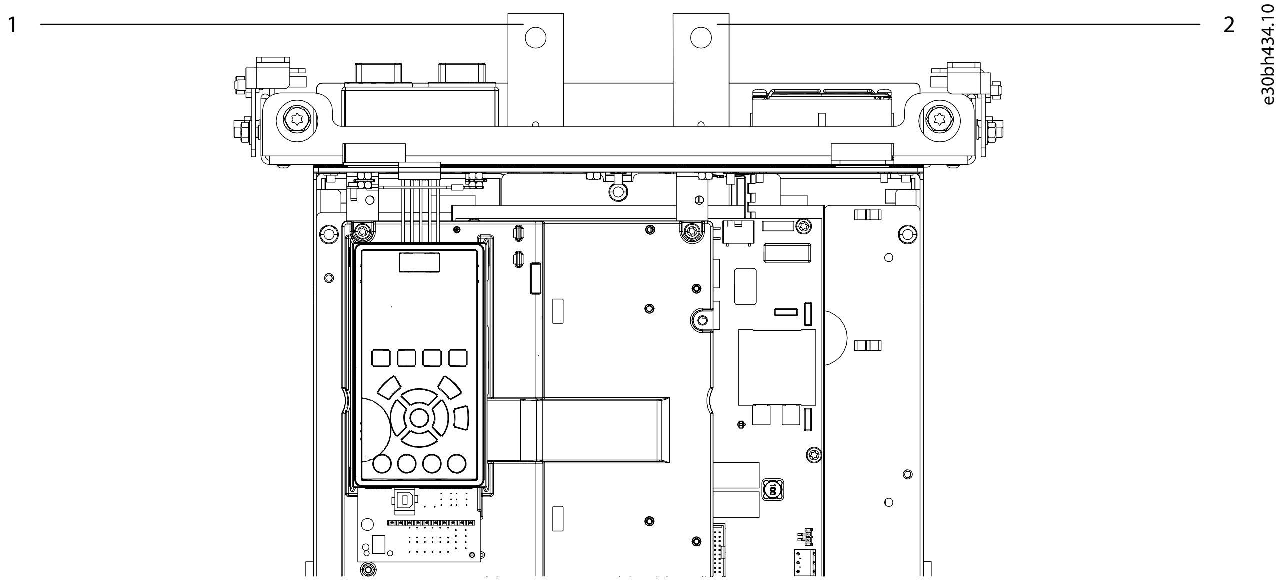
- Always refer to the safety warnings provided throughout this manual concerning these procedures.
- Unless specified otherwise, disconnect all electrical power including remote disconnect and discharge all energy storing devices such as capacitors before servicing.
- To ensure that the power cannot be inadvertently energized, follow proper lockout/tagout procedures.
- When necessary to work with live electrical components, have a qualified licensed electrician, or another individual trained in handling live electrical components, perform these tasks.

Observe the following safety measures before performing the static tests:

- Prepare the work area according to the ESD regulations.
- Ground the ESD mat and wrist strap.
- Ensure that the ground connection between body, the ESD mat, and the drive is always present while performing service.
- Handle disassembled electronic parts with care.
- Perform the static tests before powering up the faulty unit.
- Perform the static tests after completing the repair and assembly of the drive.
- Connect the drive to the mains only after completion of static tests.
- Complete all necessary precautions for system start-up, before applying power to the drive.

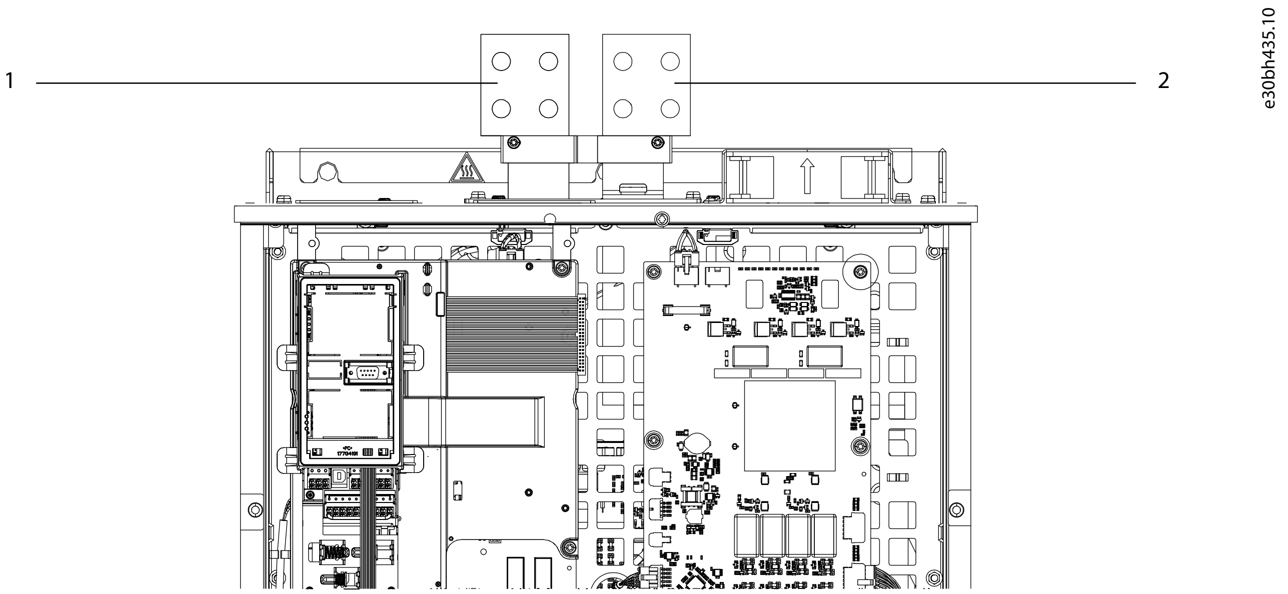
8.3.2 Access to Testing Connection Points

Many of the following test procedures require access to the DC bus at the top of the drive module. For the DC bus location in D9h–D10h enclosed drives, see illustration 51. For E5h–E6h enclosed drives, see illustration 52.



1 DC(+) bus	**2** DC(-) bus

Illustration 51: DC Bus Location in D9h–D10h



1 DC(+) bus	**2** DC(-) bus

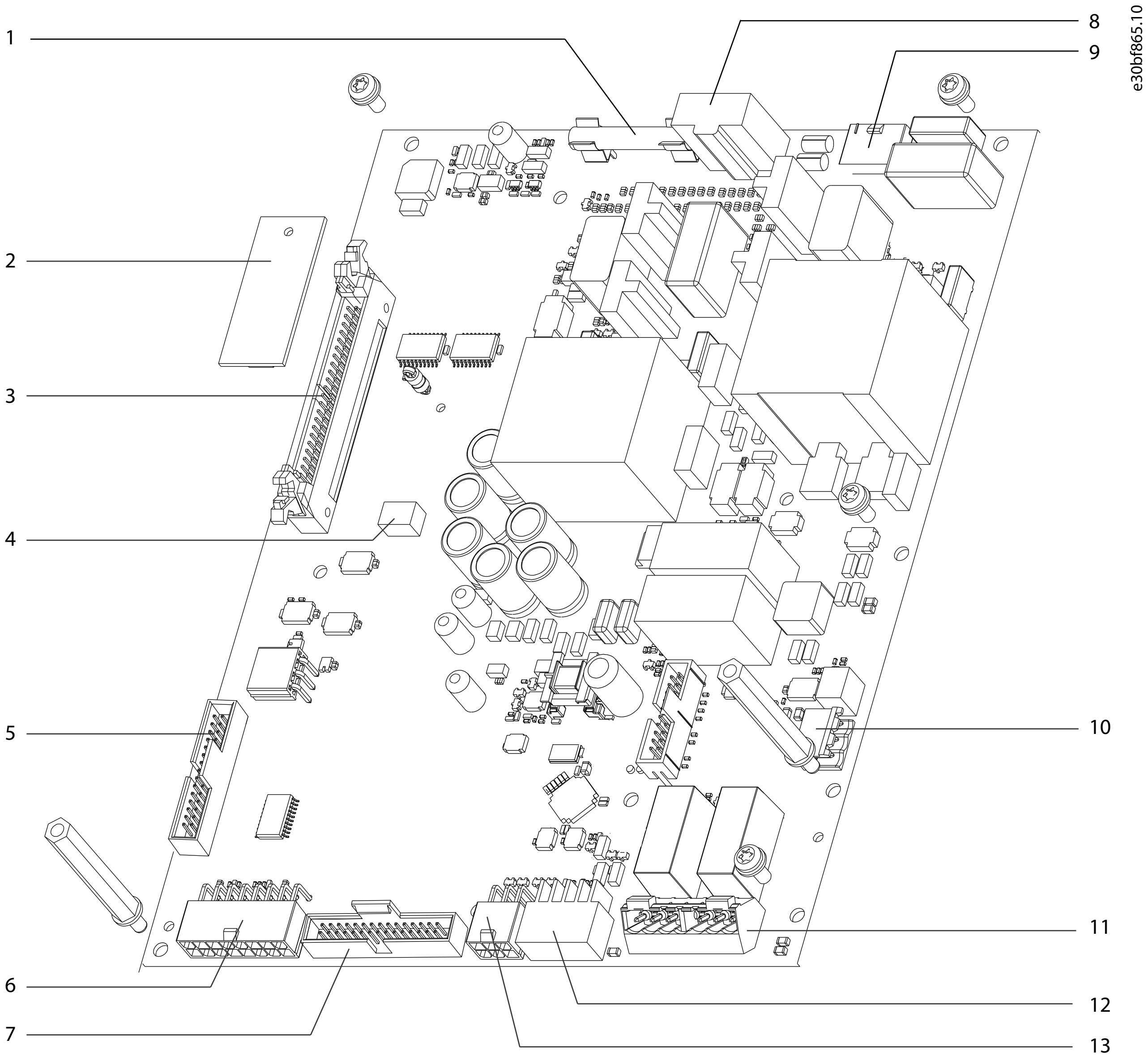
Illustration 52: DC Bus Location in E5h–E6h Drives

8.3.3 Card Connectors

This section includes illustrations of printed circuit cards and descriptions of their connectors used during testing and servicing. Some connectors are optional and not found on all configurations. The printed circuit cards shown include:

- Power card in D-sized drives
- Power card in E-sized drives
- Fan power card in E-sized drives
- Fan power card in optional filters
- Gate drive card in D-sized drives
- Gate drive card in E-sized drives

8.3.4 Power Card in D-sized Drives

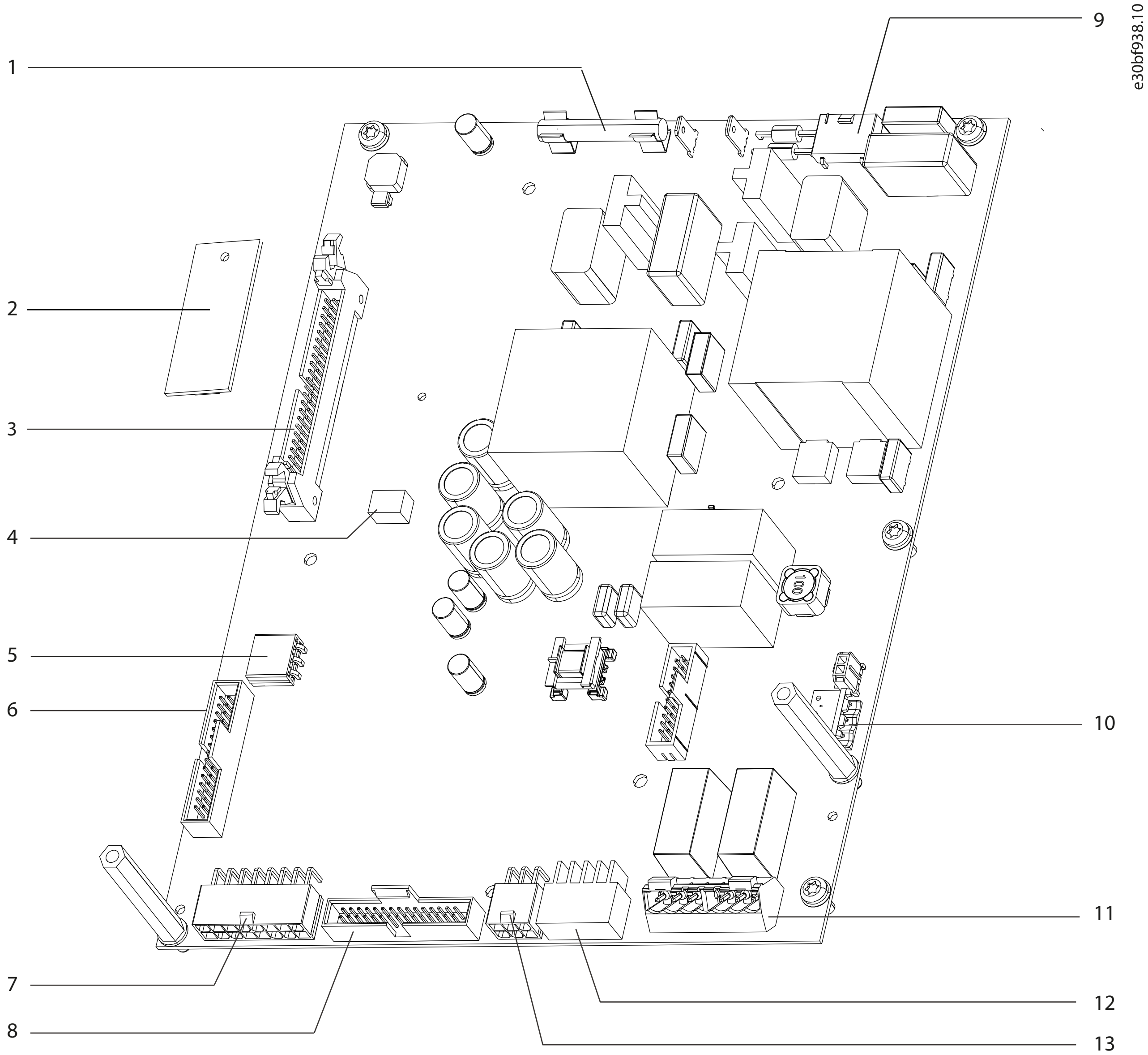


1	FK901: SMPS fuse	**2**	Current scaling card
3	MK102: Control card to power card connection	**4**	MK100: Current scaling card connector

5 MK104: Signal test board connector	**6** MK101: Current sensor feedback
7 MK103: Connector to gate drive card	**8** MK901: DC input terminals (for split bus power supply)
9 MK902: DC voltage from DC bus to power card SMPS	**10** MK106: Brake temperature switch input
11 MK500: Customer terminals for relays 1 and 2	**12** MK501: Heat sink and door/top fan control
13 MK502: EMC relay control	

Illustration 53: Power Card in D-sized Drives

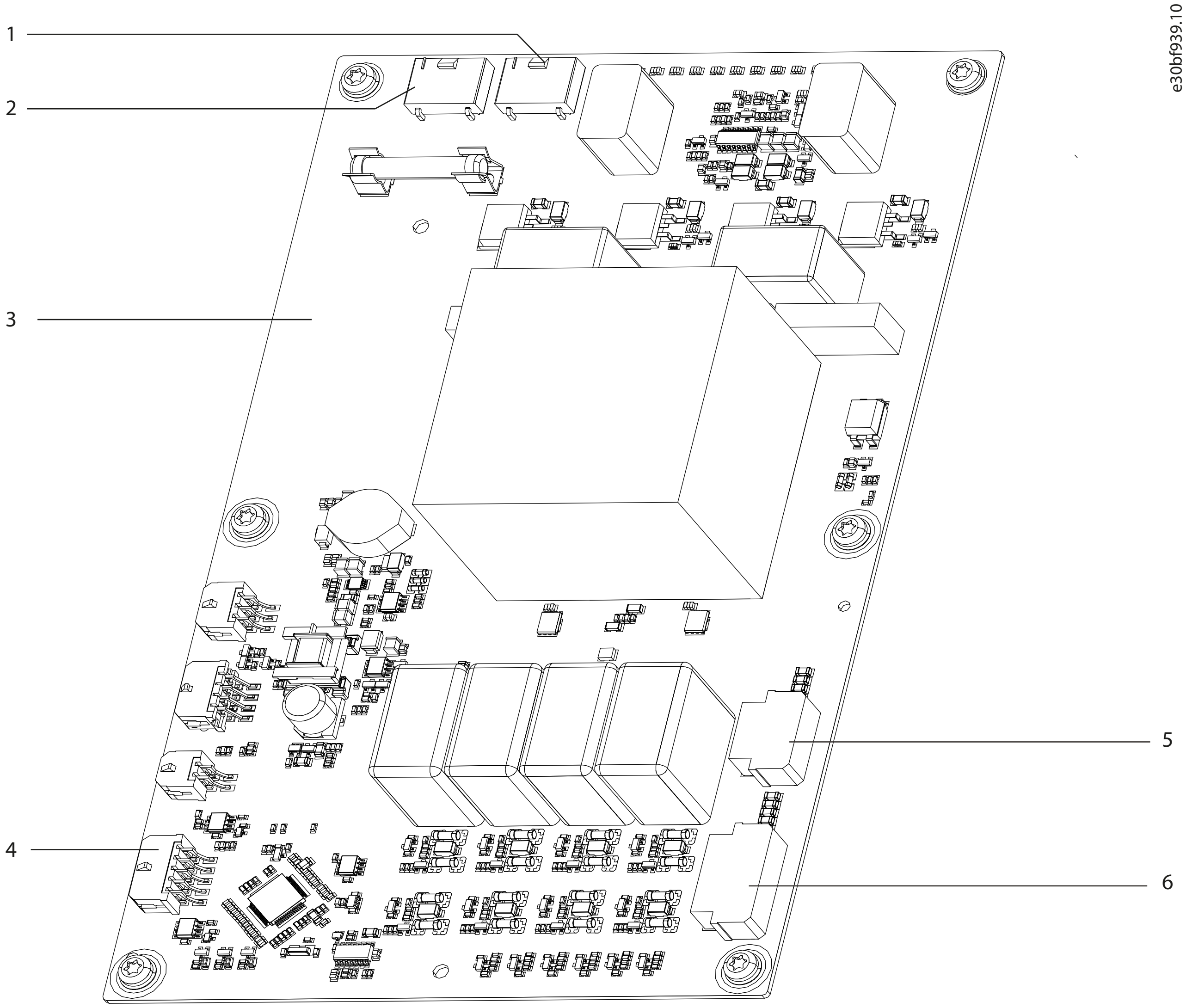
8.3.5 Power Card in E-sized Drives



1	FK901: SMPS fuse	**2**	Current scaling card
3	MK102: Control card to power card connection	**4**	MK100: Current scaling card connector
5	MK105: CANBUS connection to fan power card	**6**	MK104: Signal test board connector
7	MK101: Current sensor feedback	**8**	MK103: Connector to gate drive card
9	MK902: Fan power card signals (MK803)	**10**	MK106: Brake temperature switch input
11	MK500: Customer terminals for relays 1 and 2	**12**	MK501: Mixing fan control
13	MK502: EMC relay control		

Illustration 54: Power Card in E-sized Drives

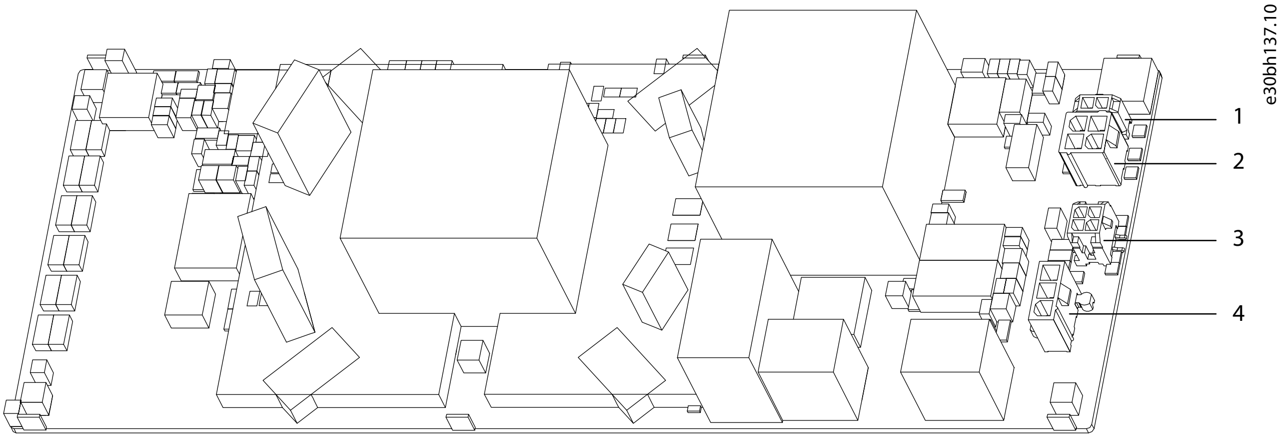
8.3.6 Fan Power Card in E-sized Drives



1	MK802: DC power	**2**	MK803: Power card signals (MK902)
3	Fan power card (PCA16)	**4**	MK1200: Inrush card (MK110) and power card (MK105)
5	MK602: Door/top fan control	**6**	MK600: Heat sink fan control

Illustration 55: Fan Power Card in E-sized Drives

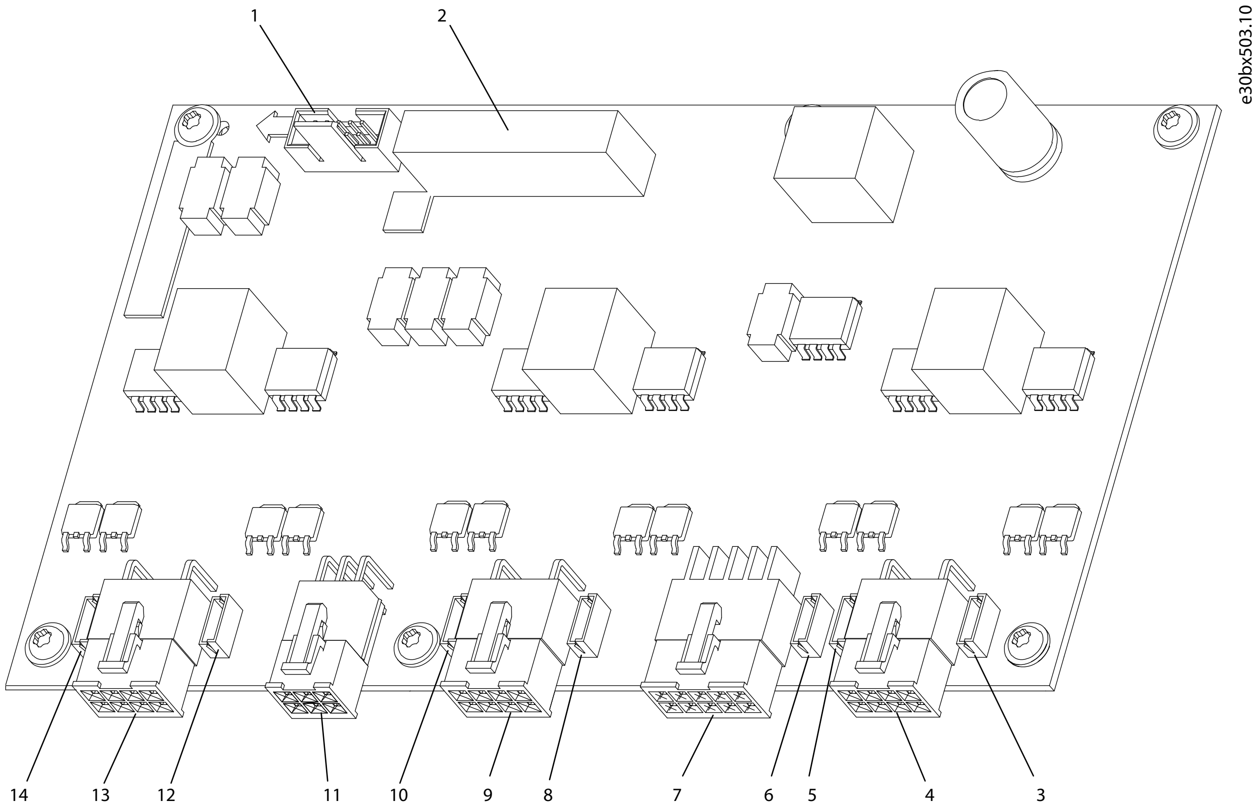
8.3.7 Fan Power Card in Enclosed Drive Filters



1	Cooling fan connector	**2**	Main fan connector
3	Not used	**4**	DC input connector

Illustration 56: Fan Power Card in Enclosed Drive Filters

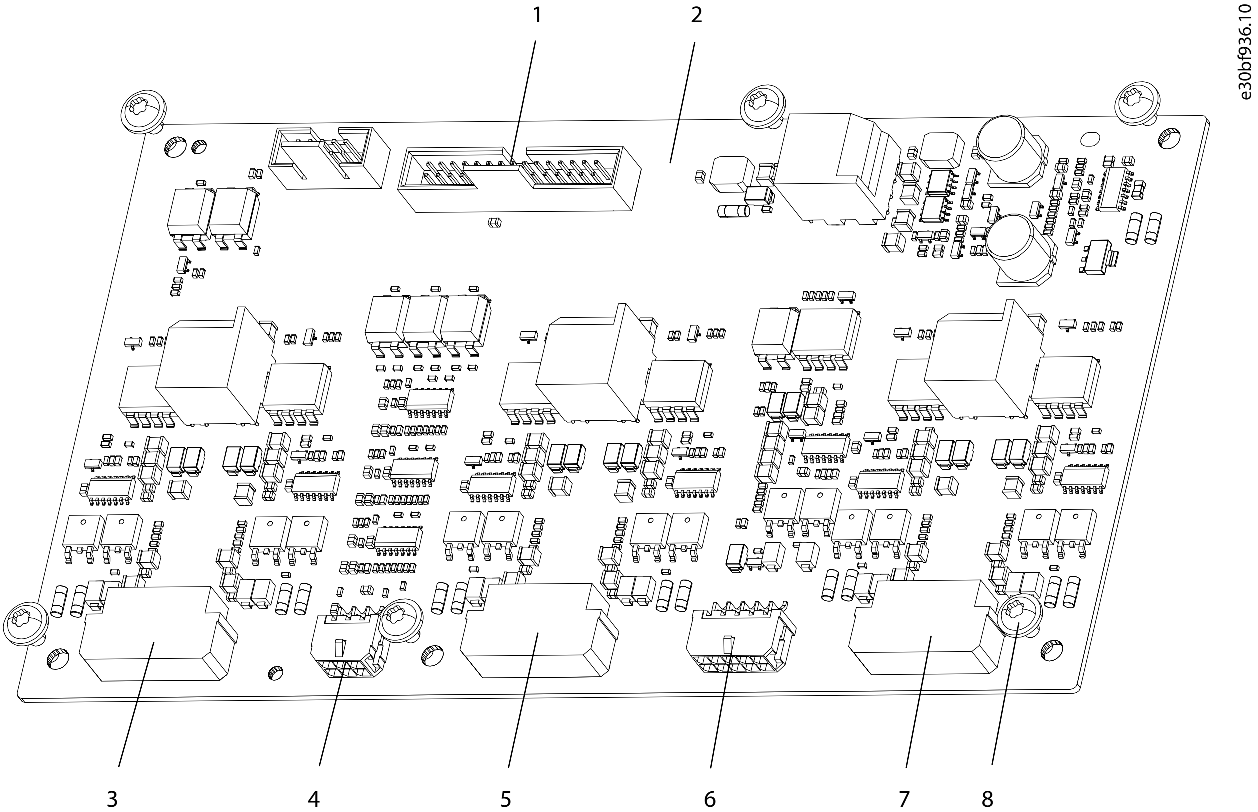
8.3.8 Gate Drive Card in D-sized Drives



1	MK102: Connection to inrush card	**2**	MK101: Gate drive/inrush signals to power card
3	MK700: W phase upper IGBT test point	**4**	MK701: W phase IGBT signal
5	MK702: W phase lower IGBT test point	**6**	MK200: Brake IGBT test point (optional)
7	MK200: Brake IGBT gate signal (optional)	**8**	MK600: V phase upper IGBT test point
9	MK601: V phase IGBT gate signal	**10**	MK602: V phase lower IGBT test point
11	MK100: IGBT temperature feedback	**12**	MK500: U phase upper IGBT test point
13	MK501: U phase IGBT gate signal	**14**	MK502: U phase lower IGBT gate signal

Illustration 57: Gate Drive Card in D-sized Drives

8.3.9 Gate Drive Card in E-sized Drives



1	MK101: Gate drive signals to power card	**2**	Gate drive card
3	MK501: U phase IGBT gate signal	**4**	MK100: IGBT temperature feedback
5	MK601: V phase IGBT gate signal	**6**	MK201: Brake IGBT gate signal (optional)
7	MK701: W phase IGBT signal	**8**	Screw (T20)

Illustration 58: Gate Drive Card in E-sized Drives

8.4 Static Tests

8.4.1 Introduction

NOTICE

TEST ORDER

For best results, perform the static test procedures in this section in the order they appear in this section.

To find the appropriate card connectors for performing the tests, see the Card Connectors section.

8.4.2 Rectifier Circuit Test for Drive Module

Context:

Use the following steps to test the rectifier circuits of the drive module in an enclosed drive system.

Procedure

1. To prepare the drive module for testing, disconnect the input and output cables to the drive.
2. Reverse meter leads by connecting the negative (–) meter lead to the negative DC(-) bus.
3. Connect the positive (+) meter lead to L1, L2, and L3 in sequence.
   → Infinity is the correct reading. The meter starts at a low value and slowly climbs toward infinity due to the meter charging capacitance within the drive.

   If an incorrect reading appears, verify first that the polarity of the meter leads is correct. With the correct test connection, the diodes in the SCR/diode modules are reverse biased. If a short circuit exists, the diodes in the SCR/diode modules are shorted. Replace the shorted SCR/diode module.

8.4.3 Inverter Section Test for Drive Module

Context:

Use the following test to perform the inverter section test on the drive module within an enclosed drive system.

Procedure

1. Reverse the meter leads by connecting the negative (-) meter lead to the negative DC(-) bus.
2. Connect the positive (+) meter lead to U, V, and W in sequence.
   → Infinity is the correct reading. The meter starts at a low value and slowly moves toward infinity due to the meter charging capacitance within the drive.

   An incorrect reading indicates a failed IGBT module. If 1 has failed, replace all the IGBT modules. Following an IGBT failure, verify that the gate drive signals are present and the wave form is correct. See IGBT Gate Drive Signals Test.

8.4.4 Brake IGBT Test for Drive Module

Context:

Use the following test to perform the brake IGBT test on the drive module within an enclosed drive system.

Procedure

1. Connect the negative (-) meter lead to the brake resistor 81 (R-).
2. Connect the positive (+) meter lead to U, V, and W in sequence.
   → A diode drop indicates a correct reading.

   An incorrect reading indicates that the brake IGBT is defective. Replace the brake IGBT module.

8.4.5 Intermediate Section Test for Drive Module

Context:

The intermediate section of the drive is composed of the:

- DC bus capacitors.
- DC coils.
- Balance circuit for the capacitors.

Use the following steps to perform the intermediate section test on the drive module within an enclosed drive system.

Procedure

1. Test for short circuits with the ohmmeter set to Rx100 scale. If using a digital meter, select diode.
2. Connect the positive (+) meter lead to the DC(+) and the negative (-) meter lead to the negative DC(-).
3. The meter starts with low ohms and then moves toward infinity as the meter charges the capacitors.
4. Reverse the meter leads so that the (-) meter lead is connected to the positive DC(+) and the positive (+) meter lead is connected to the negative DC(-).
   → The meter pegs at 0 while the meter discharges the capacitors. The meter then begins moving slowly toward 2 diode drops as the meter charges the capacitors in the reverse direction. Although the test does not ensure that the capacitors are fully functional, it ensures that no short circuits exist in the DC link.

   A short in the rectifier or inverter section could cause a short circuit reading. Ensure that the tests for these circuits have already been performed successfully. A failure in 1 of these sections could be read in the intermediate section since they are all routed via the DC bus.

   If a short circuit is present, and the unit is equipped with a brake, perform the brake IGBT test next.

   The only other likely cause for failure would be a defective capacitor. There is not an effective test of the capacitor bank when it is fully assembled. It is unlikely that a physically damaged capacitor would indicate a failure within the capacitor bank. If a failure is suspected, all the capacitors must be replaced.

8.4.6 IGBT Temperature Sensor Test for Drive Module

Context:

The temperature sensor is an NTC (negative temperature coefficient) device. As a result, high resistance means low temperature. As the temperature increases, resistance decreases. Each IGBT module has a temperature sensor mounted internally. The sensor is wired from each IGBT module to the gate drive card connector MK100.

On the gate drive card, the resistance signal is converted to a frequency signal. The frequency signal is sent to the power card for processing. The temperature data is used to regulate fan speed and to monitor for over and under temperature conditions. In D-sized drives, there are 3 sensors, 1 in each IGBT module. In E-sized drives, there are 6 IGBT modules; the left IGBT of each phase is monitored. In E-sized drives, individual IGBT module temperatures can be viewed in *parameter 43-00 Component Temp*:

- *Parameter 43-10 Heat Sink Phase U Temp ID* shows U-phase temperature.
- *Parameter 43-11 Heat Sink Phase V Temp ID* shows V-phase temperature.
- *Parameter 43-12 Heat Sink Phase W Temp ID* shows W-phase temperature.

Procedure

1. Use ohmmeter set to read ohms.
2. Unplug connector MK100 on the gate drive card, and measure the resistance across each black and white pair.
   → The relationship between temperature and resistance is nonlinear. At 25 °C (77 °F), the resistance is approximately 5k Ω. At 0 °C (32 °F), the resistance is approximately 13.7 k Ω. At 60 °C (140 °F), the resistance is approximately 1.5 k Ω. The higher the temperature, the lower the resistance.

8.4.7 Gate Resistor Test for Drive Module

Context:

NOTICE

TEST CONNECTORS

This test is applicable to D-sized drives only. E-sized drives do not have test connectors on the gate drive card.

Mounted to each IGBT module is an IGBT gate resistor card containing gate resistors for the IGBT transistors. Occasionally, a defective IGBT can produce correct readings in the previous tests. Typically, an IGBT failure results in the failure of the gate resistors, so the gate resistor test can identify an IGBT failure.

In D-sized drives, a 3-pin test connector is found on the gate drive card near each gate signal lead. These leads are labeled:

- MK500
- MK502
- MK600
- MK602
- MK700
- MK702
- MK200 (if brake option is present)

See the Card Connectors section. For testing, refer to the 3 pins as 1, 2, and 3, reading bottom to top. Pins 1 and 2 of each connector are in parallel with the gate drive signal sent to the IGBTs. Pin 1 is the signal and pin 2 is common.

Procedure

1. With an ohmmeter, measure pins 1 and 2 of each test connector.
2. Confirm that the reading is the same for each test connector.
   → An incorrect reading can indicate that:
   - The gate signal wires are not connected from the gatedrive card to the gate resistor board.
   - The gate resistors are defective.

   Connect the gate signal wires if necessary. If any of the resistors are defective, replace the entire IGBT module assembly.

8.4.8 Mains Fuse/Module Fuse Test

Context:

In enclosed drive cabinets, the fuses are located inside the fusible disconnect. The drive module also contains the semiconductor fuses. The fusible disconnect is located in the input option cabinet of E-sized drives. In D-sized enclosed drives, the fusible disconnect is located below the drive module or in the input option cabinet.

Procedure

1. Use an ohmmeter set to measure the ohms.
2. Measure the resistance across each fuse.
   → A short circuit (0 Ω) is a correct reading and indicates good continuity.

   An open circuit is an incorrect reading and means that the fuse requires replacement. Perform the additional static checks before replacing the fuse.

8.4.9 Disconnect Test

Context:

The mains disconnect switch is optional. In D9h/D10h drives, the disconnect is located in the drive cabinet. In E5h/E6h drives, the disconnect option is found in the options cabinet.

Procedure

1. Use an ohmmeter set to read ohms.
2. Open the disconnect switch.
3. Measure the resistance across each of the 3 phases.
   → An open circuit (infinite resistance) is a correct reading. A short circuit (0 Ω) indicates a problem with the switch.
4. Close the disconnect switch.
5. Measure the resistance across each of the 3 phases.
   → A short circuit (0 Ω) is a correct reading. An open circuit (infinite resistance) or high-resistance reading indicates a problem with the switch. Replace the disconnect switch.

8.4.10 Mains Contactor Test 1

Context:

NOTICE

POWER REQUIREMENT

Testing of the mains contactor coil requires 230 V AC/115 V AC power.

The mains contactor is optional. The mains contactor uses a customer-supplied 230 V AC/115 V AC control signal wired to the contactor coil. When power is applied to the contactor coil, the mains contactor is closed. When there is no power, the contact is open.

Procedure

1. Remove power from the contactor coil.
2. Using an ohmmeter, measure across each of the 3 phases.
   → An open circuit (infinite resistance) is a correct reading. A short circuit (0 Ω) indicates a problem with the mains contactor.

8.4.11 Mains Contactor Test 2

Procedure

1. Manually engage the mains contactor.
2. With the mains contactor engaged, measure the resistance across each of the 3 phases.
   → A short circuit (0 Ω) is the proper reading. An open circuit (infinite resistance) or high-resistance reading indicates a problem with the mains contactor.

8.4.12 Contactor Coil Test

Context:

NOTICE

POWER REQUIREMENTS

Testing of the contactor coil requires an external 230 V/110 V AC supply.

Procedure

1. Apply power to the coil, energizing the mains contactor.
2. Use a voltmeter set to measure AC voltage between A1 and A2 on TB6.
3. Measure the resistance across each of the 3 phases.
   → When power is applied, the contactor energizes and is engaged. A short circuit (0 Ω) is a correct reading.

   An open circuit (infinite resistance) or high-resistance reading indicates a problem with the contactor. If there is a problem with any of the phases, replace the contactor.

8.4.13 Circuit Breaker Test

Context:

The circuit breaker is optional. In a D9h/D10h drive, the circuit breaker is located in the drive cabinet. In a E5h/E6h drive, the circuit breaker is in the options cabinet.

Procedure

1. Use an ohmmeter set to read ohms.
2. Open the circuit breaker.
3. Measure the resistance across each of the 3 phases.
   → An open circuit (infinite resistance) is a correct reading. A short circuit (0 Ω) indicates a problem with the circuit breaker.
4. Close the circuit breaker.
5. Measure the resistance across each of the 3 phases.
   → A short circuit (0 Ω) is a correct reading. An open circuit (infinite resistance), or high-resistance reading indicates a problem with the circuit breaker. If there is a problem with any of the phases, replace the circuit breaker.

8.4.14 Inductor Test for Optional Filters

Context:

The inductor test is used to test the inductor that is part of certain optional filters. The test can be used with the following inductors:

- Line reactor filter inductor
- Passive harmonic filter inline inductor
- Passive harmonic filter inductor
- Sine-wave filter inductor
- dU/dt filter inductor

Procedure

1. To isolate the inductor to be tested, remove the input and output connections.
2. Using an ohmmeter set to read ohms, measure the resistance between input and output terminals of each of the 3 phases.
   → A short circuit (0 Ω) is a correct reading. An open circuit (infinite resistance of high resistance reading) indicates a problem with the inductor.
3. Measure the resistance between the phases of the inductor.
4. Measure the resistance between each phase terminal of the inductor and the chassis or enclosure.
   → An open circuit is a correct reading. A short circuit (0 Ω) or much lower resistance indicates a problem with the inductor.

8.4.15 Thermal Switch Test for Optional Filters

Context:

The thermal switches are located at the hot spot of the inductors. The selected thermal switches have NC (normally closed) contacts.

Procedure

1. Check the continuity using an ohmmeter between the thermal switch terminals.
   → If the inductor is at room temperature, measuring 0 Ω is a correct reading. An open circuit indicates a failure in the thermal switch.

8.4.16 Capacitor Test for Optional Filters

Context:

Each optional filter has 3 single-phase capacitors. The capacitors are located in the individual filter cabinet. Use the following steps to test each capacitor.

Procedure

1. Isolate the capacitor by disconnecting the leads from the system.
2. Set the ohmmeter to Rx100 scale, and test for short circuits. If using a digital meter, select diode mode.
3. Connect the positive (+) meter lead to the positive (+) capacitor terminal and the negative (-) meter lead to the negative (-) capacitor terminal.
   → The meter starts at low ohms and moves toward infinity as the meter charges the capacitor. The meter pegs at 0 while the meter discharges the capacitor. The meter then begins moving slowly toward 2 diode drops as the meter charges the capacitors in the reverse direction. Although the test does not ensure that the capacitors are fully functional, it ensures that no short circuits exist in the capacitor.
4. Repeat these steps for the remaining 2 single-phase capacitors.
5. If the digital multimeter has the capacitance measurement, measure the capacitance in each phase.
   → The correct reading shows equal capacitance. Differences of 10% or less are acceptable. An incorrect reading shows a short in the capacitor, and indicates that the capacitor has failed. If a fault is identified in a single capacitor, replace all 3 of the single-phase capacitors or the entire capacitor bank.

8.5 Dynamic Tests

8.5.1 Introduction

⚠ WARNING ⚠

SHOCK HAZARD

Contact with powered components can result in death or serious injury.

- Before starting the drive or performing any dynamic test procedures, follow all safety precautions for system start-up.
- Do not disconnect the input cabling with power applied to the drive.

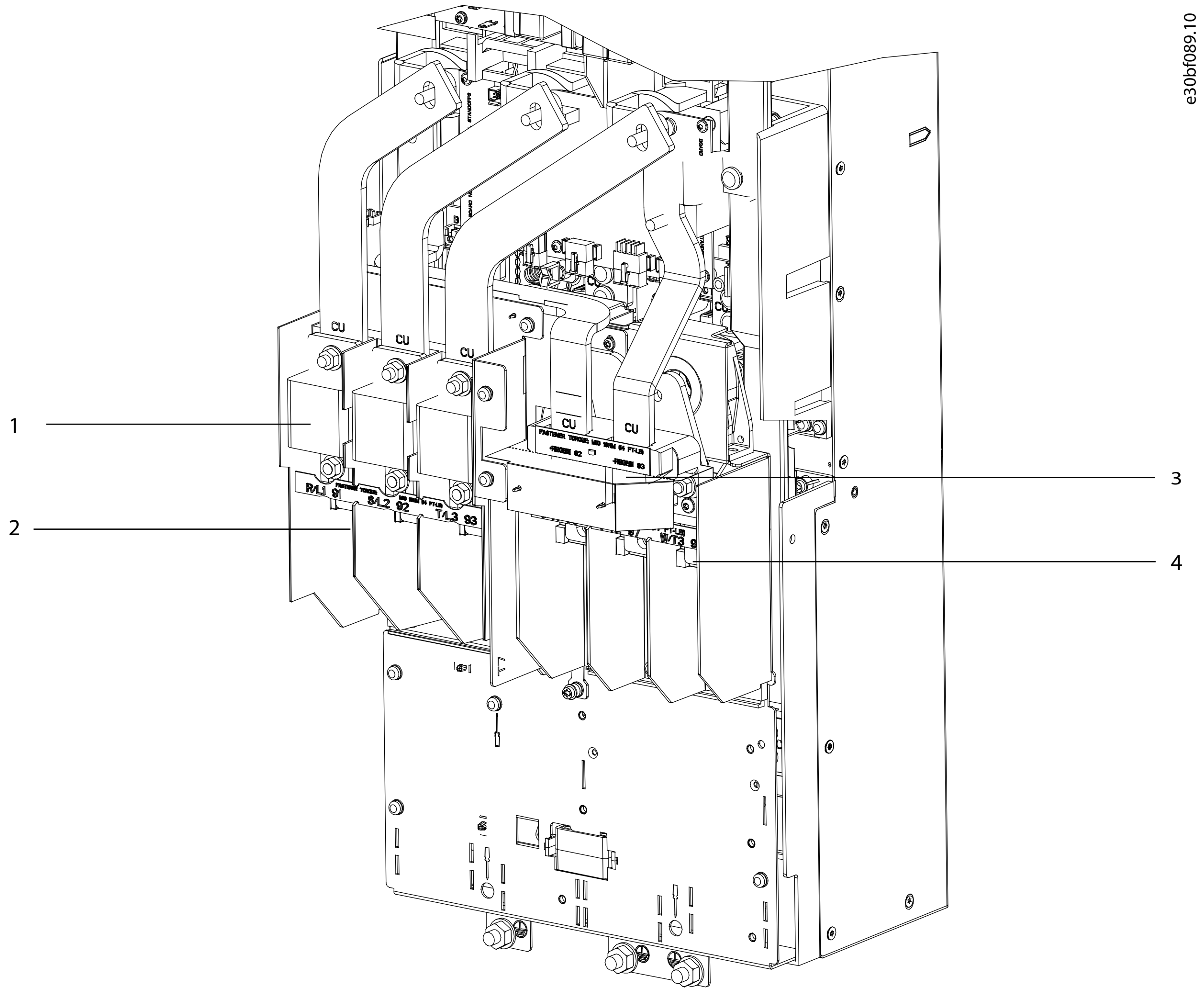
NOTICE

TEST ORDER

If the drive module is identified as failed:

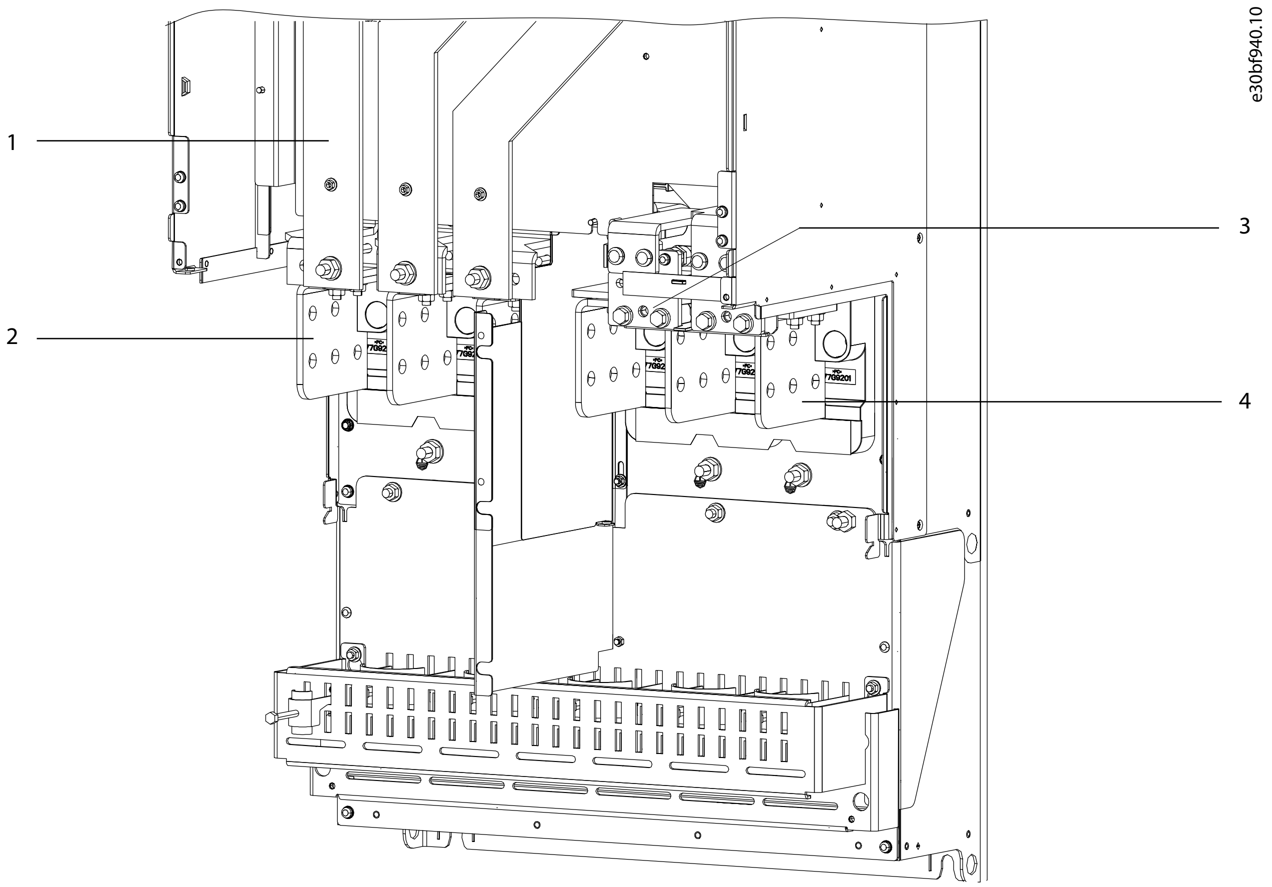
- Remove the cables and busbars connecting the input and output terminals of the drive module, and isolate it from any options.
- After repair, follow the dynamic tests in the order they appear in this section.

Whenever possible, perform these procedures with a split bus supply.



1	AC fuse	**2**	Mains input terminals
3	Brake terminals (optional)	**4**	Motor (output) terminals

Illustration 59: Power Terminals in D-sized Drive



1	AC input busbar	**2**	Mains input terminals
3	Brake/regen terminals (optional)	**4**	Motor (output) terminals

Illustration 60: Power Terminals in E-sized Drives

8.5.2 No Display Test

Context:

A drive with no display can be the result of various causes.

Procedure

1. Verify first that there is no display.
   → If the display is dark and the green power LED is not lit, proceed with the dynamic tests.

8.5.3 Input Voltage Test for Drive Modules

Context:

If the drive is equipped with input options, ensure that the options are functioning properly using the relevant static tests:

- Mains Fuse/Module Fuse Test
- Disconnect Test
- Circuit Breaker Test
- Contactor Coil Test

NOTICE

AUXILIARY COMPONENT FAILURE

Incorrect voltage or incorrect tapping installation can cause other auxiliary components in the control compartment to fail.

- When tapping the auxiliary transformer, make sure to apply the correct voltage for the drive.
- Use the correct tapping and trip settings.

Procedure

1. Apply power to the drive.
2. Use the voltmeter to measure the input mains voltage between the drive input terminals in sequence:
   A L1 to L2
   B L1 to L3
   C L2 to L3

→ For 380–480 V/380–500 V drives, all measurements must be within the range of 342–550 V AC. Readings of less than 342 V AC indicate problems with the mains voltage. For 525–690 V drives, all measurements must be within the range of 446–759 V AC. Readings of less than 446 V AC indicate problems with the mains voltage.

In addition to the actual voltage reading, the balance of the voltage between the phases is also important. The drive can operate within specifications as long as the imbalance of supply voltage is not more than 3%.

Danfoss calculates mains imbalance per an IEC specification.

- Imbalance = 0.67 X (V_{max} – V_{min})/V_{avg}

For example, if 3-phase readings are taken and the results are 500 V AC, 478.5 V AC, and 478.5 V AC; then 500 V AC is V_{max}, 478.5 V AC is V_{min}, and 485.7 V AC is V_{avg}, resulting in an imbalance of 3%.

Although the drive can operate at higher mains imbalances, this condition can shorten the lifetime of some components, such as DC bus capacitors.

An incorrect reading requires further investigation of the main supply. Typical items to check include:

- Open (blown) mains input fuses or tripped circuit breakers.
- Open disconnects or line side contactors.
- Problems with the power distribution system.

NOTICE

TEST ORDER

Open (blown) input fuses or tripped circuit breakers usually indicate a more serious problem.

- Before replacing fuses or resetting breakers, perform the static tests.

If the input voltage test result is correct, check for voltage to the control card.

8.5.4 Basic Control Card Voltage Test for Drive Modules

Procedure

1. Measure the control voltage at terminal 12 in relation to terminal 20.
   → A correct reading is 24 V DC (21–27 V DC).

   An incorrect reading can indicate that a fault in the customer connections is loading down the supply. Check the customer connections. Unplug the terminal strip and repeat the test.
2. Measure the 10 V DC control voltage at terminal 50 in relation to terminal 55.
   → A correct reading is 10 V DC (9.2–11.2 V DC).

   An incorrect reading can indicate that a fault in the customer connections is loading down the supply. Check the customer connections. Unplug the terminal strip and repeat the test. A correct reading of both control card voltages indicates that the LCP or the control card is defective. Replace the LCP. If the problem persists, replace the control card.

8.5.5 DC Bus Voltage Test 1 for Drive Modules

Procedure

1. Using a voltmeter, read the DC bus voltage.
   → A correct reading is at least 1.35 x the AC mains voltage.

   An incorrect reading can indicate a problem in the inrush circuit or with the rectifier.

8.5.6 DC Bus Voltage Test 2 for Drive Modules

Procedure

1. Power down the drive.
2. Wait for the DC bus to discharge. See the label on the drive for discharge times.
3. Remove the control card mounting plate.
4. Use an ohmmeter set to measure ohms.
5. Measure between MK902 pin 1 on the power card to DC(+).
6. Measure between MK902 pin 2 on the power card to DC(-).
   → A short circuit (0 Ω) is the correct reading for both measurements.

   An incorrect reading indicates that the wire harness is defective. Replace the wire harness.

8.5.7 Switch Mode Power Supply Test for Drive Modules

Context:

The switch mode power supply (SMPS) derives its power from the DC bus. The first indication that the DC bus is charged is that the DC bus charge indicator light on the power card is lit. However, this LED can be lit at a voltage still too low to enable the supplies.

First, test for the presence of the DC bus voltage.

Procedure

1. Install the signal test board.
2. Install the split bus supply. Power the power card using split bus mode.
3. Connect the negative (-) meter lead to terminal 4 (common) of the signal board. With a positive (+) meter lead, check the following terminals on the signal board.

→ **Table 80: Measured Voltages at Select Terminals**

Terminal	Supply	Voltage range
11	(+)18 V	16.5–19.5 V DC
12	(-)18 V	(-)16.5–19.5 V DC
23	(+) 24 V	23–25 V DC
24	(+) 5 V	4.75–5.25 V DC

In addition, the signal test board contains 3 LED indicators that show the presence of voltage as follows:

- Red LED (±) 18 V DC supplies present.
- Yellow LED (+) 24 V DC supply present.
- Green LED (+) 5 V DC supply present.

The lack of any of these supplies indicates that the low voltage supplies on the power card are defective. Replace the power card.

8.5.8 Input Imbalance of Supply Voltage Test for Drive Modules

Context:

Ideally, all 3 phases have an equal current draw. Some imbalance is possible, however, due to variations in the phase-to-phase input voltage.

A current measurement of each phase reveals the balanced condition of the line. To obtain an accurate reading, it is necessary for the drive to run at more than 40% of its rated load.

Procedure

1. Perform the input voltage test before checking the current. See 8.5.3 Input Voltage Test for Drive Modules.
   → Voltage imbalances automatically result in a corresponding current imbalance.
2. Apply power to the drive and place it in run mode.
3. Using a clamp-on amp meter (analog preferred), read the current on each of 3 input lines at L1(R), L2(S), and L3(T).
   → Typically, the current does not vary from phase to phase by more than 5%. If a greater current variation exists, it indicates a possible problem with the mains supply, or a problem within the drive itself.

   One way to determine if the mains supply is at fault is to swap 2 of the incoming phases. See the following steps.
4. Remove power to drive.
5. Swap the phases. If all 3 phases are different, swap the phase with the highest current for the phase with the lowest current.
6. Reapply power to the drive and place it in run mode.
7. Repeat the current measurements.
   → If the imbalance of supply current moves when swapping the leads, then the mains supply is suspect. Otherwise, there could be a problem with the gating of the SCR, possibly due to a defective SCR/diode module. This result can also indicate a problem in the gate signals from the inrush card to the module. Check the wire harness from the inrush card to the SCR gates. Perform the 8.5.9 Input Waveform Test for Drive Modules and 8.5.11 Input SCR Test 1 for Drive Modules.

8.5.9 Input Waveform Test for Drive Modules

Testing the current waveform on the input of the drive module helps in troubleshooting mains phase loss conditions or suspected problems with the SCR/diode modules. This test easily detects phase loss caused by the mains supply.

The SCR/diode modules control the rectifier section. If an SCR/diode module is defective or the gate signal to the SCR is lost, the drive responds as if losing a phase.

The following measurements require an oscilloscope with voltage and current probes.

Under normal operating conditions, the waveform of a phase of input AC voltage to the drive appears as in illustration 61.

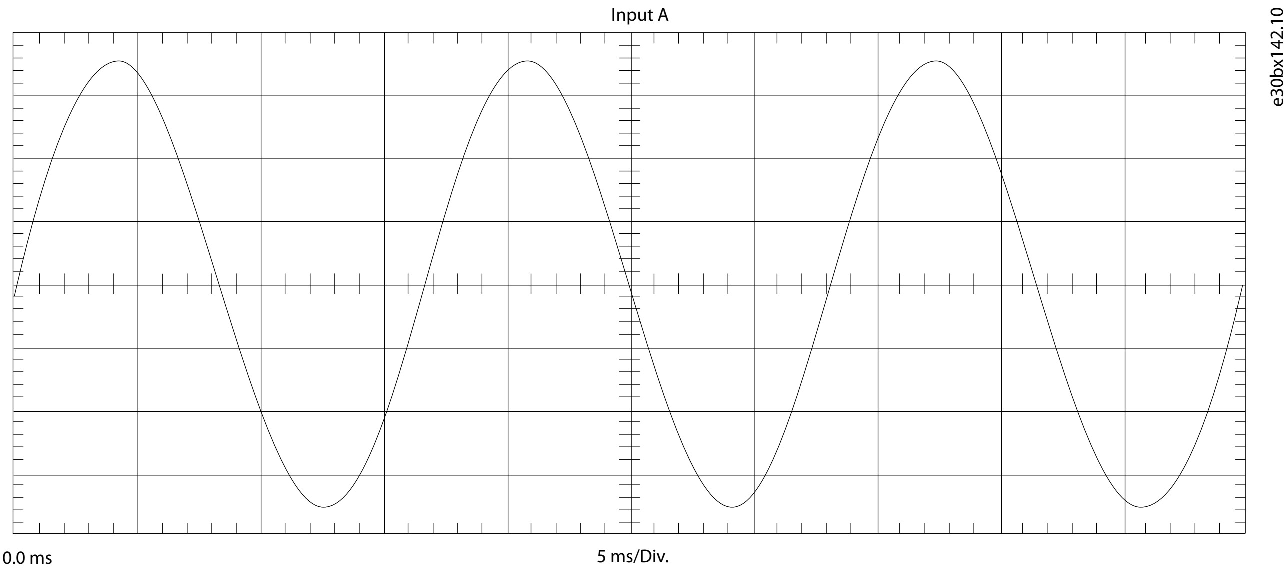


Illustration 61: Normal AC Input Voltage Waveform

The waveform in illustration 62 shows the input current waveform for the same phase as while the drive is running at 40% load. The 2 positive and 2 negative humps are typical of any 6 diode bridge. It is the same for drives with SCR/diode modules.

The same waveform is seen when measuring a 12-pulse drive between the rectifier and the transformer.

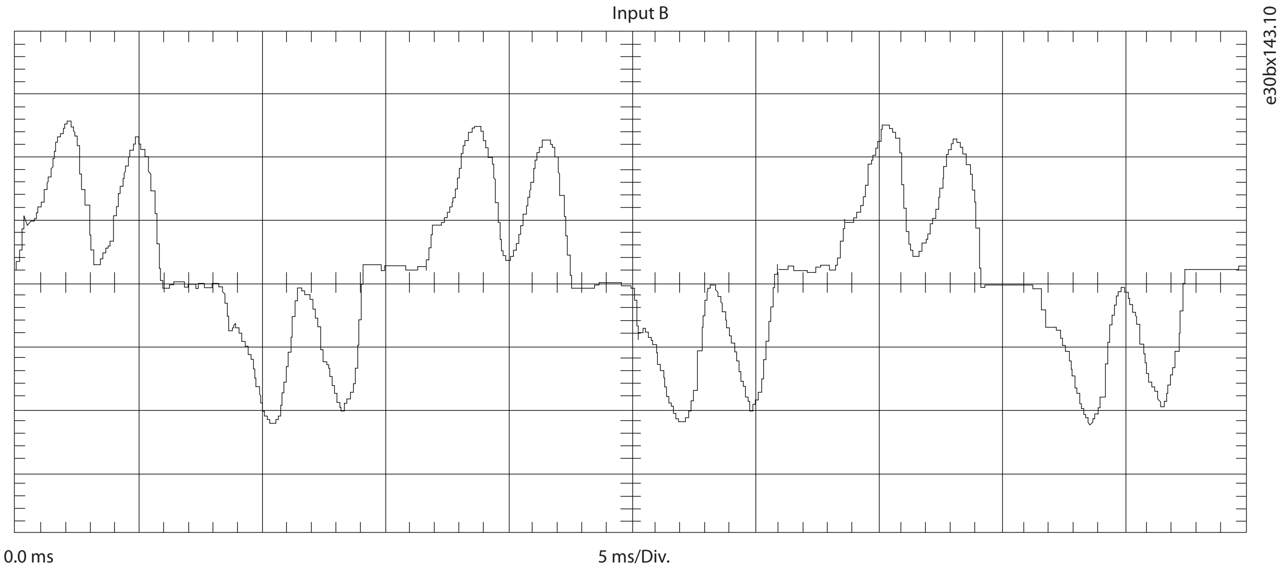


Illustration 62: AC Input Current Waveform with Diode Bridge

With a phase loss, the current waveform of the remaining phases resembles illustration 63.

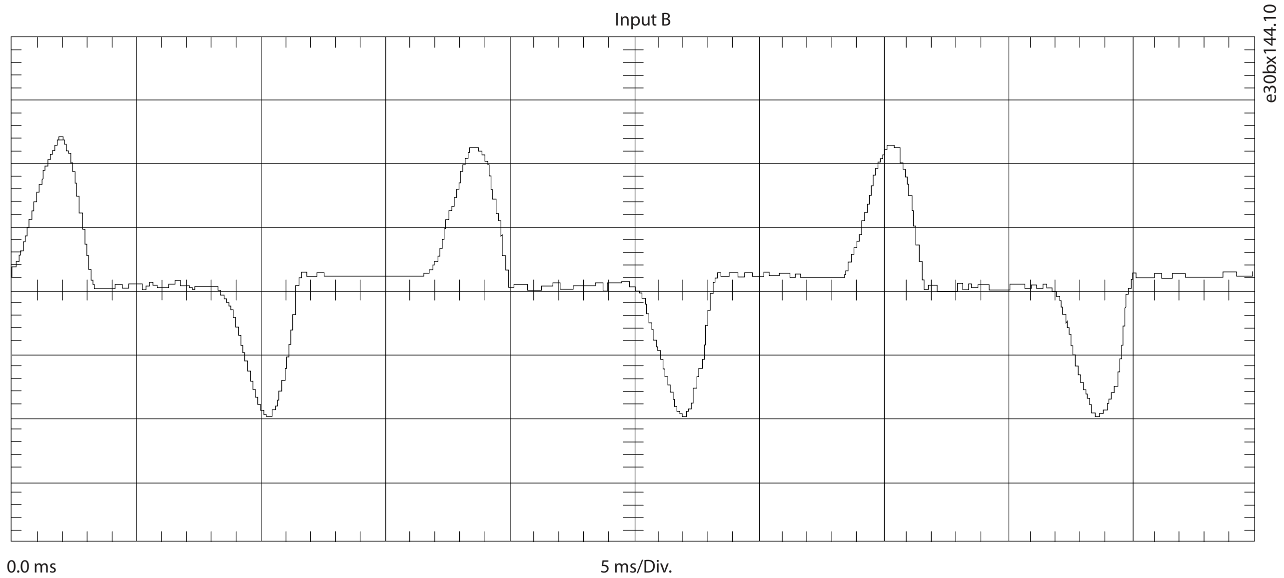


Illustration 63: Input Current Waveform with Phase Loss

Always verify the condition of the input voltage waveform before forming a conclusion. The current waveform follows the voltage waveform. If the voltage waveform is incorrect, investigate the reason for the AC supply problem. If the voltage waveform on all 3 phases is correct, but the current waveform is not, then check the input rectifier circuit. Perform the rectifier tests.

8.5.10 Input Waveform Test for Passive Harmonic Filter

The passive harmonic filter (PHF) is an option located in a separate cabinet of the enclosed drive. The PHF is an LC filter with 3 inductors inside the cabinet. The passive harmonic filter is used for reducing the current harmonics at the grid side. The PHF reduces major harmonics such as 5^{th}, 7^{th}, 11^{th}, and 13^{th} produced by 6-pulse drives.

The passive harmonic filters consist of a main inductor L_0 and a 2-stage absorption circuit with indicators L_1 and L_2 and capacitors C_1 and C_2. The absorption circuit is specially tuned to eliminate harmonics starting with the 5^{th} harmonic and is specific for the designed supply frequency. Therefore, the circuit rated for 50 Hz has different parameters than the circuit for 60 Hz.

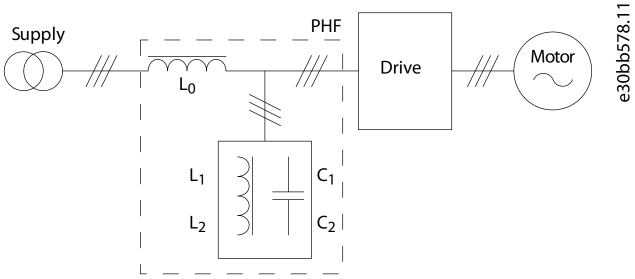


Illustration 64: Passive Harmonic Filter Circuit

PHFs are available in 2 variants for 2 performance levels:

- PHF 005 with 5% THDi (total harmonic current distortion).
- PHF 008 with 8% THDi.

The filter performance in terms of THDi varies as a function of the load. At nominal load, the performance of the filter is equal or less than 8% THDi for PHF 008 and 5% for PHF 005.

At partial load, the THDi has higher values. However, the absolute value of the harmonic current is lower at partial loads even if the THDi has a higher value. Therefore, the negative effect of the harmonics at partial loads is lower than at full load.

According to the PHF block diagram, the parallel capacitors are disconnected while the enclosed drive is powered up. When the drive reaches 15% of the load condition, the capacitors are connected to the system by the PHF contactor. This result is achieved by the *parameter 188 AHF Capacitor Connect*. With the passive harmonic filter, the *parameter 14-51 DC Link Compensation* of the drive always must be set to off.

Testing the current waveforms in different portions of the PHF helps in troubleshooting the PHF filter. The following measurements require an oscilloscope with voltage and current probe. The waveforms in illustration 65 show both the grid side (input current of the cabinet) and the drive side input current.

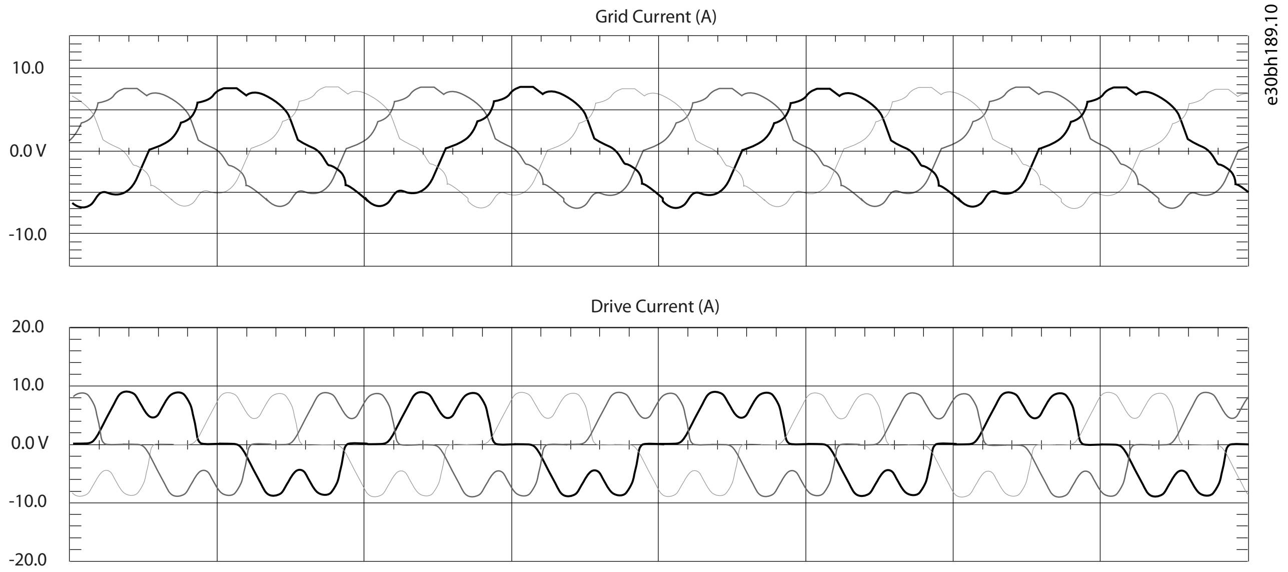


Illustration 65: PHF Grid Side and Drive Side Input Current Waveforms

If there is a phase loss, the waveform is distorted at the grid side current.

If the voltage waveform is incorrect, check for an AC supply problem. If the input voltage is correct but the current waveform is wrong, check the passive harmonic filter.

PHF capacitor disconnect function check

The power factor of the passive harmonic filter PHF 005/PHF 008 decreases with decreasing load. At no load, the power factor is 0 and the capacitors produce leading current of approximately 25% of the rated filter current. In applications where the reactive current is not acceptable, the terminal X3.1, X3.2, X3.3 and X4.1, X4.2, X4.2 provide access to the capacitor bank so it can be disconnected.

The passive harmonic filter in standby and under low load conditions (when the capacitors are connected) boosts the input voltage up to 5%. This means that the voltage at the drive terminals can be up to 5% higher than the voltage at the input of the filter. However, a capacitor disconnect is standard in the passive harmonic filter.

8.5.11 Input SCR Test 1 for Drive Modules

Context:

The SCRs can be disabled as a result of an input, or lack of input, at power card connector MK106, the external brake temperature switch. Unless used as an input, a jumper must be placed between terminals 104 and 106 of MK106. The following test is to measure the SCR gate resistance.

Procedure

1. Remove the power card mounting plate.
2. In D-sized units, unplug inrush board connector MK1802. In E-sized units, unplug inrush board connector MK109.
3. The plug has 3 pairs of wires, 1 for each SCR module. Measure the resistance of each pair. Red is the SCR gate and black is the SCR cathode.
   - → A correct reading is between 5–50 Ω.

     A higher reading or an open circuit indicates a failed SCR or a faulty connection.

8.5.12 Input SCR Test 2 for Drive Modules

Procedure

1. Check the connections of the gate cables to the SCR/diode modules.
2. If the connections are good, replace the failed SCR/diode module.
   → If the SCR checks are successful and there is still no DC bus voltage, replace the inrush board.

8.5.13 Output Imbalance of Motor Voltage and Current Test

Context:

Checking the balance of the drive output voltage and current is a way to measure the electrical functioning between the drive and the motor. In testing the phase-to-phase output, both voltage and current are monitored. Conduct static tests on the inverter section of the drive before performing this procedure.

If the voltage is balanced but the current is not, the motor can draw an uneven load. This condition can be the result of:

- A defective motor.
- A poor connection in the wiring between the drive and the motor.
- A defective motor overload, if applicable.
- Failure in sine-wave filter inductor or capacitor.
- Failure of dU/dt inductor or capacitor.

If the output current and the voltage are unbalanced, the drive is not gating the output properly. This condition can be the result of:

- A defective control card.
- A defective power card.
- A defective gatedrive card.
- Improper connections between the gatedrive card and IGBTs.
- Improper connections in the output circuitry of the drive.
- Defective sine-wave filter or dU/dt filter.

NOTICE

COMPATIBLE VOLTMETERS

Digital voltmeters are sensitive to waveform and switching frequencies and commonly return erroneous readings.

- Use a PWM-compatible digital or analog voltmeter for monitoring output voltage.

The initial test can be made with the motor connected and running its load. If suspect readings are recorded, disconnect the motor cables to isolate the problem further.

Procedure

1. Monitor 3 output phases at motor terminals 96 (U), 97 (V), and 98 (W) with the clamp on the ammeter. An analog device is preferred. To achieve an accurate reading, run the drive above 40 Hz, which is normally the frequency limitation of such meters.
   → The correct result is a balanced output current from phase to phase. A variation of more than 2–3% is an incorrect result. If the test is successful, the drive is operating normally.
2. Using a voltmeter, measure AC output voltage at motor terminals 96 (U), 97 (V), and 98 (W). Measure phase to phase in the following order:
   - **A** U to V
   - **B** U to W
   - **C** V to W

   → A variation of more than 8 V AC among the 3 readings in an incorrect result. The actual value of the voltage depends on the speed at which the drive is running. The volts/hertz ratio is relatively linear (except in VT mode) so at 50 Hz/60 Hz the voltage is approximately equal to the mains voltage applied. At 25 Hz/30 Hz, it is about half of that voltage.

   The exact voltage reading is less important than balance between phases. If a greater imbalance exists, disconnect the motor cables and repeat the voltage balance test.

   Since the current follows the voltage, it is necessary to differentiate between a load problem and a drive problem. If a voltage imbalance in the output occurs with the motor disconnected, test the gate drive circuit for proper firing.

   If the voltage was balanced but the current imbalanced when the motor was connected, then the load is suspect. There could be a faulty connection between the drive and motor or a defect in the motor itself. Look for bad connections at any junctions of the output wires including connections made to contactors and overloads. Also, check for burned or open contacts in such devices.

8.5.14 IGBT Switching Test for Drive Modules

Context:

⚠ WARNING ⚠

DISCHARGE TIME

The drive contains DC-link capacitors and, when input filter options are present, it contains extra capacitors and inductors. These components can remain charged even when the drive is not powered. High voltage can be present even when the warning indicator lights are off.

Failure to wait the specified time after power has been removed before performing service or repair work could result in death or serious injury.

- Stop the motor.
- Disconnect AC mains, permanent magnet type motors, and remote DC-link supplies, including battery back-ups, UPS, and DC-link connections to other drives.
- Wait for the capacitors to discharge fully. The minimum waiting time is specified both in the Discharge Time table and on the nameplate on top of the drive.
- Before performing any service or repair work, use an appropriate voltage measuring device to make sure that the capacitors are fully discharged.

Table 81: Discharge Time

Drive model	Minimum waiting time
D9h/D10h	20 minutes

Drive model	Minimum waiting time
E5h/E6h	40 minutes

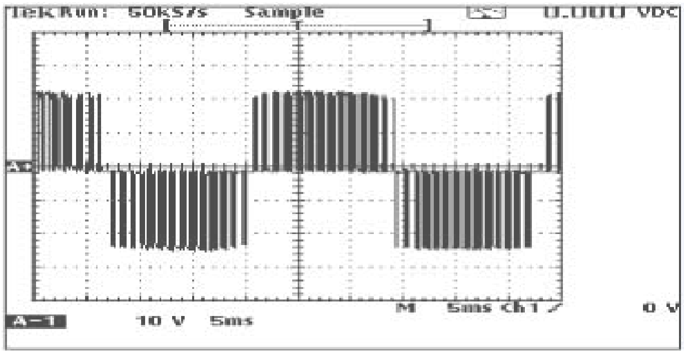
To determine whether the IGBTs are switching correctly, use the following procedure.

Procedure

1. Connect the split bus supply.
2. Switch on the 650-V DC supply and 24-V DC supply.
3. Apply a run command and speed command of approximately 40 Hz.
4. Measure the phase-to-phase output waveform on all 3 output phases of the drive using an oscilloscope (preferred) or a voltmeter.

→ When measuring with an oscilloscope, the waveform appears the same as in normal operation, except that the amplitude is 24-V peak. See illustration 66.

When measuring with a voltmeter set to read AC voltage, the meter reads approximately 17 V AC on all 3 phases. Differences in drive settings can cause a slight variation in this reading, but it is important that the readings are equal on all 3 phases.



e30bx504.10

Illustration 66: Output Wave Form

An incorrect reading indicates either a defective IGBT or gate drive signal. To determine if the gate drive signal is correct, perform the gate drive signal test.

8.5.15 IGBT Gate Drive Signals Test for Drive Modules

Context:

NOTICE

DRIVE TYPE

This test is applicable to only D-sized drives. E-sized drives do not have test connectors on the gate drive card.

NOTICE

POTENTIAL PIN DAMAGE

The drive can be damaged if the probe is inadvertently connected to the wrong pins.

- Disable the DC bus when performing this test with split bus supply.

This procedure tests the gate drive signals at the output of the gate drive card just before they are delivered to the IGBTs. A simple test to check for the presence of the gate signals can be performed with a voltmeter. To check the waveforms more precisely, however, an oscilloscope is required.

Procedure

1. Before beginning the tests, ensure that power is removed from the unit and that the DC bus capacitors have fully discharged.
2. Remove the AC busbars or RFI filter (option).
3. Connect the split bus supply.
   → In D-sized drives, there is a 3-pin test connector on the gate drive card near each gate signal lead. These leads are labeled:
   - MK500
   - MK502
   - MK600
   - MK602
   - MK700
   - MK702
   - MK200 (if equipped with a brake option)

   Refer to the 3 pins as 1, 2, and 3, reading bottom to top. Pins 1 and 2 of each connector are in parallel with the gate drive signal sent to the IGBTs. Pin 1 is the signal and pin 2 is common.
4. Turn on the split bus supply (only 650 V).
5. In stop mode, measure pins 1 and 2 of each test connector.
6. Apply the run command to the drive and 30-Hz reference.
7. If using a voltmeter, measure pins 1 and 2 of each connector.
   → Waveform to IGBTs is a square wave that goes positive to 14 V DC and negative to -9 V DC. Average voltage read by the voltmeter is 2.2–2.5 V DC.

   When using an oscilloscope, the readings in illustration 67 are correct.

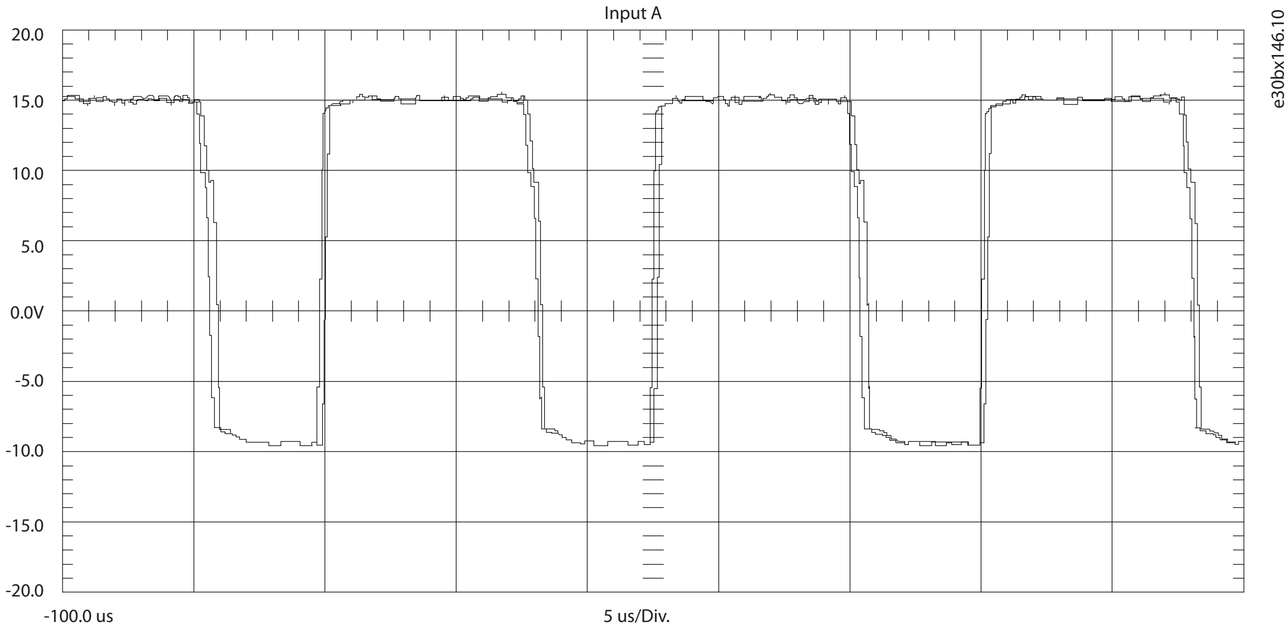


Illustration 67: Gate Signal Waveform from Gate Drive Card

IGBT gate signal measured on the gatedrive card: 5 V per division vertical scale, 50 ms per division time scale. Unit running at 30 Hz.

An incorrect reading of a gate signal indicates that the gatedrive card is defective or the signal has been lost before arriving at the gate card. The gate signals can then be checked with the signal test board to verify their presence from the control card to the power card as follows.

8. Insert the signal test board into power card connector MK104.
9. With scope probe common connected to terminal 4 (common) of the signal board, measure 6 gate signals at signal board terminals 25–30.
10. Place the drive in run mode at 30 Hz.
    → The waveform in illustration 68 is the correct result.

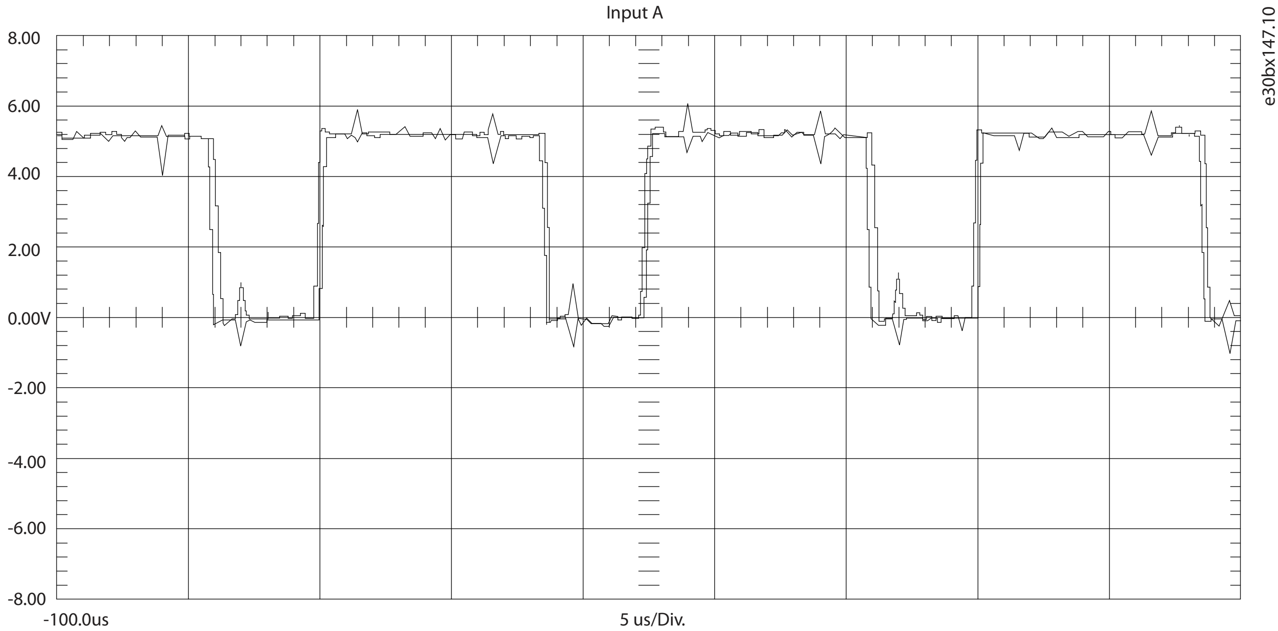


Illustration 68: Gate Signal Waveform from Signal Test Board

IGBT gate signal measured with the signal test board: 2 V per division vertical scale, 50 ms per division time scale. Unit running at 30 Hz.

11. Using a voltmeter, again check these same signal board terminals.
    → A correct reading is 2.2–2.5 V DC.

    An incorrect reading of a gate signal indicates that the control card is defective. Replace the control card. If the signal is good on the signal test card, but missing on the gatedrive card, the failure can be due to:
    - The gate drive card.
    - The power card.
    - The ribbon cable between them.

    Replace the gate drive board and repeat the test.

8.5.16 Current Sensor Test 1 for Drive Modules

Context:

The current sensors are Hall effect devices that send a signal proportional to the actual output current waveform to the power card. The current scaling card scales the signals from the current sensors to the proper level for monitoring and processing motor control data. A defective current sensor can cause erroneous ground faults and overcurrent trips. In these instances, the faults occur only at higher loads. If the incorrect current scaling card is installed, the current signals are not scaled properly. Incorrect scaling could cause erroneous overcurrent trips. If the current scaling card is not installed, the drive trips.

In D-sized drives and E-sized drives, the current scaling card is found on the power card.

To determine the status of the sensors, perform Current Sensor Tests 1–3.

If the control card parameters are set to provide holding torque at 0 speed, the current shown is greater than expected. To perform the sensor tests, disable these parameters.

Procedure

1. Apply power to the drive.
2. Ensure that the following parameter settings are disabled:
   - **A** Motor check.
   - **B** Premagnetizing.
   - **C** DC hold.
   - **D** DC brake.
   - **E** Any others that create a holding torque while at 0 speed.
3. Run the drive with a 0 speed reference and check the output current reading in the display.
   - → A correct reading is approximately 1–2 A. If these parameters are not disabled, the current shown exceeds 1–2 A. If the current is greater than 1–2 A and no current producing parameters are active, perform the next test. See 8.5.17 Current Sensor Test 2 for Drive Modules.

8.5.17 Current Sensor Test 2 for Drive Modules

Procedure

1. Remove power from the drive.
2. Remove the output motor cables from terminals U, V, and W.
3. Apply power to the drive.
4. Run the drive with a 0 speed reference, and check the output current reading in the display.
   - → A correct reading is less than 1 A.

     If these steps result in incorrect readings, perform a test of the current feedback signals using the signal test board. See 8.5.18 Current Sensor Test 3 for Drive Modules.

8.5.18 Current Sensor Test 3 for Drive Modules

Context:

Procedure

1. Remove power to the drive. Make sure that the DC bus is fully discharged.
2. Connect the signal test board to power card connector MK104.
3. Using an ohmmeter, measure the resistance between terminals 1 and 4, 2 and 4, and 3 and 4 of the signal test board.
   → The correct resistance is an identical reading on all 3 terminals.
4. Reapply power to the drive.
5. Using a voltmeter, connect the negative (-) meter lead to terminal 4 (common) of the signal test board.
6. Run the drive with a 0 speed reference.
7. Measure the AC voltage in sequence at terminals 1, 2, and 3 of the signal test board. These terminals correspond with current sensor outputs U, V, and W, respectively.
   → A correct reading is near 0 V, and no greater than 15 mV.

   The current sensor feedback signal in the circuit reads approximately 400 mV at a drive load of 100%. When the drive is at 0 speed, any reading above 15 mV negatively impacts the way the drive interprets the feedback signal.

   Replace the corresponding current sensor if the reading is greater than 15 mV.

   The following tables list approximate resistance readings for drive modules based on power and voltage rating, and the current scaling card. When measuring with the signal test board, the reading could be higher due to meter lead resistance. A reading of no resistance indicates a missing scaling card.

Table 82: Scaling Resistance, D-sized Modules, 380–500 V

Scaling resistance measured in Ω	FC 102, FC 103, and FC 202	FC 302
4.6	N110	N90k
3.8	N132	N110
3.1	N160	N132
2.6	N200	N160
5.1	N250	N200
4.2	N315	N250

Table 83: Scaling Resistance, D-sized Modules, 525–690 V

Scaling resistance measured in Ω	FC 102, FC 103, and FC 202	FC 302
5.9	N75k	N55k
5.9	N90k	N75k
5.9	N110	N90k
5.9	N132	N110
5.0	N160	N132
4.0	N200	N160

Scaling resistance measured in Ω	FC 102, FC 103, and FC 202	FC 302
3.2	N250	N200
2.7	N315	N250
5.6	N400	N315

Table 84: Scaling Resistance, E-sized Modules, 380–500 V

Scaling resistance measured in Ω	FC 102, FC 103, and FC 202	FC 302
2.7	N355	N315
2.5	N400	N355
2.3	N450	N400
2.0	N500	N450
1.8	N560	N500

Table 85: Scaling Resistance, E-sized Modules, 525–690 V

Scaling resistance measured in Ω	FC 102, FC 103, and FC 202	FC 302
4.0	N450	N355
3.8	N500	N400
3.1	N560	N500
2.7	N630	N560
2.5	N710	N630
2.1	N800	N710

8.5.19 Fan Tests for Drive Modules

Context:

All fan tests can be performed with the unit powered from the AC mains or with the power card powered in split bus mode. Any time a fan is commanded to start, the control card checks the fan feedback signal. If the feedback is missing, the drive issues an alarm or warning based on which fan feedback is missing.

In E-sized drives, there are parameters that show the speed feedback for each fan. Fan speed differences of less than 200 RPM are meaningless.

- *Parameter 43-13 PC Fan A Speed* for input plate mixing fan.
- *Parameter 43-14 PC Fan B Speed* for left input plate mixing fan or power card mixing fan.
- *Parameter 43-20 FPC Fan A Speed* for left heat sink fan.
- *Parameter 43-21 FPC Fan B Speed* for the middle heat sink fan.
- *Parameter 43-22 FPC Fan C Speed* for the right heat sink fan.
- *Parameter 43-24 FPC Fan E Speed* for LCP side door fan.
- *Parameter 43-25 FPC Fan F Speed* for lock side door fan.

NOTICE

POWER REQUIREMENTS

Fan load in E-sized drives is >700 W.

- The split bus supply must have sufficient power when testing E-sized drives.

In D-sized drives, the mixing fan operates any time the drive is powered up. If the drive is powered and the mixing fan is not running, replace the mixing fan. In E-sized drives, the operation of the mixing fan is controlled and only runs when commanded.

Parameter 14-52 Fan Control can be used to command the heat sink fans and door/top fans to run at 100% speed.

Procedure

1. Use *parameter 14-52 Fan Control* to command the fans to run at 100% speed.
2. Confirm that the heat sink fan is running by checking for airflow through the back channel of the drive.
3. Confirm that the top fan is running by checking for airflow around the fan.
   → The 2 fans accelerate at different rates and can take several seconds, but both operate at 100% speed.

   If neither fan is running, the most likely cause is that the fan control circuit on the power card (or fan power card in E-sized drives) is faulty. Replace the power card or fan power card. If only 1 fan is running, the most likely cause is that the other fan is faulty. Replace the failed fan.

8.5.20 Fan Tests for Enclosed Drives

Context:

Enclosed drive systems have both DC and AC powered fans.

The AC fans are 230 V/115 V AC powered and are located in the doors of the cabinets. The power input to the fans is either through the auxiliary transformer or by external customer input, depending on the options present. The fans are turned on by switching the miniature circuit breaker in the control compartment.

The AC fans start running when they receive 230 V/115 V supply. If the fans are not running, check the supply input and the wire harnesses for damage. Refer to the block diagram.

DC fans are 48-V DC rated fans. They are found in the back channel of the optional filters (sine-wave filter, passive harmonic filter, and dU/dt filter cabinets). The DC fans are powered by a fan power card that is located in the filter cabinets. The fan power card receives DC-link voltage as input. The DC fans start running when the drive is powered up and DC link is built.

Procedure

1. Verify whether the door fans are running by looking for airflow through the cabinet doors.
2. Verify whether the DC fans are running by checking for airflow through the back channel of the optional filters.
   → If the fans are not running, the most likely causes are disconnected or damaged wire harnesses, or a failed fan power card.

   If the AC fan is not running, check that the external supply and the auxiliary transformer are working. If these both are operating, the cause is typically fan failure. Replace the fan.

8.5.21 Input Voltage Signal Test for Enclosed Drives

Context:

In the enclosed drives, the input terminals are extended to the control compartment. To find the corresponding terminal number in the enclosed drive, refer to the control compartment section or the block diagram.

The presence of signals on either the digital or analog input terminals of the drive can be verified on the drive display. *Parameter 16-60 Digital Input – parameter 16-64 Analog Input 54* show the status for the standard inputs. Other parameters show the status of option inputs.

8.5.21.1 Digital Inputs

Context:

View the digital inputs by using *parameter 16-60 Digital Input*. The status of control terminals 18, 19, 27, 29, 32, and 33 are shown (left to right) with terminal 33 on the right of the display. A 1 indicates the presence of a signal, which means the logic is true and the input is on.

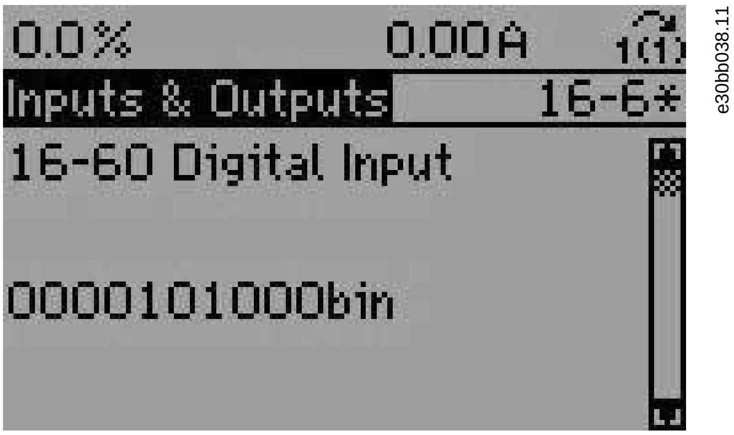


Illustration 69: Digital Inputs Display

If the display does not show the correct signal, investigate the following:

- External control wiring to the drive.
- Incorrect programming of *parameter 5-00 Digital I/O Mode*.
- Faulty control card.

Use *parameter 5-00 Digital I/O Mode* to program the digital inputs to either accept a sourcing output (PNP) or a sinking output (NPN). When programmed for PNP (factory default), the digital input turns on when 24 V DC is applied to the digital input terminal. When programmed for NPN, the digital input turns on when the terminal is connected to signal common (terminal 20).

The power for the digital inputs can either come from the (+) 24 V DC built into the drive, or from an external supply. If an external supply is used, reference the common of the supply to terminal 20.

Procedure

1. To check for an internal power supply, connect the (-) negative meter lead to terminal 20.
2. Connect the (+) positive meter lead to terminal 12 or terminal 13 and measure the DC voltage.
   → A correct reading is 21–27 V DC. If the supply voltage is not present, perform the basic control card voltage test.
3. If *parameter 5-00 Digital I/O Mode* is PNP, check the individual inputs. Connect the (-) negative meter lead to terminal 20.
4. Connect the (+) positive meter lead to each digital input in sequence and measure the DC voltage.
   → The correct display for each digital input where the voltage reading is greater than 10 V DC is 1. The correct display for each digital input where the voltage reading is less than 5 V DC is 0. If the display does not correspond with the measured inputs, the digital inputs on the control card have failed. Replace the control card.
5. If *parameter 5-00 Digital I/O Mode* is NPN, check the individual inputs. Connect the (-) negative meter lead to terminal 20.
6. Connect the (+) positive meter lead to each digital input in sequence and measure the DC voltage.
   → The correct display is 1 for each digital input where the voltage reading is less than 14 V DC. The correct display is 0 for each digital input where the voltage reading is greater than 19 V DC. If the display does not correspond with the measured inputs, the digital inputs on the control card have failed. Replace the control card.
7. If *parameter 5-00 Digital I/O Mode* is NPN 1, check the individual inputs. Connect the (-) negative meter lead to terminal 20. 2.
8. Connect the (+) positive meter lead to each digital input in sequence and measure the DC voltage.
   → The correct display for each digital input where the voltage reading is less than 14 V DC is 1. The correct display for each digital input where the voltage reading is greater than 19 V DC is 0. If the display does not correspond with the measured inputs, the digital inputs on the control card have failed. Replace the control card.

8.5.21.2 Analog Inputs

Context:

Terminals 53 and 54 are the standard analog input terminals. Each terminal can be configured as a voltage input or a current input. Switch S201 on the control card configures terminal 53. Switch S202 configures terminal 54.

Use *parameter 16-62 Analog Input 53* to show the value on terminal 53 and *parameter 16-64 Analog Input 54* to show the value on terminal 54.

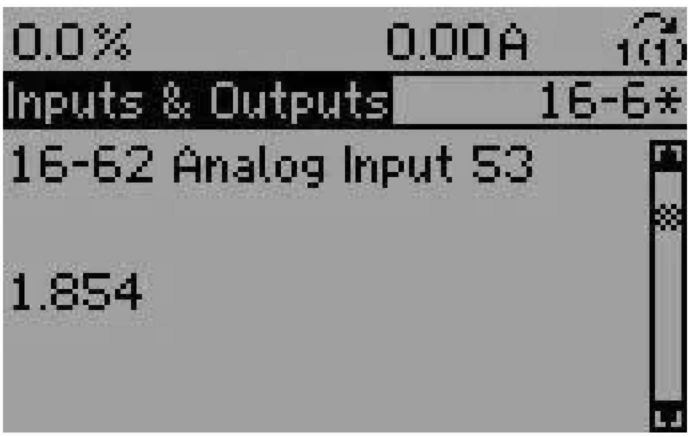


Illustration 70: Analog Inputs Display

Incorrect signals indicate problems in the external control wiring to the drive, configuration of the switches, or a faulty control card.

The power for the analog inputs either comes from the supply built into the drive, or from an external supply. If an external supply is used, reference the common of the supply to terminal 55.

Procedure

1. To verify the control voltage supply, connect the (-) negative meter lead to terminal 55.
2. Connect the (+) positive meter lead to terminal 50.
   → The correct reading is 9.2–11.2 V DC. If the supply voltage is not present, perform the basic control card voltage test.

   Verify that the analog input is configured for the type of signal being sent to the drive. *Parameter 16-61 Terminal 53 Switch Setting* shows the configuration of terminal 53, and *parameter 16-63 Terminal 54 Switch Setting* shows the configuration of terminal 54. If the inputs are not configured correctly, power down the drive and change switches S201 and S202.
3. Check the individual inputs if configured for voltage. Connect the (-) negative meter lead to terminal 55.
4. Connect the (+) positive meter lead to terminal 53 or terminal 54 and measure the DC voltage.
   → For each analog input, the measured DC voltage must match the value shown in the display parameter. If the display does not correspond with the measured input and the switch is configured for voltage, the analog input on the control card has failed. Replace the control card.
5. Check the individual inputs if configured for current. Connect the (-) negative meter lead to terminal 55.
6. Connect the (+) positive meter lead to terminal 53 or terminal 54 and measure the DC voltage.
   → When configured for current, the current flows through a 200 Ω resistor to create a voltage drop. A 4 mA current flow creates approximately a 0.8 V DC voltage reading. A 20 mA current flow creates approximately a 4.0 V DC voltage reading. The display shows the mA value. If the display does not correspond with the measured input, the analog input on the control card has failed. Replace the control card.

   A negative voltage reading indicates a reversed polarity. Reverse the wiring to the analog input.

8.6 After-repair Test

Context:

Following testing or repair of a drive, use these steps to ensure that all circuitry is functioning properly before putting the drive into operation.

Procedure

1. Perform visual inspection procedures as described in the Visual Inspection section.
2. To ensure that the drive is safe to start, perform the static test procedures.
3. Disconnect motor cables from output terminals (U, V, W).
4. Apply AC power to the unit.
5. Give the drive a run command and slowly increase reference (speed command) to approximately 40 Hz.
6. Using an analog voltmeter, or a digital voltmeter capable of measuring true RMS, measure phase-to-phase output voltage on all 3 phases: U to V, U to W, V to W. All voltages must be balanced within 8 V. If unbalanced voltage is measured, refer to 8.5.3 Input Voltage Test for Drive Modules.
7. Stop the unit and remove input power. Allow DC capacitors to discharge fully.
8. Reconnect motor cables to the output terminals (U, V, W).
9. Reapply power and restart the unit. Adjust the motor speed to a nominal level.
10. Using a clamp-on style ammeter, measure output current on each output phase. All currents must be balanced.

9 Disassembly and Assembly

9.1 Control Compartment

9.1.1 Local Control Panel

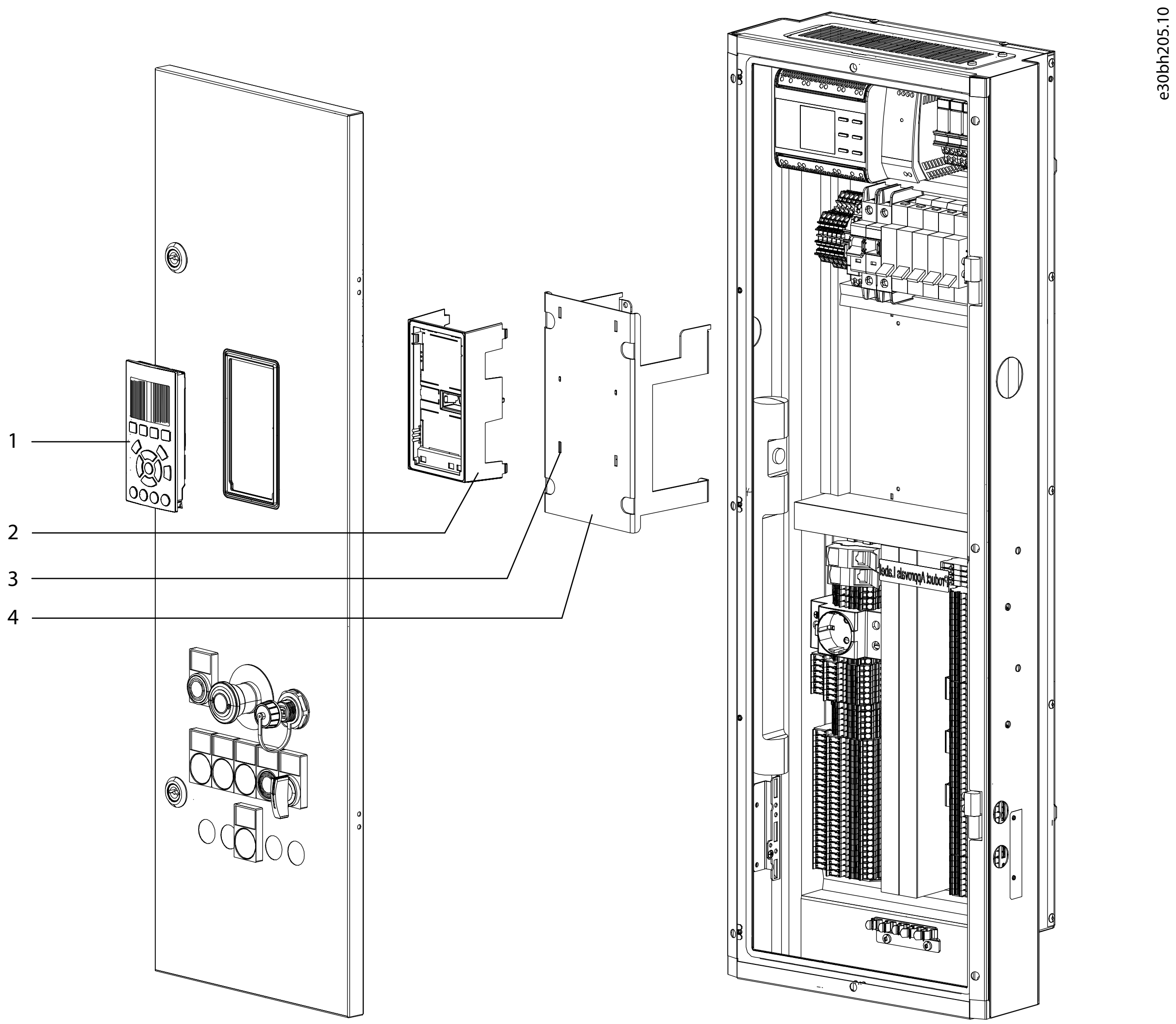
Context:

To remove the local control panel (LCP) and mounting bracket from the control compartment, use the following steps.

Procedure

1. Remove the LCP from the control compartment door.
2. Open the control compartment door.
3. Pull the LCP cradle free from the slots in the mounting bracket. (No tools are required.).
4. To remove the LCP mounting bracket, remove 4 screws (T20) 1 from each leg of the mounting bracket.
5. Reinstall in reverse order of this procedure.

Example:



1 LCP	**2** LCP cradle
3 LCP mounting bracket	**4** Mounting hole

Illustration 71: LCP and Bracket Removal

9.1.2 Insulation Monitor

Context:

To remove the insulation monitor from the control compartment, use the following steps.

Procedure

1. Open the control compartment door.
2. Disconnect all wires from the insulation monitor terminals.

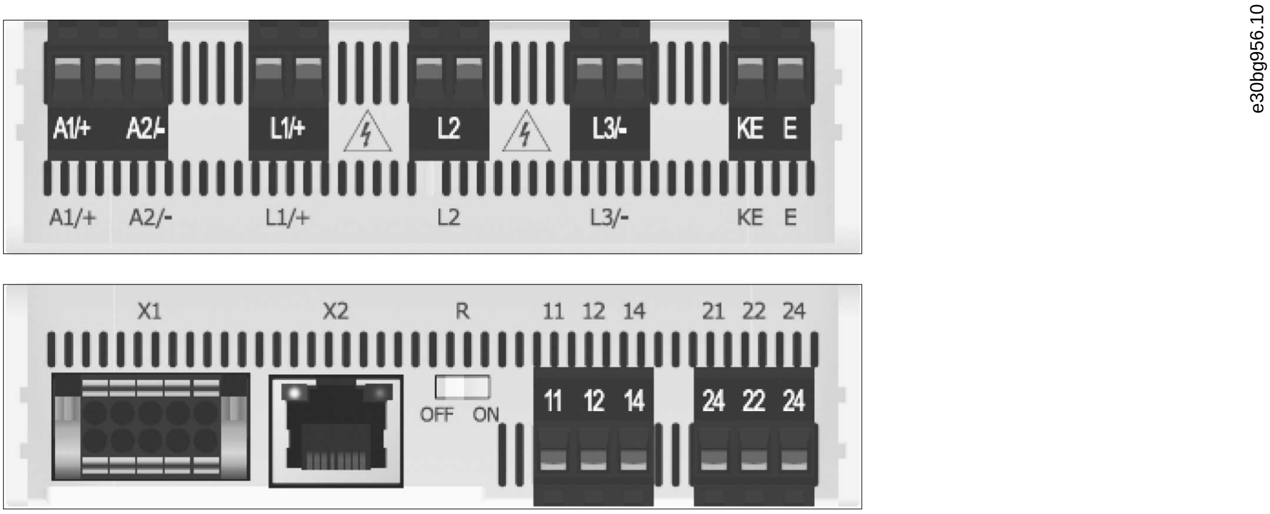


Illustration 72: Insulation Monitor Terminals

3. To release the insulation monitor from the DIN rail, pull down the 3 mounting clips on the lower edge of the insulation monitor.
4. Replace in reverse order of this procedure.

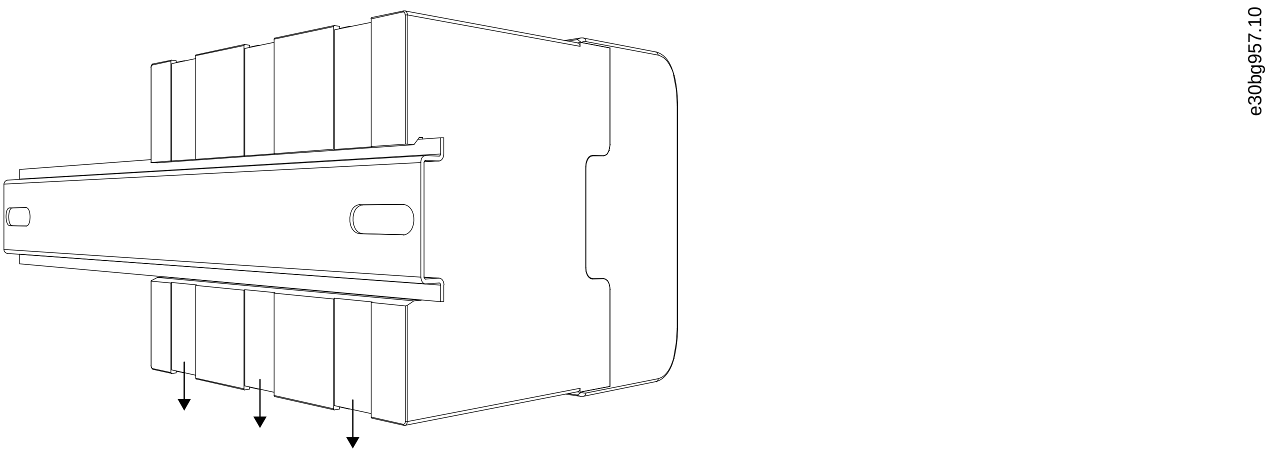


Illustration 73: Insulation Monitor Removal

9.1.3 24-V DC Supply

Context:

To remove the 24-V DC supply from the control compartment, use the following steps.

Procedure

1. Open the control compartment door.
2. Disconnect all wiring from the 24-V DC supply.
3. To release the 24-V DC supply from the DIN rail, pull down the mounting clip on the back of the supply.
4. Replace in reverse order of this procedure.

Example:

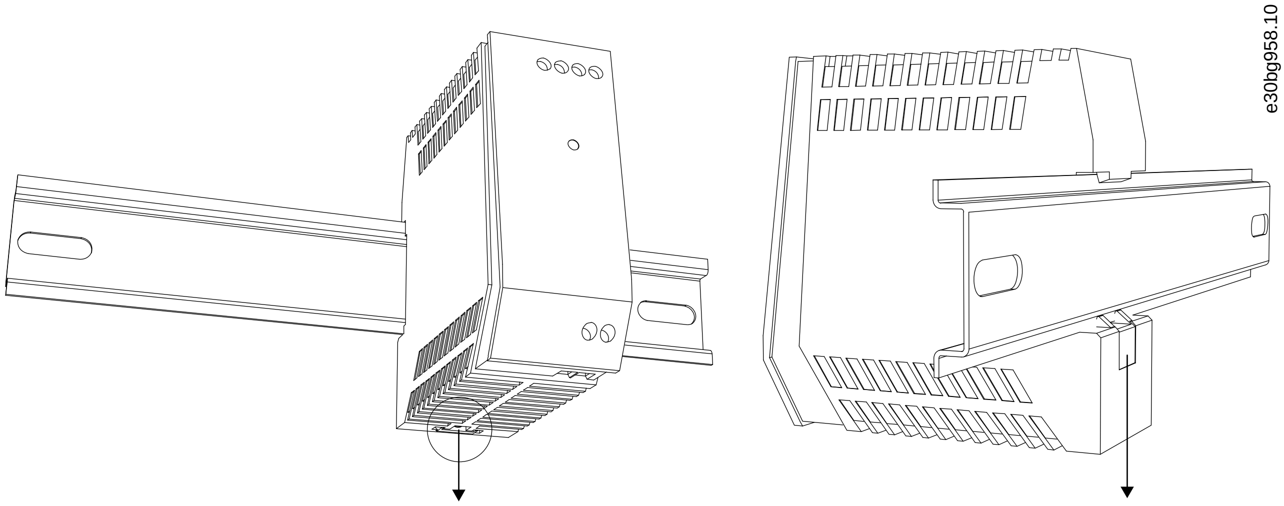


Illustration 74: 24-V DC Supply Removal

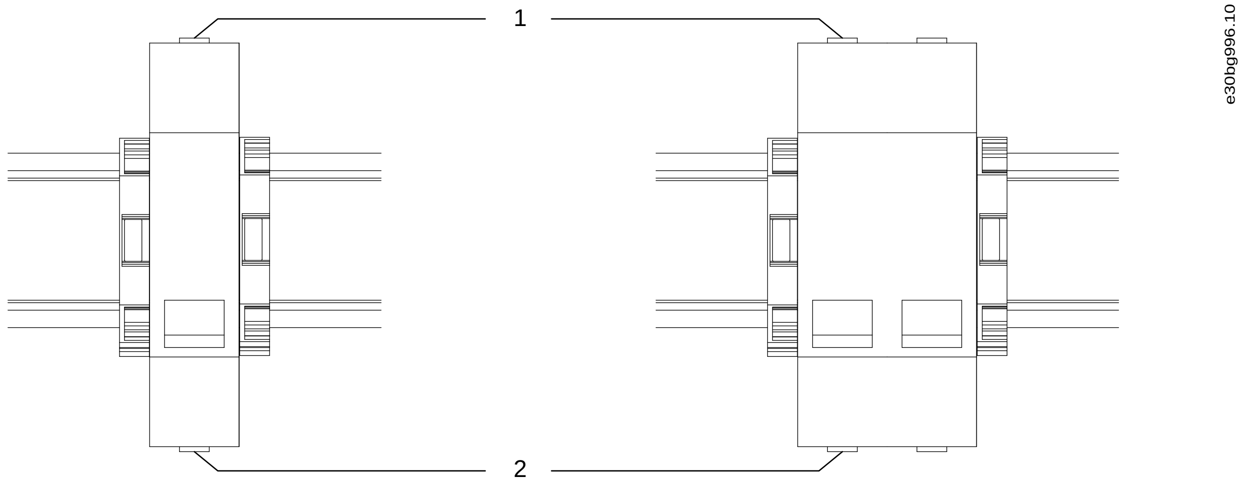
9.1.4 Miniature Circuit Breakers

Context:

To remove the miniature circuit breakers from the control compartment, use the following steps.

Procedure

1. Open the control compartment door.
2. Disconnect all wiring from the miniature circuit breaker terminals.
3. Release the miniature circuit breakers from the DIN rail.



1	Upper terminals	**2**	Lower terminals

Illustration 75: Miniature Circuit Breaker Wiring

4. Reinstall in reverse order of this procedure.

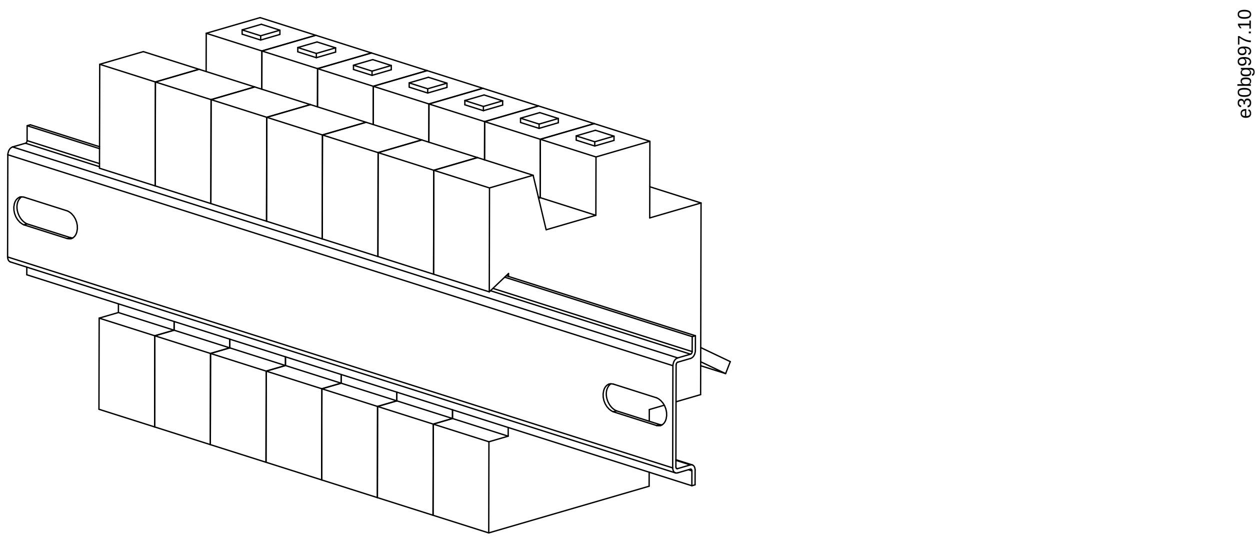


Illustration 76: Miniature Circuit Breaker Removal

9.1.5 Customer Socket

Context:

To remove the customer electrical socket from the control compartment, use the following steps.

Procedure

1. Open the control compartment door.
2. Disconnect all wires from the customer electrical socket terminals N, L, and PE. Use a Pz2 bit and torque 2 Nm.

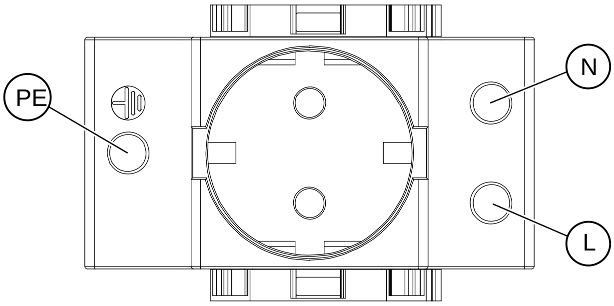


Illustration 77: Customer Socket Terminals

3. Release the customer electrical socket from the DIN rail.
4. Reinstall in reverse order of this procedure.

Example:

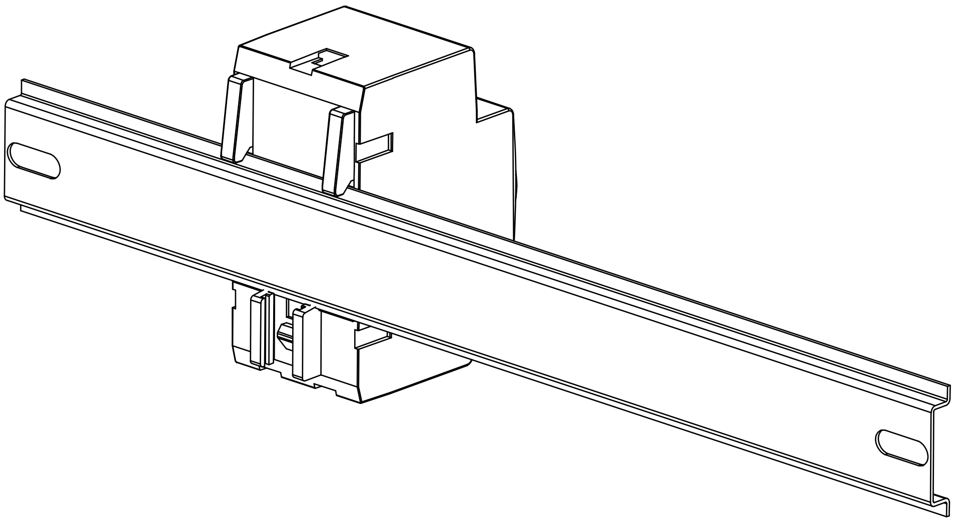


Illustration 78: Customer Socket Removal

9.1.6 Auxiliary Relay

Context:

To remove the auxiliary relay from the control compartment, use the following steps. See illustration 79 and illustration 80.

Procedure

1. Open the control compartment door.
2. Disconnect all wiring from the auxiliary relay terminals.

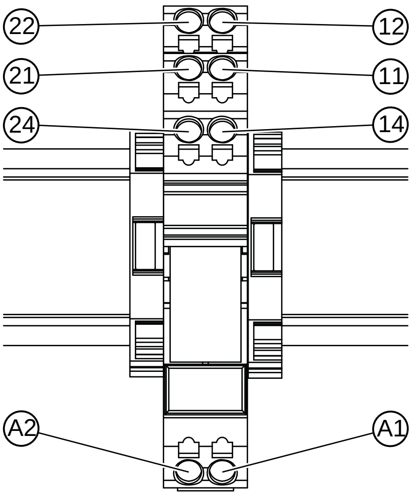


Illustration 79: Auxiliary Relay Terminals

3. Rotate the auxiliary relay, releasing it from the DIN rail.
4. Reinstall in reverse order of this procedure.

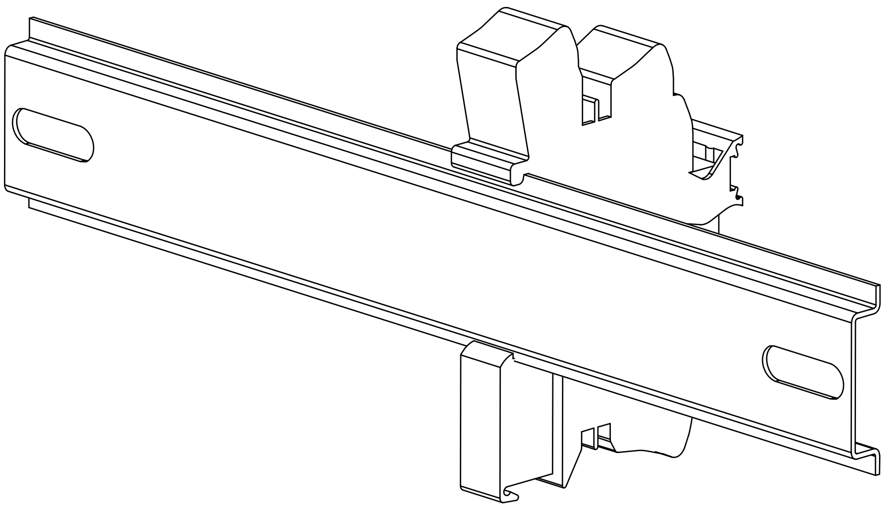


Illustration 80: Auxiliary Relay Removal

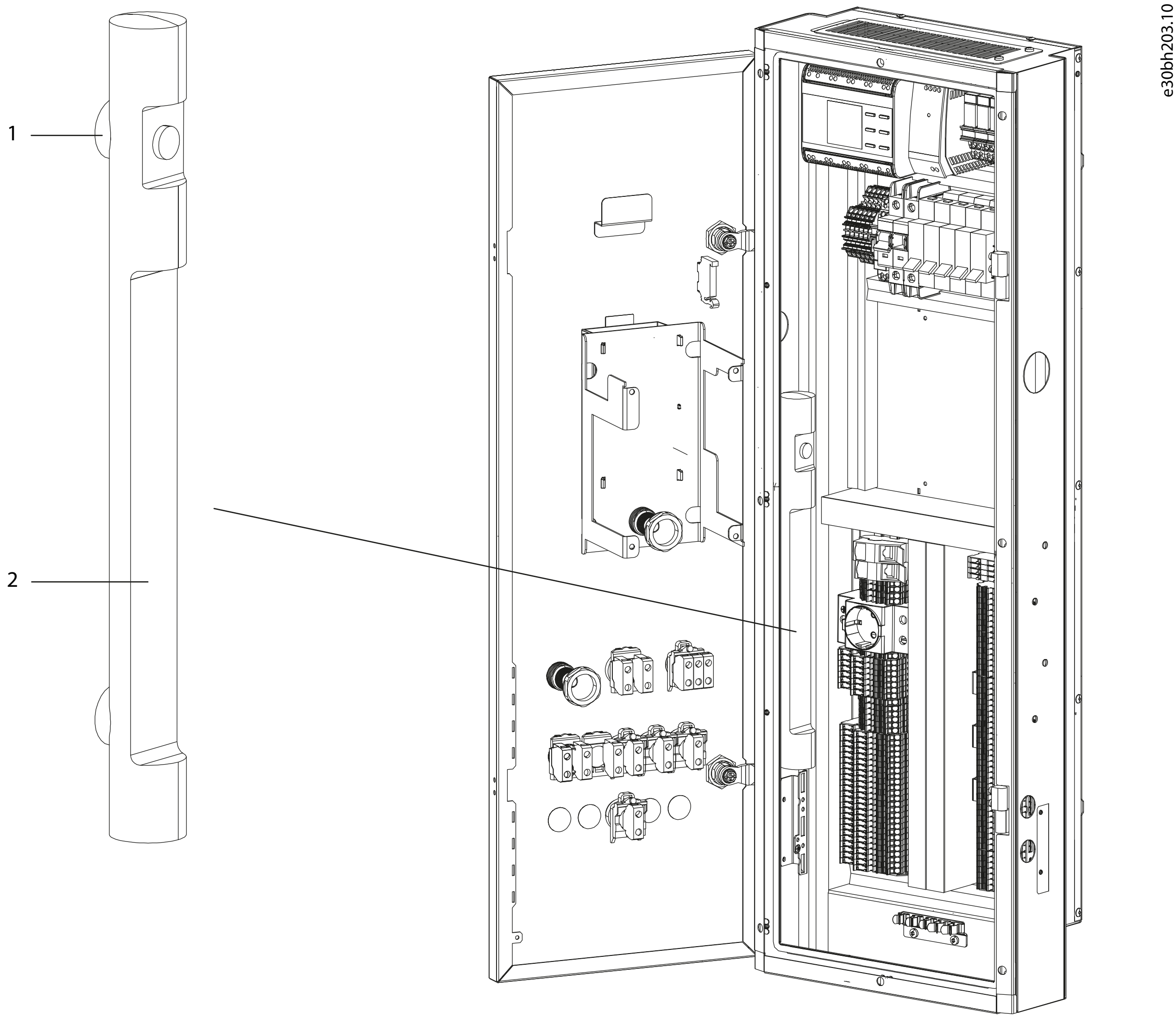
9.1.7 Cabinet Light

Context:

The optional cabinet light is mounted inside the control compartment on magnets. The magnets allow the light to be easily repositioned for service procedures.

Procedure

1. Open the control compartment door.
2. Locate the optional cabinet light at the left edge of the control compartment, and pull it outward to free it from the cabinet.
3. Use the mounting magnets on the back of the light to reposition it during use, and to remount it in the control compartment after use.



1 Mounting magnet	**2** Cabinet light

Illustration 81: Cabinet Light Location

9.2 Safety Shields

Context:

The cabinets of D9h–D10h/E5h–E6h enclosed drives include safety shields to protect against inadvertent touching of interior components. Use the following steps to remove safety shields for servicing.

Procedure

1. Open the cabinet door.
2. Partially loosen 4 screws (T25) along the edges of the shield.
3. Lift the shield free of the loosened fasteners.
4. Replace in reverse order or this procedure.

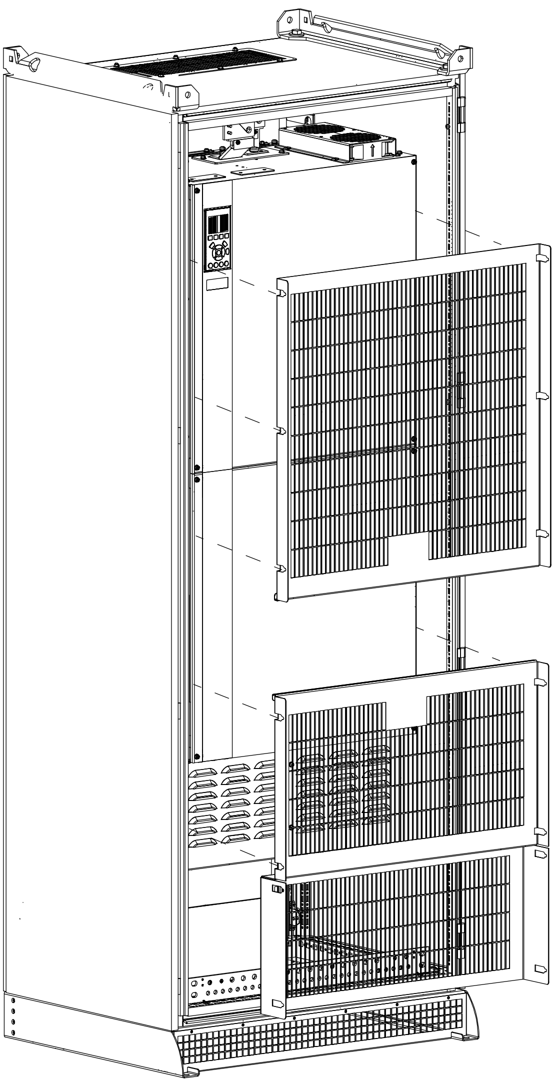


Illustration 82: Safety Shield Removal

9.3 Auxillary Equipment

9.3.1 Cabinet Heater

Context:

To remove the cabinet heater from the enclosure, use the following steps.

Procedure

1. Open the enclosure.
2. Remove the lower safety shield.
3. Disconnect all wires from the cabinet heater.

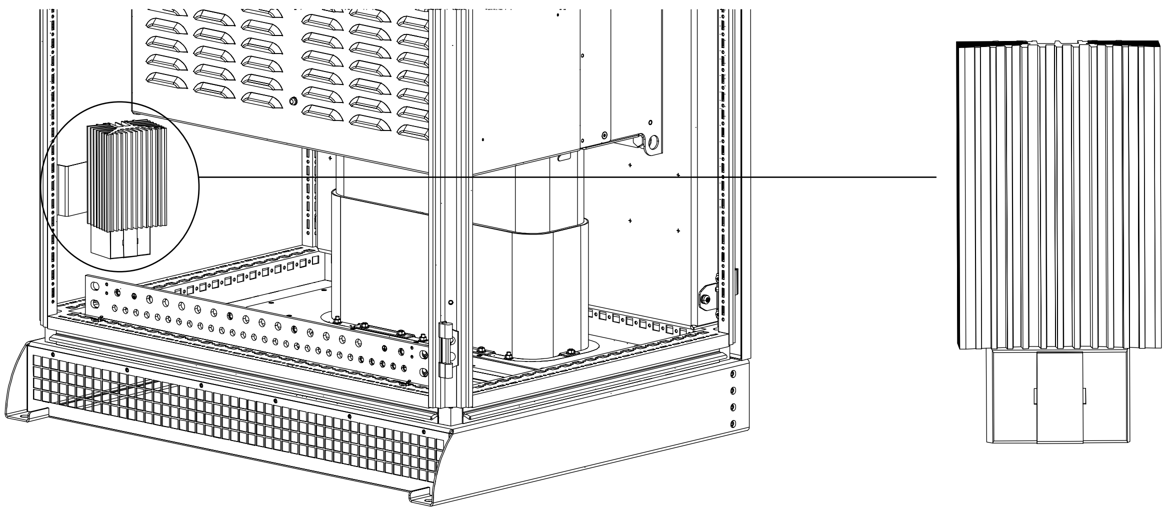


Illustration 83: Cabinet Heater Location

4. Release the cabinet heater from the DIN rail.

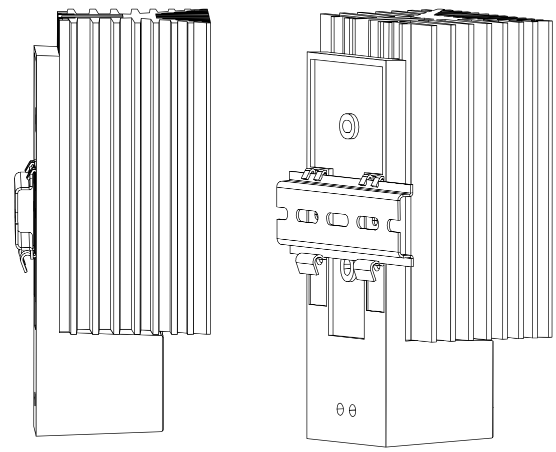


Illustration 84: Cabinet Heater on DIN Rail

5. Reinstall in reverse order of this procedure.

9.3.2 Voltage Transformer

Context:

To remove the voltage transformer, use the following steps.

Procedure

1. Open the cabinet.
2. Remove the safety shield.
3. Release all wires from the transformer terminals.

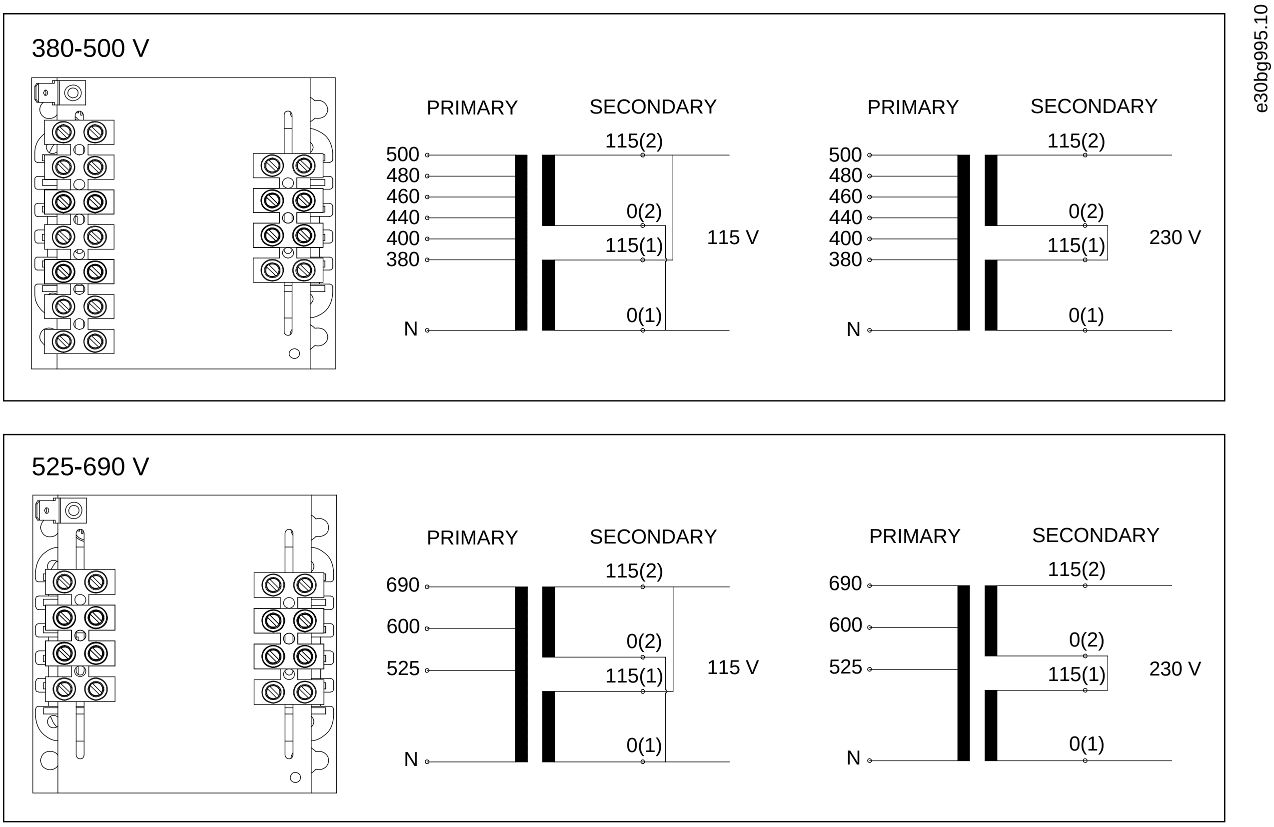
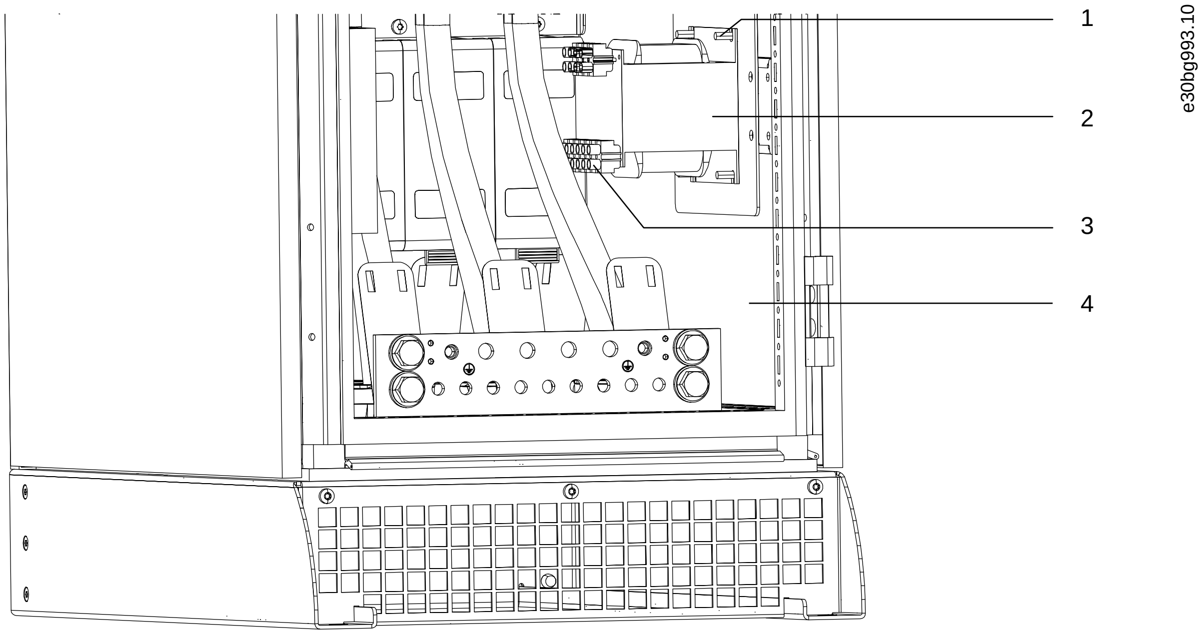


Illustration 85: Voltage Transformer Wiring

4. Remove the voltage transformer by removing 4 screws (T25), 1 from each corner of the voltage transformer.
5. Reinstall in reverse order of this procedure.

Example:



1 Screw (T25)	**2** Voltage transformer
3 Voltage transformer terminals	**4** Enclosure

Illustration 86: Voltage Transformer Removal

9.4 Drive Module

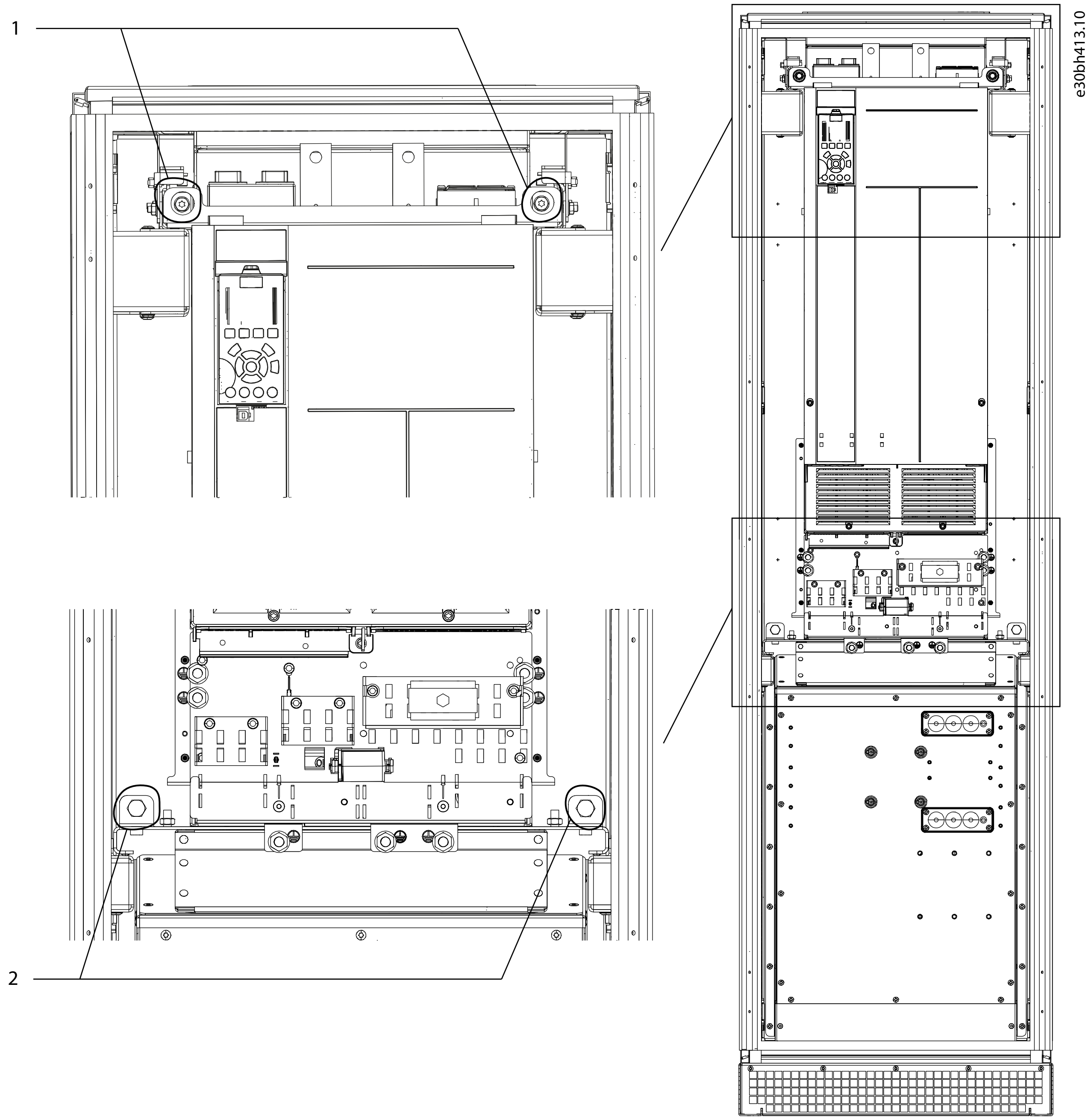
Context:

The D9h–D10h drive module can be extended from the drive cabinet using a special fabricated service tool. Then, the heat sink fan can be serviced or the drive module can be lifted from the cabinet.

To remove the D9h–D10h drive module from the cabinet, use the following steps. To disassemble the components within a drive module or to remove the E5h–E6h drive module, see the *VLT® FC Series Service Guide for D1h–D8h, Da2/Db2/Da4/Db4, E1h–E4h, J8/J9* (130R0296).

Procedure

1. Open the cabinet door, and remove the safety shields.
2. Remove customer input wiring.
3. Unfasten 4 Torx screws (T25), 1 at each corner of the drive module where it attaches at the back of the enclosure. Reaching the fasteners requires an extension attached to a rachet. See illustration 87.



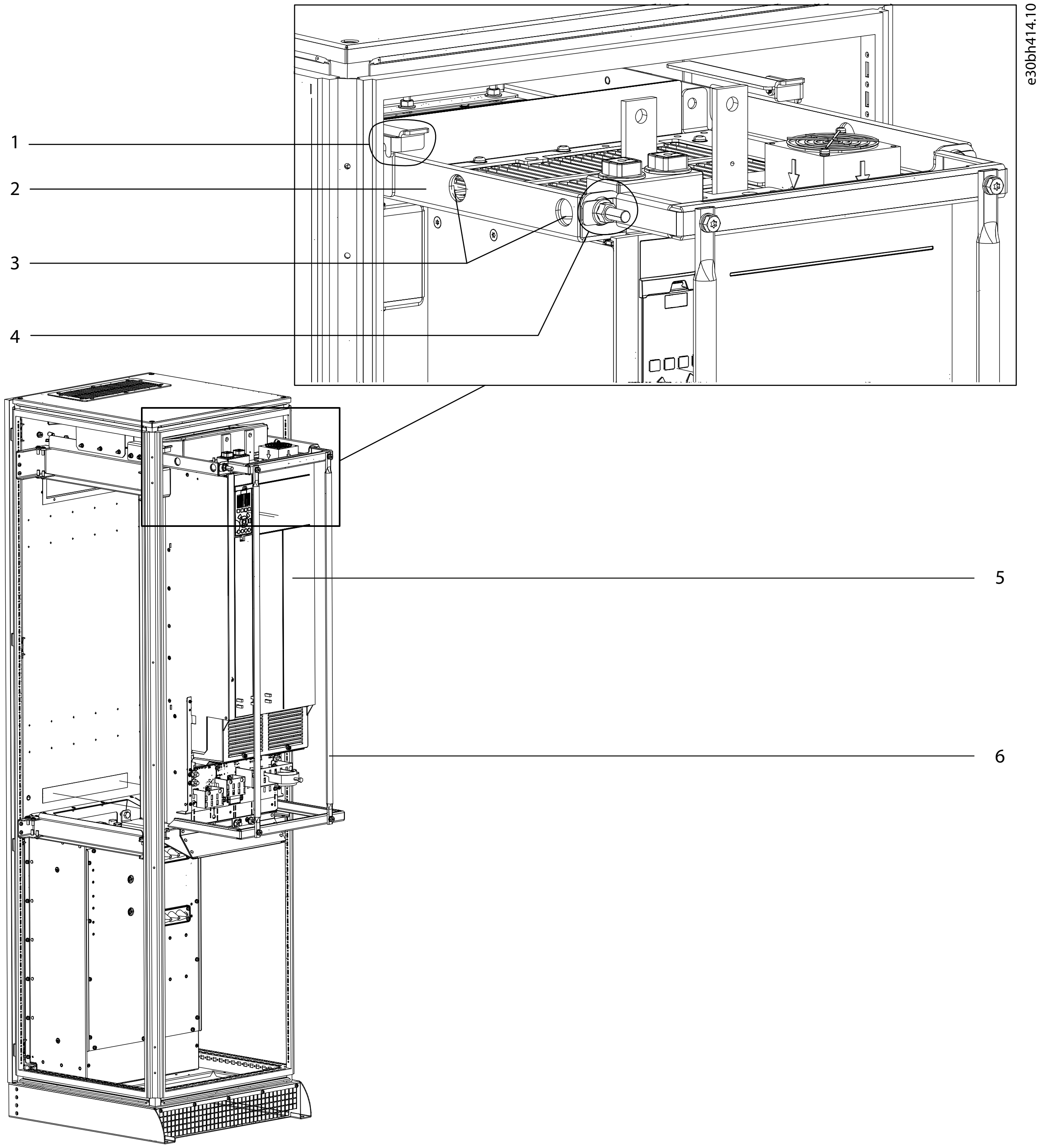
1	Upper Torx screws (T25)	**2**	Lower Torx screws (T25)

Illustration 87: Drive Module Fastener Location in D9h/D10h

4. Attach the service tool to the front corners of the drive module by securing 4 nuts, 1 at each corner of the tool. See illustration 88.
5. Pull on the rods of the service tool to slide the drive module forward on the extendable track beyond the frame of the enclosure.

   In this position, the heat sink fan at the bottom of the drive module can be serviced. See 9.5.1 Heat Sink Fan.
6. Attach lifting cables to 4 holes at the top of the drive module, 2 on each side. Then, attach the cables to a crane or similar lifting equipment.
7. Release the 2 safety latches at the ends of the extendable track, 1 on each side.
8. Pull the drive module free of the extendable track, and lift it from the cabinet.
9. Reinstall in reverse order of this procedure.

Example:



1 Safety latch	**2** Extendable track
3 Holes for lifting	**4** Fastener (attaching service tool to drive)

5 Drive module	**6** Service tool rods

Illustration 88: Drive Module Removal for D9h/D10h

9.5 Fans and Filters

9.5.1 Heat Sink Fan

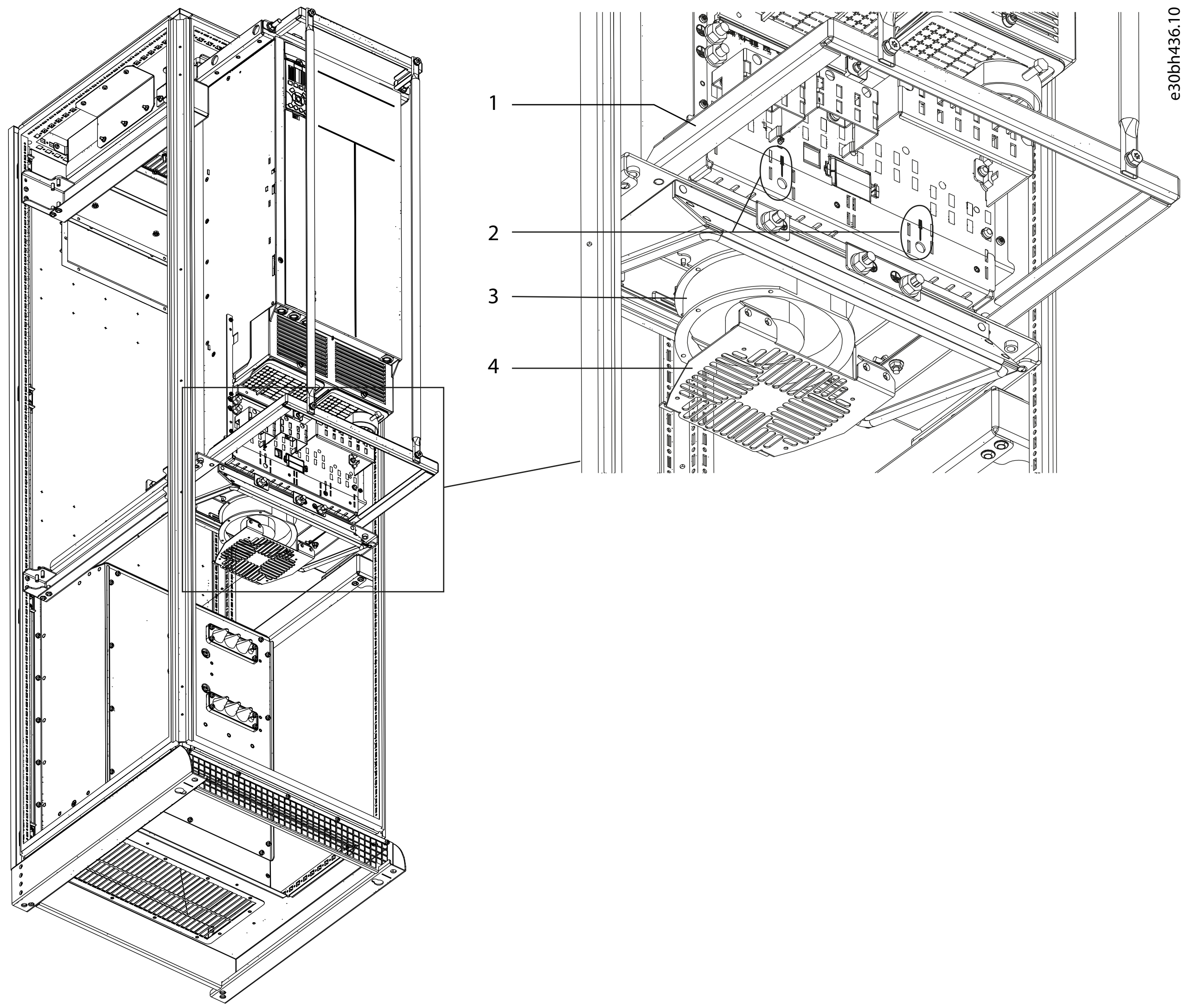
Context:

To allow access to the heat sink fan, the drive module in D9h/D10h enclosed drives can be extended out of the cabinet using a special service tool. The E5h/E6h heat sink fan can be accessed without moving the drive module. To remove the heat sink fan, use the following steps.

Procedure

1. For D9h/D10, extend the drive module from the cabinet using the service tool. See 9.4 Drive Module.
2. Remove 2 screws (T25), unfastening the heat sink fan cover plate. The fasteners can be reached through the access holes in the input plate. See illustration 89.
3. Remove the heat sink fan cover, and pull the heat sink fan off the mounting studs. The heat sink fan cable is still connected.
4. Squeeze together the top of the rubber cable grommet until it pops through the cable hole, releasing the heat sink fan cable.
5. Disconnect the heat sink fan cable connector. Take care not to drop the cable into the drive.

Example:



1 Drive module removal tool	**2** Access holes for heat sink fan fasteners
3 Heat sink fan	**4** Heat sink fan cover plate

Illustration 89: Heat Sink Fan Removal for D9h–D10h Drive Modules

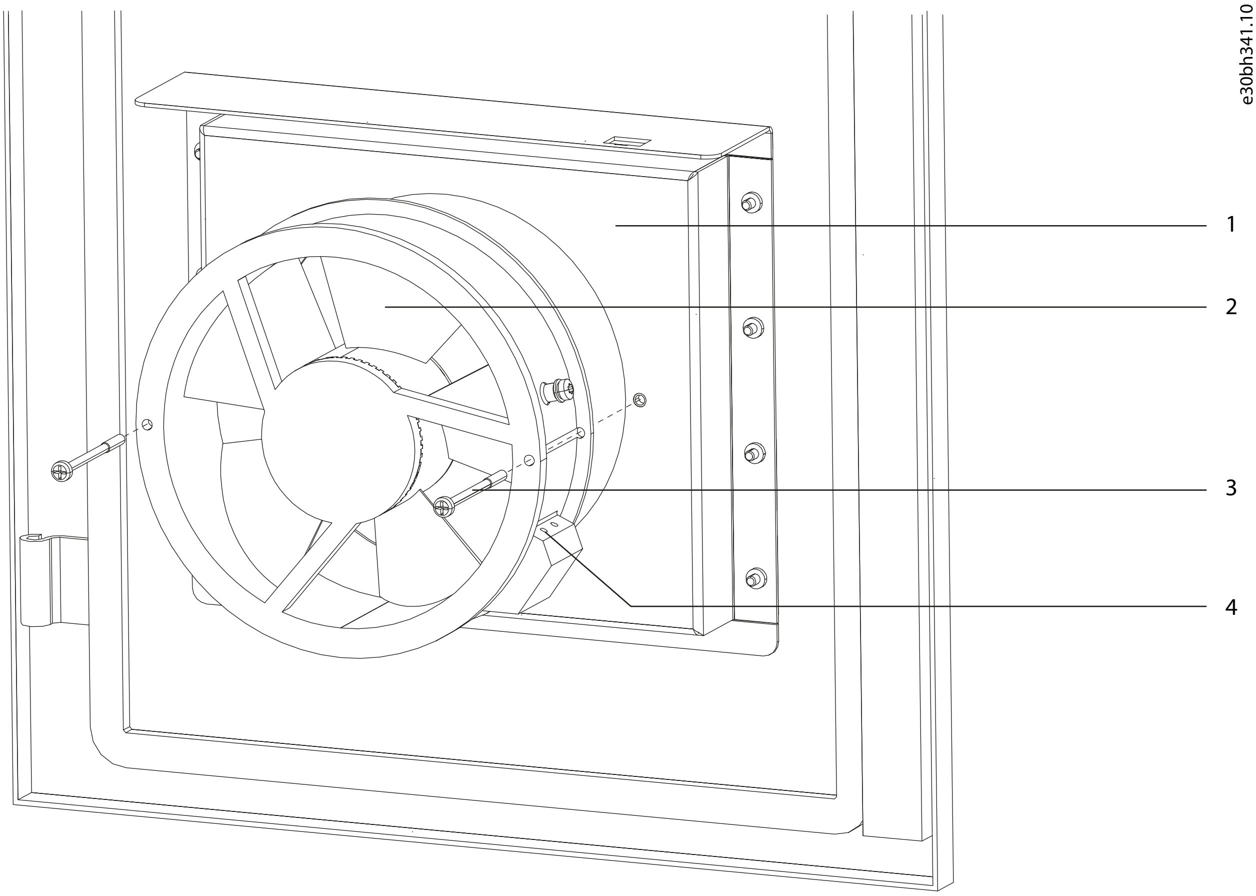
9.5.2 Door Fan

Context:

Cabinets in enclosed drive systems can have 1 or 2 door fans, depending on the cabinet size. To remove a door fan from a cabinet door, use the following steps.

Procedure

1. Open the cabinet.
2. Remove 2 screws (T20) from the inside of the cabinet door using a Phillips star screwdriver, 1 from each edge of the door fan.



1 Door fan mounting plate	**2** Door fan
3 Screw (T20)	**4** Cable terminal

Illustration 90: Door Fan Removal

3. Lift the door fan from the mounting plate.
4. Detach 2 fan cables from the connectors. (The cables can be reattached to either terminal).
5. Reinstall in reverse order of this procedure.

9.5.3 Door Air Filter

Context:

To remove a door air filter from any of the enclosure doors, use the following steps.

Procedure

1. Pull off the filter grill by lifting from the bottom.
2. Remove the air filter and clean or replace it.
3. Snap the filter grill back in place on the door.

Example:

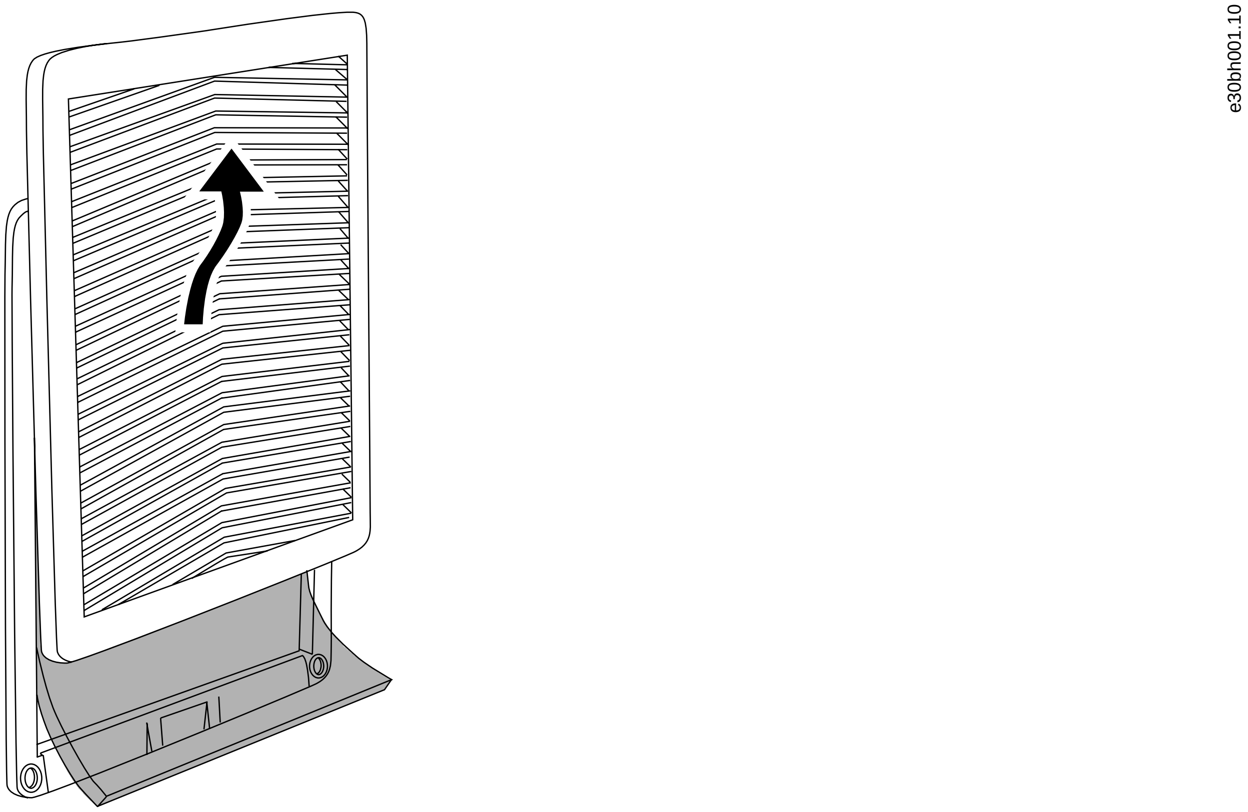


Illustration 91: Door Filter Removal

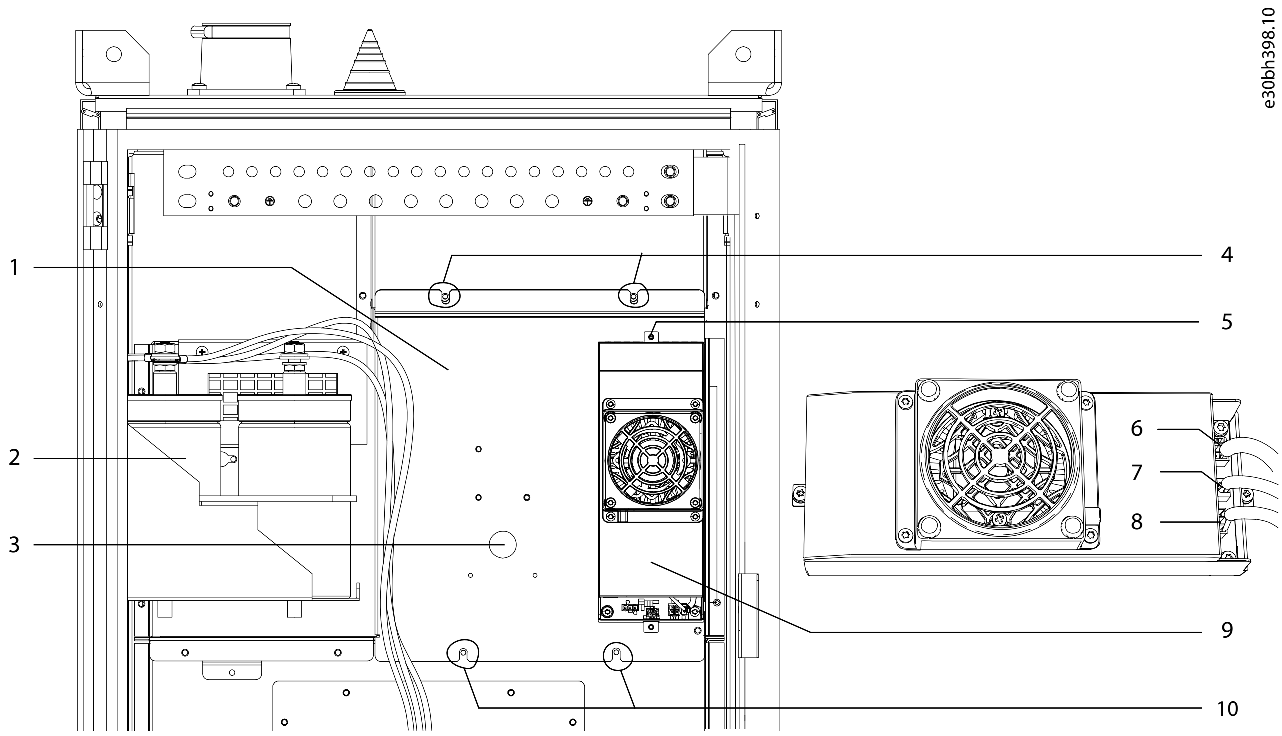
9.5.4 Back-channel Fan

Context:

Back-channel fans are found in passive harmonic filter cabinets, sine-wave filter cabinets, dU/dt filter cabinets, and others. Depending on the configuration, the back channel can have either 1 or 2 fans. The fan power supply is mounted to the front of the fan mounting plate, and the back-channel fan is mounted on the back of the plate. To remove the back-channel fan, use the following steps.

Procedure

1. Open the cabinet door.
2. If a capacitor shelf is present, remove the capacitor shelf to reveal the fan assembly by removing 2–6 screws (T25) from the capacitor shelf. See 9.8.1 PHF Capacitors or 9.7.1 Sine-wave Filter Capacitors.
3. Disconnect all wires from the fan power supply.
   A Main fan wire from connector X81.
   B Fan control wire from connector X61.
   C DC wire from connector X8.
4. Unfasten 2–3 nuts (8 mm) from the lower edge of the back-channel fan mounting plate.
5. Remove 4 screws (T20), 1 from each corner of the fan mounting plate.
6. Unfasten 2 screws (T25) from the top of the fan mounting plate.
7. Lift the plate from the cabinet. The fan power supply and fan are attached.



1	Back-channel fan mounting plate	2	Capacitor shelf (sine-wave filter shown)
3	Fan cable grommet hole	4	Upper mounting plate fastener location
5	fan power supply upper fastener location	6	Connector X81
7	Connector X61	8	Connector X8
9	Back-channel fan power supply	10	Lower mounting plate fastener location

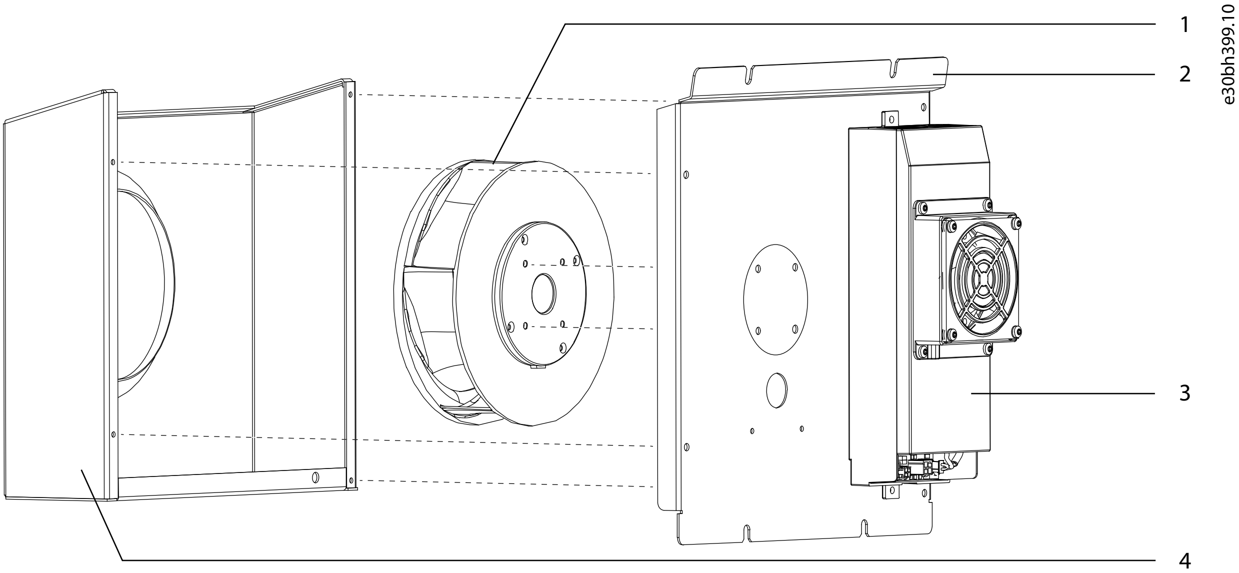
Illustration 92: Back-channel Fan Location

8. To remove the fan from the fan mounting plate:
   A Unfasten 4 Torx screws (T20).

B Release the fan cable grommet from the fan mounting plate and pull out the cable.

9. To remove the fan power supply from the fan mounting plate:

A Remove 3 screws (T20), 1 from the upper end and 2 from the lower end of the fan power supply.



1 Back-channel fan	2 Back-channel fan mounting plate
3 Fan power supply	4 Back channel

Illustration 93: Back-channel Fan Removal

10. To replace the back-channel fan or fan power supply, reinstall in reverse order of this procedure.

9.5.5 Back-channel Air Filter

Context:

Depending on the options present, the cabinet can contain 1 or more small back-channel air filters. The air filter requires regular cleaning.

Procedure

1. In passive harmonic filters or sine-wave filters, remove the capacitor bank shelf if it is blocking air filter access. See 9.8.1 PHF Capacitors or 9.7.1 Sine-wave Filter Capacitors.
2. Locate the back-channel air filter. The filter can be found next to or on the side of the back-channel fan assembly. It is not necessary to remove the cabinet side to reach the air filter.
3. Grasp the frame of the air filter and remove the frame and filter from the cabinet. Refer to illustration 94 and illustration 95.
4. Clean the filter, replace it in the frame, and place it back in the filter slot in the cabinet.

Example:

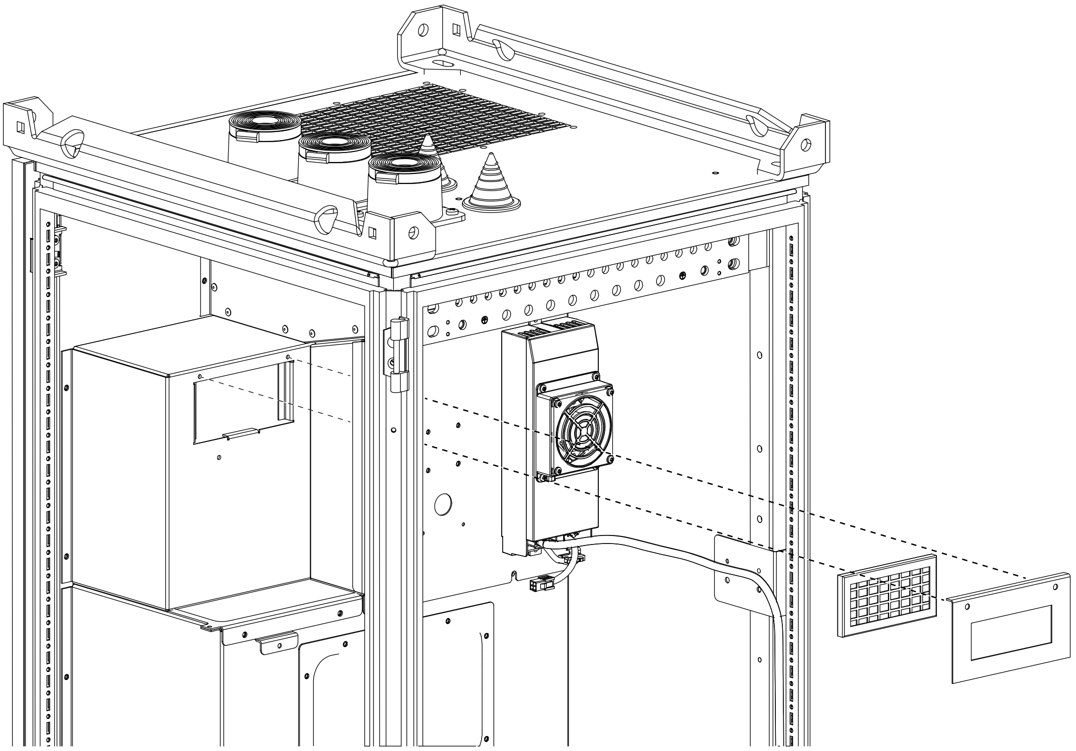


Illustration 94: Back-channel Air Filter (Front Location)

Example:

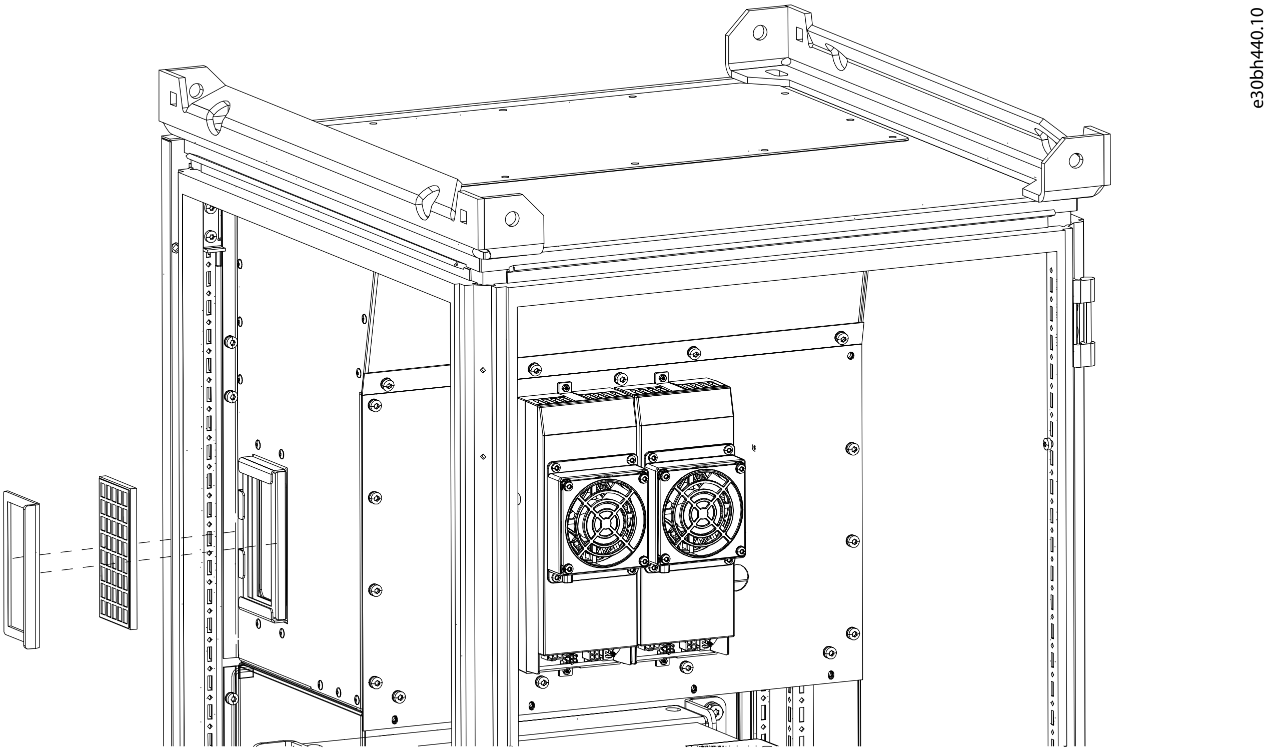


Illustration 95: Back-channel Air Filter (Side Location)

9.6 Input Power Options

9.6.1 Fusible Disconnect

Context:

The fusible disconnect is optional. To remove the fusible disconnect, use the following steps. Fastener size varies based on the power size of the enclosed drive.

CAUTION

COMPONENT WEIGHT

The fusible disconnect weighs over 25 kg (45 lbs).

- To avoid injury, lift the part only with assistance.

NOTICE

SWITCH SHAFT

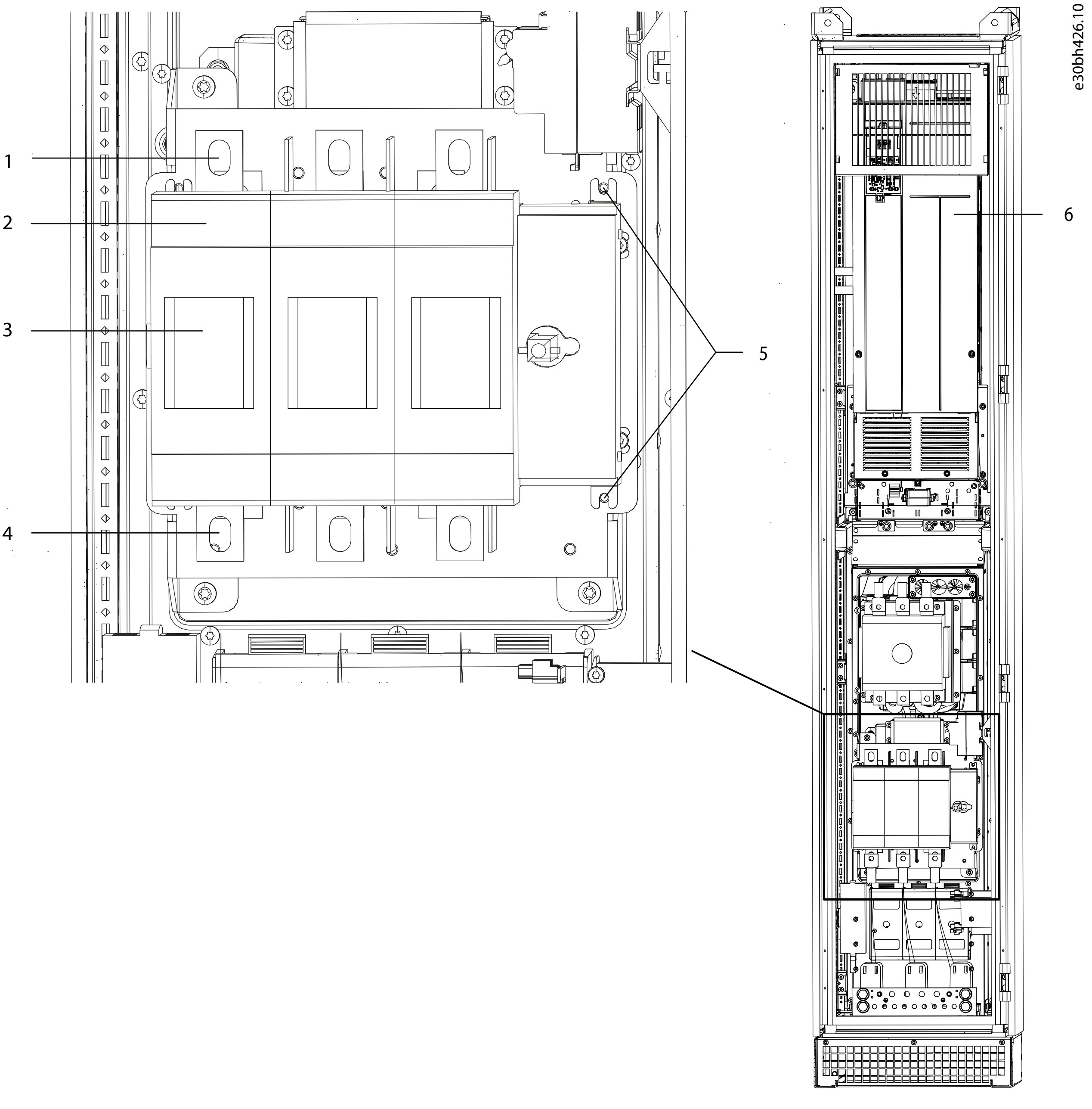
When reinstalling the disconnect, ensure that the switch shaft is installed at the correct length.

- The switch shaft must allow the door handle to operate and the switch to close properly.

Procedure

1. Open the cabinet, and remove the safety shield.
2. Remove 3 cables form the lower end of fusible disconnect by removing 3 fasteners (17 mm), 1 per phase.
3. Remove 3 plastic terminal covers at the top of the fusible disconnect.
4. Remove 3 cables form the upper end of fusible disconnect by removing 3 fasteners (17 mm), 1 per phase.
5. If an optional auxiliary transformer or insulation monitor is present, remove the wires for those components.
6. Loosen 2 screws (T25), 1 at each corner of the lower edge of the fusible disconnect mounting plate.
7. Remove 2 screws (T25), 1 from each corner at the top of the disconnect mounting plate.
8. Lift the fusible disconnect from the cabinet.
9. Reinstall in reverse order of this procedure.

Example:



1 Upper cable fastener holes	**2** Fusible disconnect
3 Fuse (visible through cover)	**4** Lower cable fastener hole
5 Mounting screws	**6** Drive module cabinet (D9h)

Illustration 96: Fusible Disconnect Removal

9.6.2 Fuses (IEC Fusible Disconnect)

Context:

To change the fuses in the IEC fusible disconnect, use the following steps.

Procedure

1. Open the enclosure door and remove the safety shield.
2. Rotate the plastic fuse cover downward to expose the fuse.

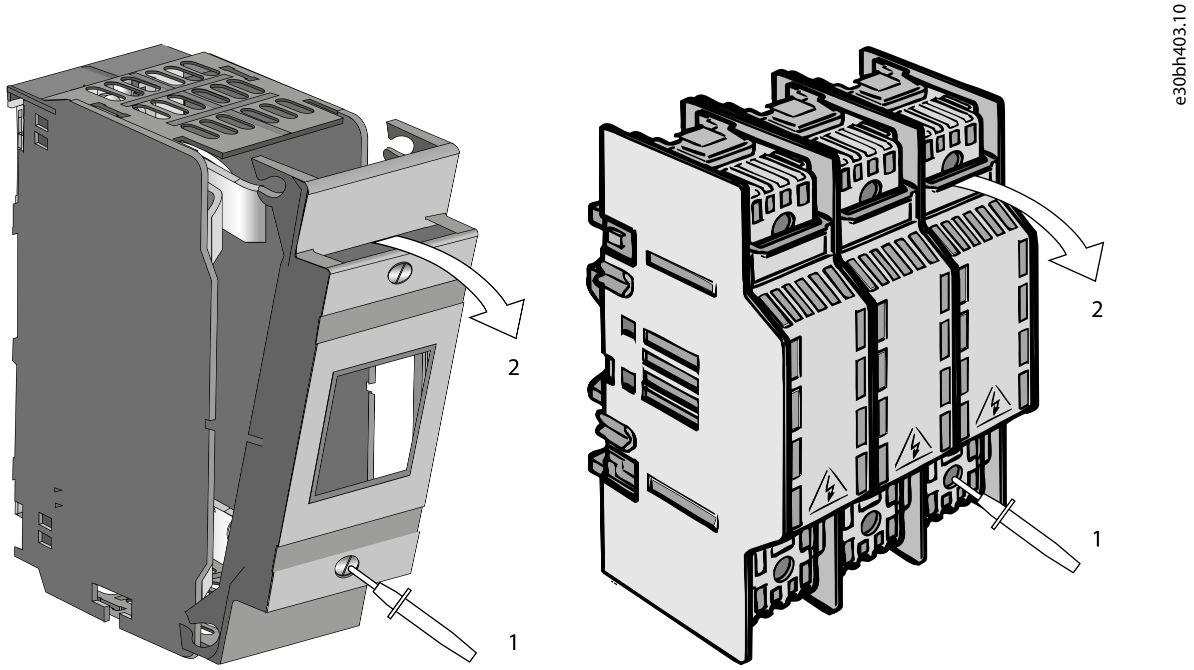


Illustration 97: IEC Fuse Cover on Fusible Disconnect

3. For smaller fuse sizes, the fuses are held in place by a clamp and have no bolts. Pull the fuse forward to remove it from the clamp. An optional fuse removal tool is available from the fuse manufacturer.

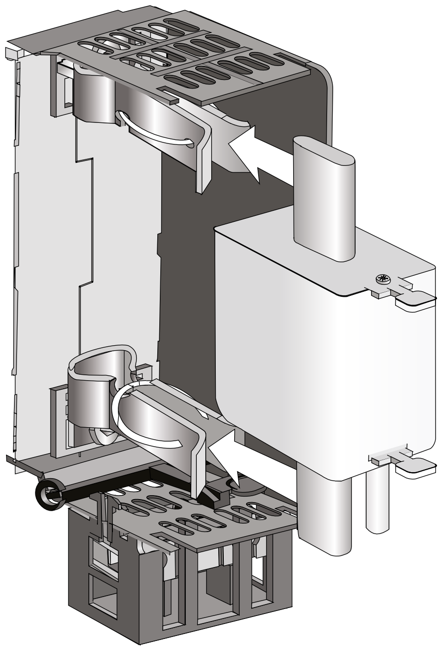


Illustration 98: Clamped Fuse Installation

4. For larger fuse sizes, remove 2 bolts (18/19 mm), 1 from the upper end and 1 from the lower end of the fuse. Remove the fuse from the disconnect.
5. Reinstall in reverse order of this procedure.

9.6.3 Fuses (UL Fusible Disconnect)

Context:

To change the fuses in the UL fusible disconnect, use the following steps.

Procedure

1. Open the enclosure door, and remove the safety shield.
2. Rotate the plastic fuse cover downward to expose the fuse.
3. Remove 2 bolts (19 mm) from the upper end of the fuse.
4. Remove 2 bolts (19 mm) from the lower end of the fuse.
5. Remove the fuse from the disconnect.
6. Replace in reverse order of this procedure.

9.6.4 Non-fusible Disconnect

Context:

The non-fusible disconnect is optional. The size of the non-fusible disconnect varies depending on the power size of the enclosed drive. To remove the non-fusible disconnect, use the following steps.

CAUTION

COMPONENT WEIGHT

The disconnect weighs over 25 kg (45 lbs).

- To avoid injury, lift the part only with assistance.

NOTICE

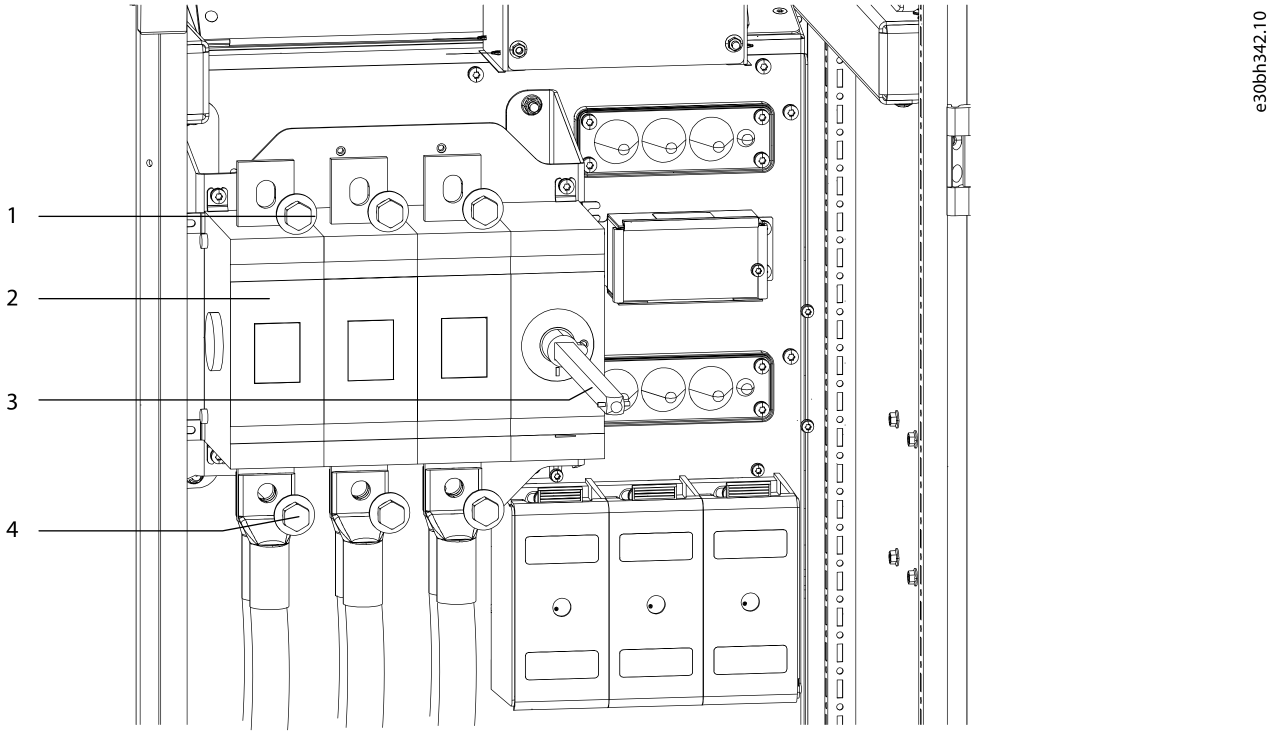
SWITCH SHAFT

When reinstalling the disconnect, ensure that the switch shaft is installed at the correct length.

- The switch shaft must allow the door handle to operate and the switch to close properly.

Procedure

1. Open the enclosure door, and remove the safety shield.
2. Remove 3 fasteners (17 mm), 1 from each phase at the bottom of the non-fusible disconnect.
3. Remove 3 fasteners (17 mm), 1 from each phase at the top of the non-fusible disconnect.



1	Upper bolts (10 mm)	**2**	Non-fusible disconnect
3	Disconnect switch shaft	**4**	Lower bolts (10 mm)

Illustration 99: Non-fusible Disconnect Removal

4. Loosen 2 bolts (10 mm), 1 in each corner at the bottom edge of the non-fusible disconnect.
5. Remove 2 bolts (10 mm), 1 in each corner at the top of the non-fusible disconnect.
6. Lift the non-fusible disconnect from the cabinet.
7. Reinstall in reverse order of this procedure.

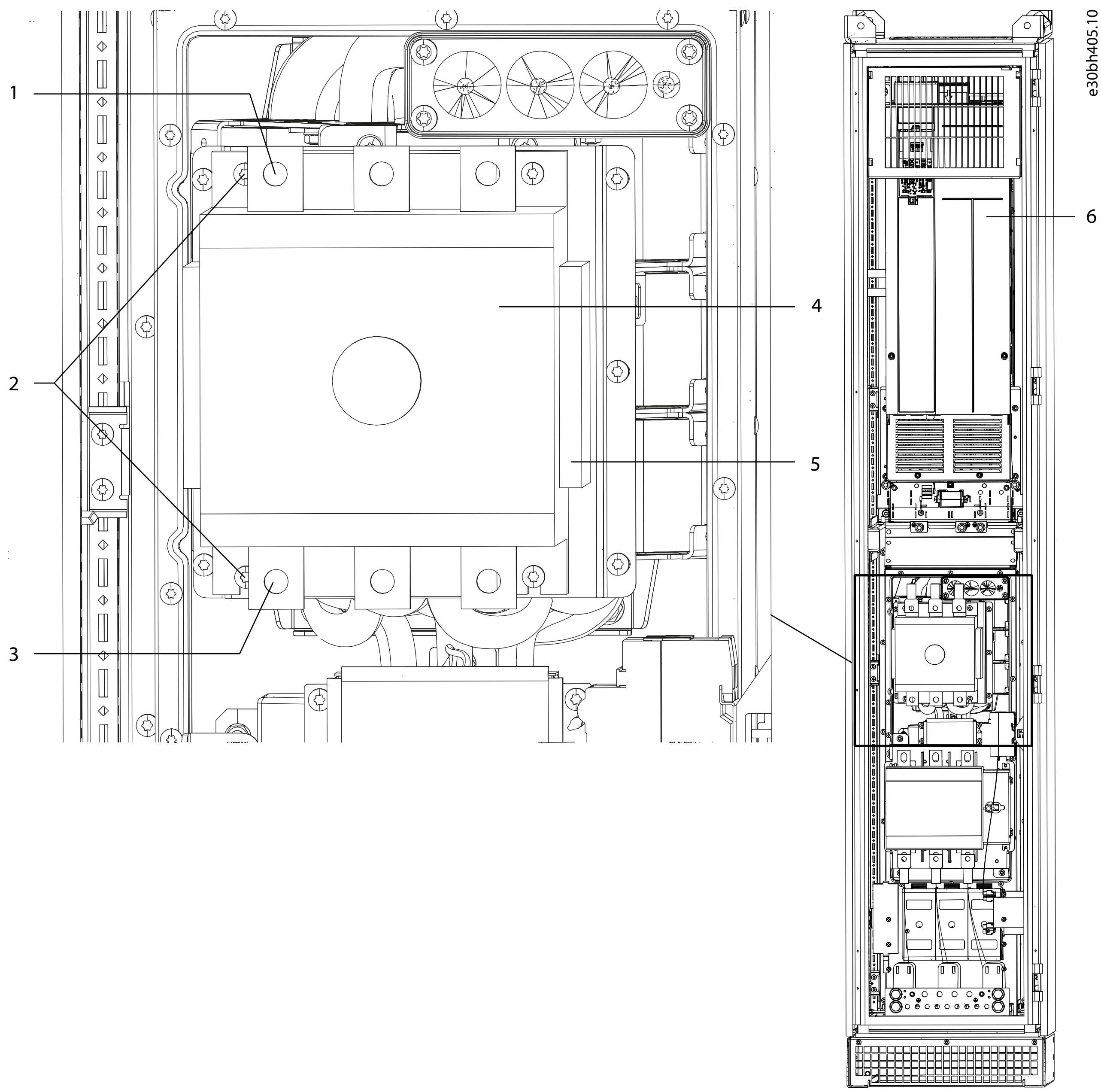
9.6.5 Mains Contactor

Context:

The mains contactor is optional, and varies based on the power size of the enclosed drive. In a D9h enclosed drive, the mains contactor is found in the drive cabinet. In a D10h enclosed drive, the mains contactor is found in either the drive cabinet or the input options cabinet depending on the configuration. In an E5h/E6h enclosed drive, the mains contactor is found in the input options cabinet. Use the following steps to remove the mains contactor. Fastener size varies based on power size.

Procedure

1. Open the enclosure door, and remove the safety shield.
2. Using a small screwdriver, unfasten 2 wires from terminals A1 and A2 on the auxiliary terminal block at the left side of the mains contactor.
3. Remove 3 fasteners (17 mm), 1 from each phase at the lower end of the mains contactor.
4. Remove 3 fasteners (17 mm), 1 from each phase at the top of the mains contactor.
5. Loosen 2 screws (10 mm), 1 in each corner at the bottom of the mains contactor.
6. Remove 2 screws (10 mm), 1 in each corner at the top of the mains contactor.
7. Lift the circuit breaker from the cabinet.
8. Reinstall in reverse order of this procedure.



1	Cable fastener holes	**2**	Mains contactor
3	Contactor fastener holes	**4**	Drive module cabinet

Illustration 100: Mains Contactor Removal from Drive Module Cabinet

9.6.6 Circuit Breaker

Context:

The circuit breaker is optional, and varies based on the power size of the enclosed drive. To remove the circuit breaker, use the following steps.

⚠ CAUTION ⚠

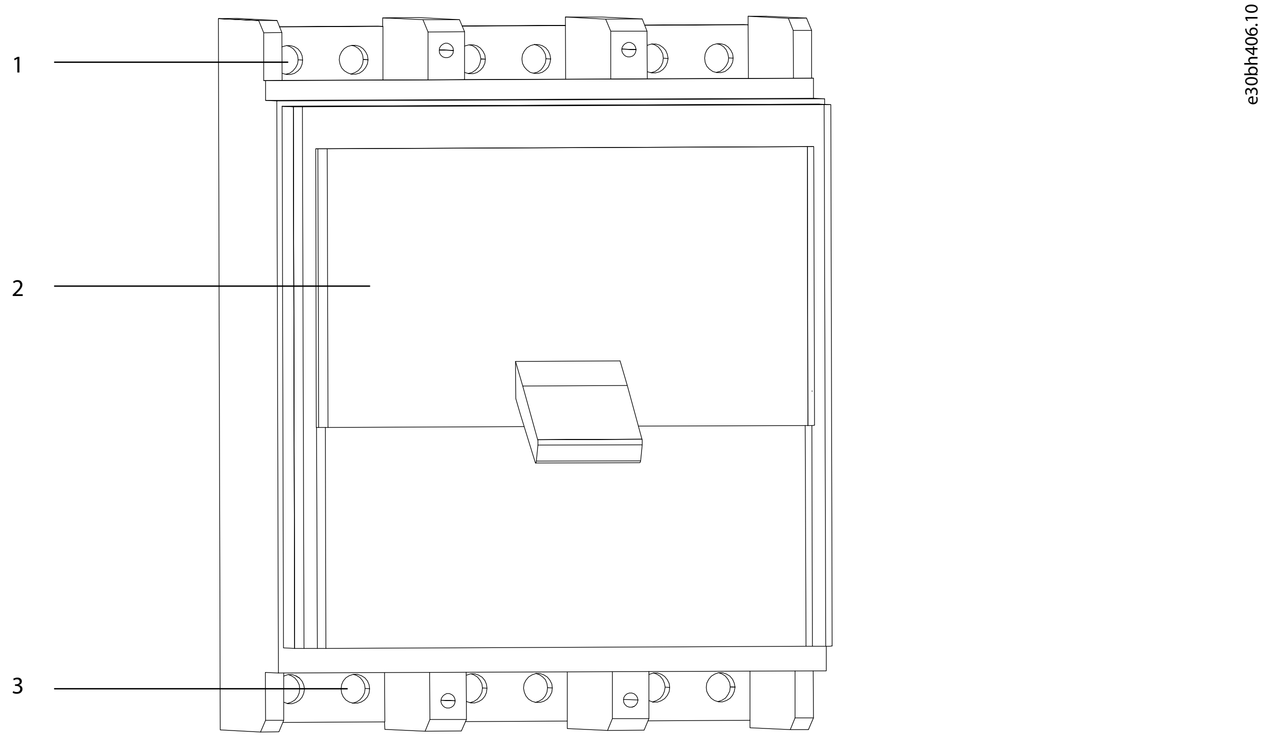
COMPONENT WEIGHT

The circuit breaker weighs over 73 kg (160 lbs).

- To avoid injury, lift the part only with assistance.

Procedure

1. Open the enclosure door, and remove the safety shield.
2. Remove the wiring and fasteners (17 mm) from the 3 phases at the bottom of the circuit breaker, up to 4 bolts per phase.
3. Remove 6 fasteners (17 mm), 2 from each phase at the top of the circuit breaker.



1	Upper fastener holes (2 per phase)	**2**	Circuit breaker
3	Lower fastener holes (up to 4 per phase)		

Illustration 101: Circuit Breaker Removal

4. Loosen 4 screws (8 mm), 2 in each corner at the bottom of the circuit breaker.
5. Remove 4 screws (8 mm), 2 in each corner at the top of the circuit breaker.
6. Lift the circuit breaker from the cabinet.
7. Reinstall in reverse order of this procedure.

9.7 Sine-wave Filter

9.7.1 Sine-wave Filter Capacitors

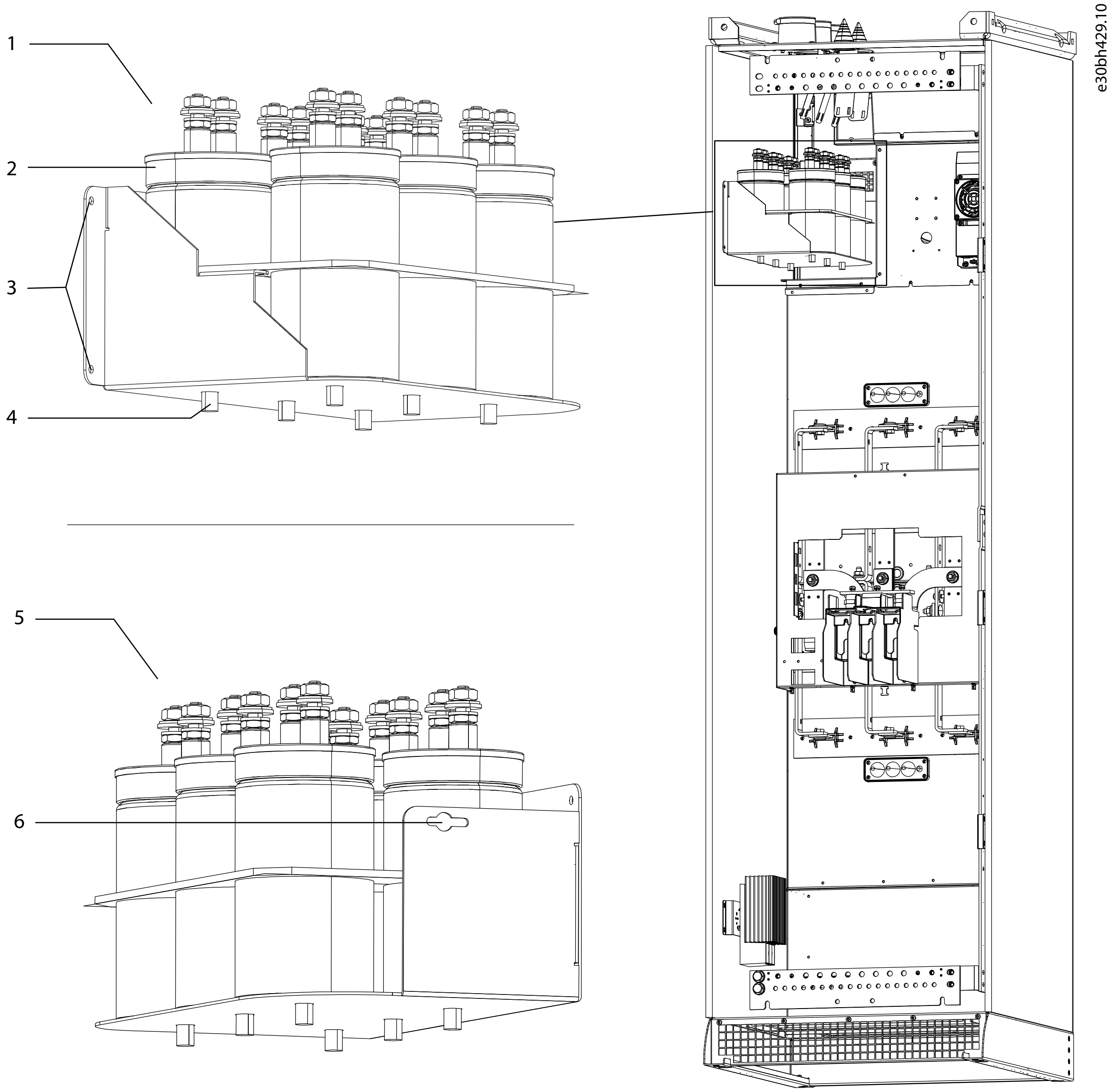
Context:

The sine-wave filter is optional. The sine-wave filter capacitors are found on the capacitor shelf. The shelf is either at the top of the sine-wave filter cabinet (in bottom entry/top exit cabinets), or near the bottom of the cabinet (in top entry/bottom exit cabinets).

Procedure

1. Open the enclosure door, and remove the safety shield.
2. Unplug the wiring between the capacitors and inductor output.
3. To remove an individual capacitor, remove one fastener from the bottom of the capacitor on the underside of the capacitor shelf. Lift the capacitor from the cabinet.
4. To remove the entire capacitor shelf, remove 2 fasteners from the front edge of the capacitor shelf.
5. The back of the capacitor shelf is held by a screw in a keyhole slot. Slide the capacitor shelf to the right until the screw lines up with the largest part of the keyhole. Then pull the shelf forward to free it.
6. Reinstall in reverse order of this procedure.

Example:



1	Front view of sine-wave filter capacitor shelf	**2**	Capacitor
3	Fastener holes in capacitor shelf front	**4**	Fastener for individual capacitor
5	Back view of sine-wave filter capacitor shelf	**6**	Keyhole slot in back of capacitor shelf

Illustration 102: Sine-wave Filter Capacitor Removal

9.8 Passive Harmonic Filter

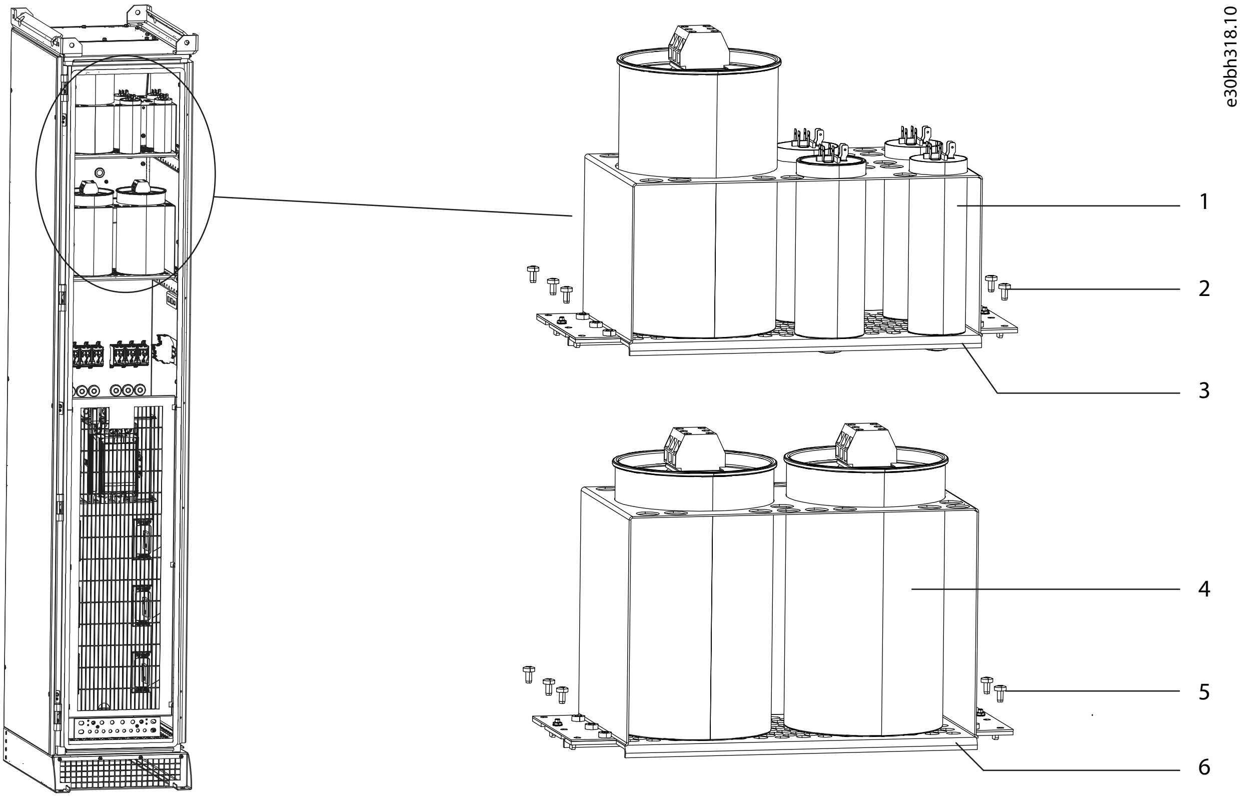
9.8.1 PHF Capacitors

Context:

The optional passive harmonic filter is available in 3 sizes. The number of PHF capacitors in the filter varies based on the size of the passive harmonic filter. Use the following steps to remove the PHF capacitor shelves from the cabinet, and to remove individual capacitors from the shelf.

Procedure

1. Open the enclosure door, and remove the safety shield.
2. To remove a capacitor shelf (with capacitors attached), unfasten 6 screws (10 mm), 3 each from the left and right sides of the capacitor shelf. See illustration 103.
3. Lift the capacitor shelf from the passive harmonic filter cabinet.

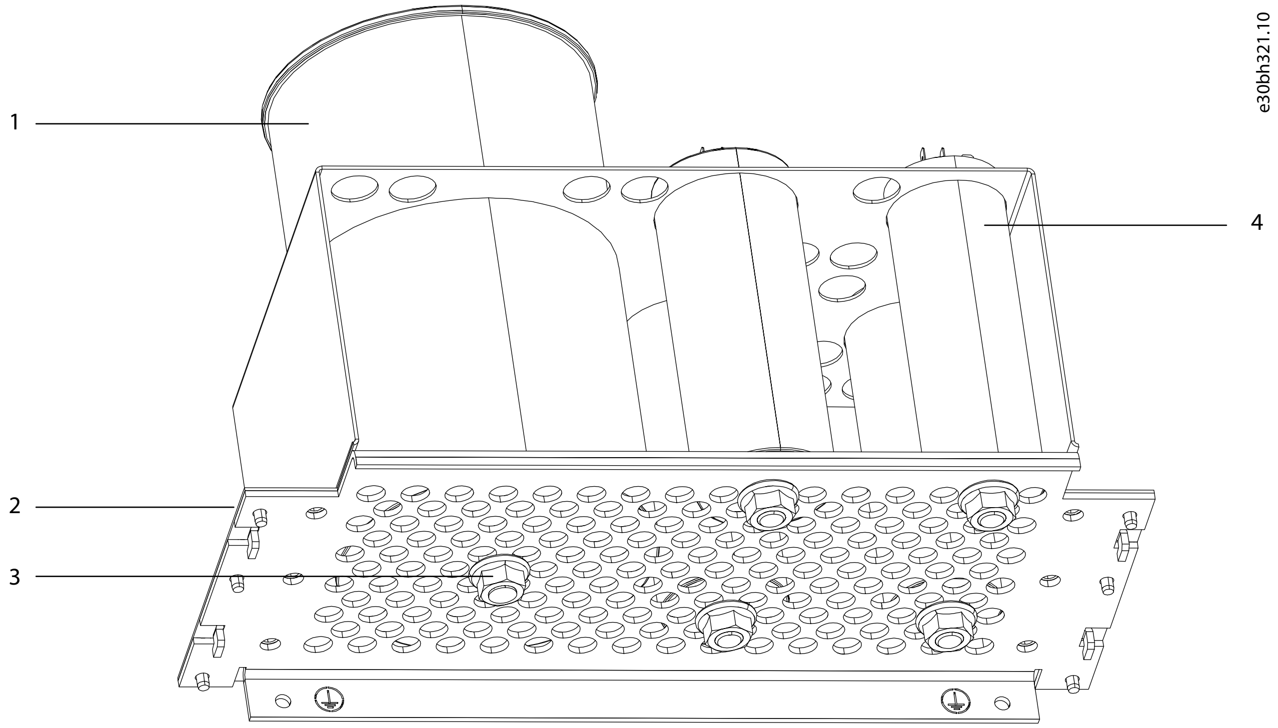


1 Small PHF capacitor	**2** Screws (10 mm) to mount upper shelf
3 Upper capacitor shelf	**4** Large PHF capacitor
5 Screws (10 mm) to mount lower shelf	**6** Lower capacitor shelf

Illustration 103: PHF Capacitor Shelf Removal

4. To remove an individual capacitor from the capacitor shelf, unfasten 1 nut (17 mm) from the underside of the capacitor shelf and lift the capacitor off the shelf. See illustration 104.
5. Reinstall in reverse order of this procedure.

Example:



1 Large PHF capacitor	**2** Capacitor shelf
3 Capacitor fastener	**4** Small PHF capacitor

Illustration 104: PHF Capacitor Removal

9.8.2 PHF Contactor

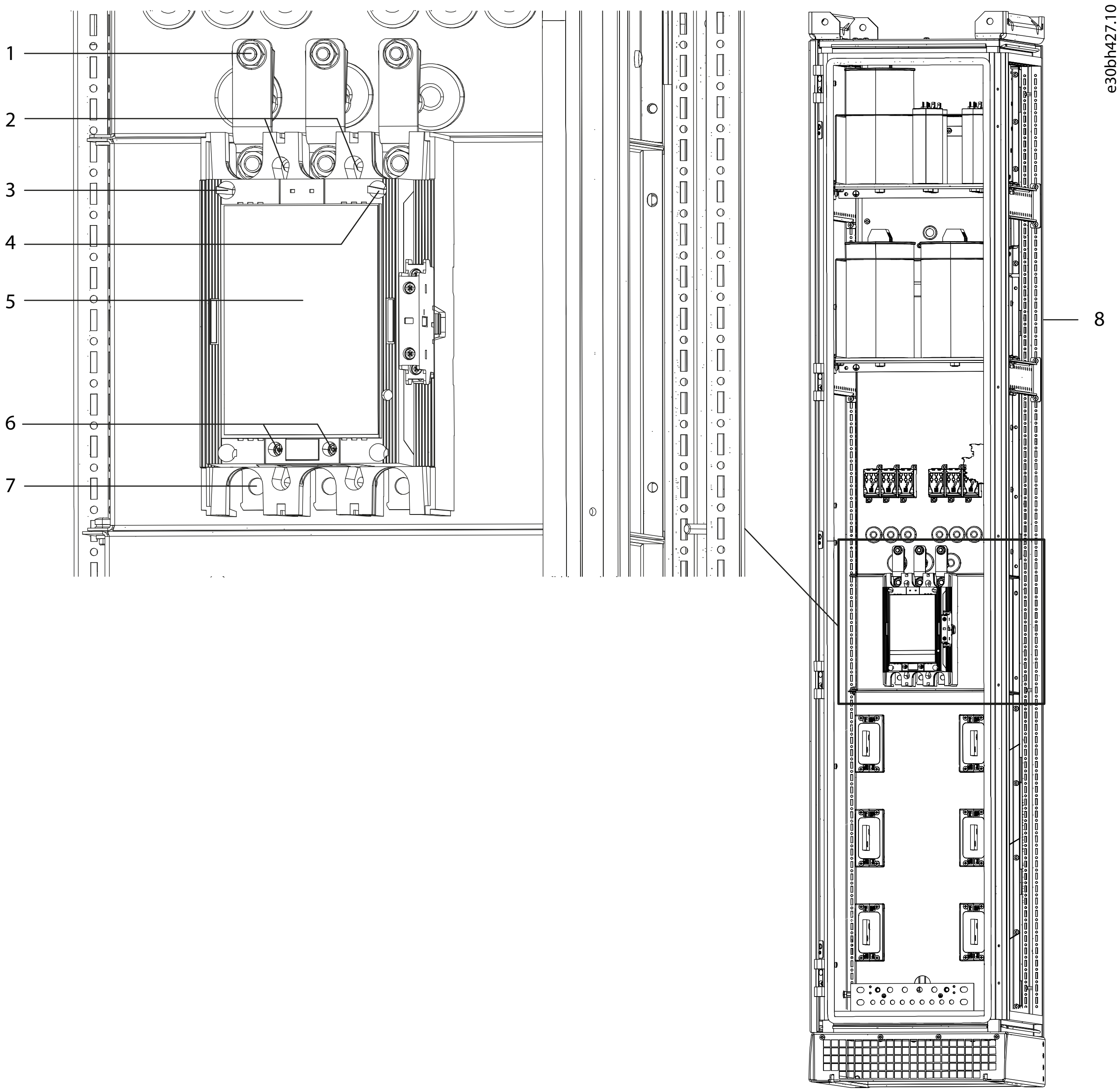
Context:

Passive harmonic filter cabinets come in widths of 400 mm (15.7 in), 600 mm (23.6 in), and 800 mm (31.5 in). Depending on the size of the cabinet, the passive harmonic filter has either 1 or 2 PHF contactors. To remove a PHF contactor, use the following steps.

Procedure

1. Open the enclosure door, and remove the safety shield.
2. Remove the power cables from the upper end of the PHF contactor by removing 3 fasteners, 1 per phase.
3. Remove the cables from the lower end of the PHF contactor by removing 3 fasteners, 1 per phase.
4. Remove 2 wires from the front of the PHF contactor, 1 each from the A1 and A2 terminals.
5. Remove 4 mounting screws with a Phillips screwdriver, and lift the PHF contactor from the cabinet.
6. Reinstall in reverse order of this procedure.

Example:



1	Upper power cable fastener holes	**2**	Upper mounting screws
3	A1 terminal	**4**	A2 terminal
5	PHF contactor	**6**	Lower mounting screws
7	Lower power cable fastener holes	**8**	Passive harmonic filter cabinet, 400 mm (15.7 in)

Illustration 105: PHF Contactor Removal

9.9 dU/dt Filter

9.9.1 dU/dt Filter Capacitors

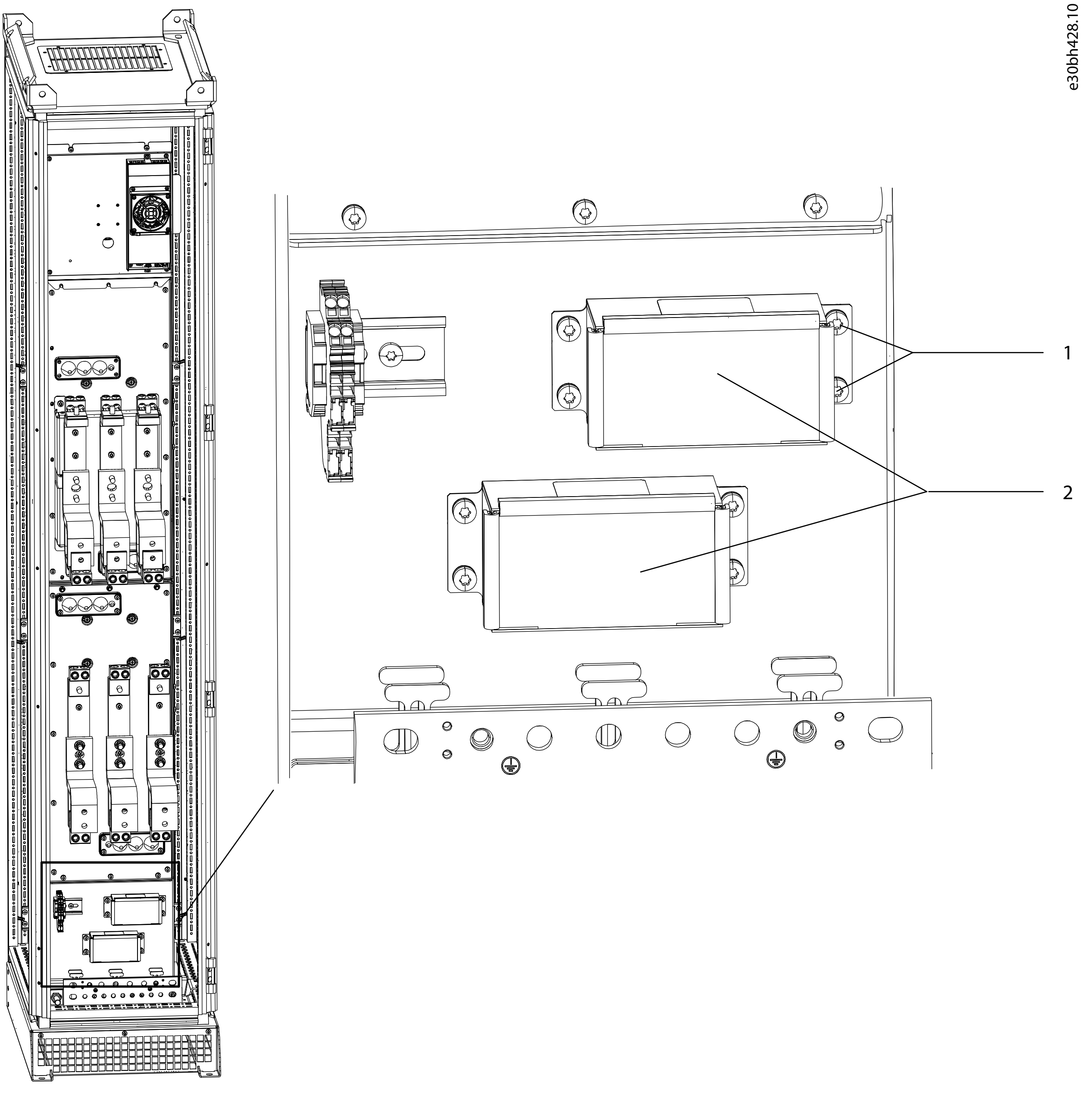
Context:

The dU/dt filter is optional. To remove the capacitors from the dU/dt filter, use the following steps.

Procedure

1. Open the cabinet door, and remove the lower safety shield.
2. Remove 4 screws (T20), 1 from each corner of the dU/dt capacitor.
3. Lift the capacitor from the cabinet.

Example:



1 Screws (T25)	**2** dU/dt filter capacitors

Illustration 106: dU/dt Capacitor Removal

10 Product Specifications

10.1 Fastener Torque Ratings

Apply the correct torque when tightening fasteners in the locations that are listed in the table. Too low or too high torque when fastening an electrical connection results in a bad electrical connection. To ensure correct torque, use a torque wrench.

Table 86: Fastener Torque Ratings

Location	Bolt size	Torque [Nm (in-lb)]
Mains terminals	M10/M12	19 (168)/37 (335)
Motor terminals	M10/M12	19 (168)/37 (335)
Ground terminals	M8/M10	9.6 (84)/19.1 (169)
Brake terminals	M8	9.6 (84)
Relay terminals	–	0.5 (4)
Door/panel cover	M5	2.3 (20)
Cable entry plate	M5	2.3 (20)
Serial communication cover	M5	2.3 (20)

10.2 DC Voltage Levels

Table 87: DC Voltage Levels

FC 102/ FC 103/FC 202/FC 302	380–480/500 V		525–690 V
Inrush circuit enabled [V DC]	370		550
Inrush circuit disabled [V DC]	395		570
Inverter undervoltage disable [V DC]	373		553
Undervoltage warning [V DC]	410		585
Inverter undervoltage re-enable (warning reset) [V DC]	412		602
	380–480 V	**380–500 V**	**525–690 V**
Overvoltage warning (without brake) [V DC]	778	817	1084
Dynamic brake turn on [V DC]	778	810	1099
Inverter overvoltage re-enable (warning reset) [V DC]	786	821	1099
Overvoltage warning (with brake) [V DC]	810	828	1109
Overvoltage trip [V DC]	820	855	1130

10.3 Warning and Alarm Trip Points

Table 88: Warning and Alarm Trip Points, D9h–D10h Drives, 380–480/500 V AC

FC 102/FC 103/FC 202	N110	N132	N160	N200	N250	N315
FC 302	**N90K**	**N110**	**N132**	**N160**	**N200**	**N250**
Overcurrent Warning [A_{rms}]	327	392	481	583	731	888
Overcurrent alarm [A_{rms}](1.5 s delay)	330	395	483	585	734	893
Ground (earth) fault alarm [A_{rms}]	27	32	39	47	59	72
Short circuit alarm [A_{pk}]	593	711	868	1051	1318	1595
Heat sink overtemperature trip [°C (°F)]	110 (230)	110 (230)	110 (230)	110 (230)	110 (230)	110 (230)
Control card overtemperature trip [°C (°F)]	75 (167)	75 (167)	75 (167)	80 (176)	80 (176)	80 (176)
PHF overtemperature trip [°C (°F)]	145 (293)	145 (293)	145 (293)	145 (293)	145 (293)	145 (293)
dU/dt filter overtemperature trip [°C (°F)]	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)
Sine-wave filter overtemperature trip [°C (°F)]	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)

Table 89: Warning/Alarm Trip Points, E5h–E6h Drives, 380–480/500 V AC

FC 102/FC 103/FC 202	N355	N400	N450	N500	N560
FC 302	**N315**	**N355**	**N400**	**N450**	**N500**
Heat sink overtemperature trip [°C (°F)]	110 (230)	110 (230)	110 (230)	110 (230)	100 (212)
Control card overtemperature trip [°C (°F)]	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)
PHF overtemperature trip [°C (°F)]	145 (293)	145 (293)	145 (293)	145 (293)	145 (293)
dU/dt filter overtemperature trip [°C (°F)]	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)
Sine-wave filter overtemperature trip [°C (°F)]	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)

Table 90: Warning/Alarm Trip Points, D9h–D10h Drives, 525–690 V AC

FC 102/FC 103/FC 202	N110	N132	N160	N200	N250	N315	N400	N450
FC 302	**N90K**	**N110**	**N132**	**N160**	**N200**	**N250**	**N315**	**N355**
Overcurrent Warning [A_{rms}]	209	253	300	372	468	561	666	–
Overcurrent alarm [A_{rms}](1.5 s delay)	255	255	330	483	483	585	734	–
Ground (earth) fault alarm [A_{rms}]	17	21	24	30	38	45	54	–
Short circuit alarm [A_{pk}]	459	459	593	870	869	1050	1319	–
Heat sink overtemperature trip [°C (°F)]	110 (230)	110 (230)	110 (230)	110 (230)	110 (230)	110 (230)	110 (230)	110 (230)
Control card overtemperature trip [°C (°F)]	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)
PHF overtemperature trip [°C (°F)]	145 (293)	145 (293)	145 (293)	145 (293)	145 (293)	145 (293)	145 (293)	145 (293)

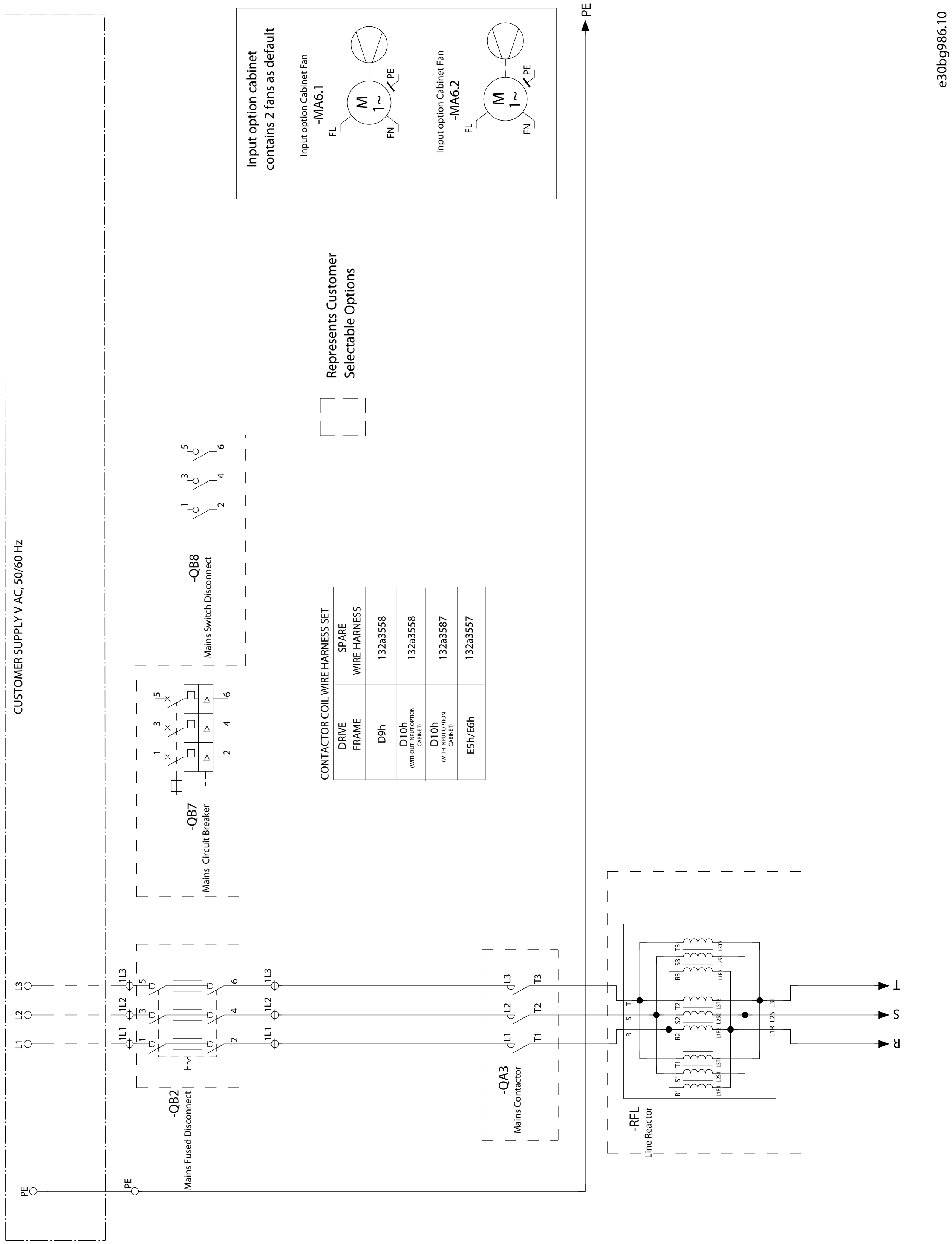
FC 102/FC 103/FC 202	N110	N132	N160	N200	N250	N315	N400	N450
dU/dt filter overtemperature trip [°C (°F)]	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)
Sine-wave filter overtempera-ture trip [°C (°F)]	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)	150 (302)

Table 91: Warning/Alarm Trip Points, E5h–E6h Drives, 525–690 V AC

FC 102/FC 103/FC 202	N500	N560	N630	N710	N800
FC 302	**N400**	**N500**	**N560**	**N630**	**N710**
Heat sink overtemperature trip [°C (°F)]	110 (230)	110 (230)	110 (230)	110 (230)	110 (230)
Control card overtemperature trip [°C (°F)]	80 (176)	80 (176)	80 (176)	80 (176)	80 (176)
PHF overtemperature trip [°C (°F)]	145 (293)	145 (293)	145 (293)	145 (293)	145 (293)
dU/dt filter overtemperature trip [°C (°F)]	150 (302)	150 (302)	150 (302)	150 (132)	150 (132)
Sine-wave filter overtemperature trip [°C (°F)]	150 (302)	150 (302)	150 (302)	150 (132)	150 (132)

11 Block Diagrams

11.1 Input Power



CONTACTOR COIL WIRE HARNESS SET

DRIVE FRAME	SPARE WIRE HARNESS
D9h	132a3558
D10h (WITHOUT INPUT OPTION CABINET)	132a3558
D10h (WITH INPUT OPTION CABINET)	132a3587
E5h/E6h	132a3557

Illustration 107: Input Power Block Diagram for D9h–D10h/E5h–E6h

11.2 Passive Harmonic Filter 1 for D9h–D10h

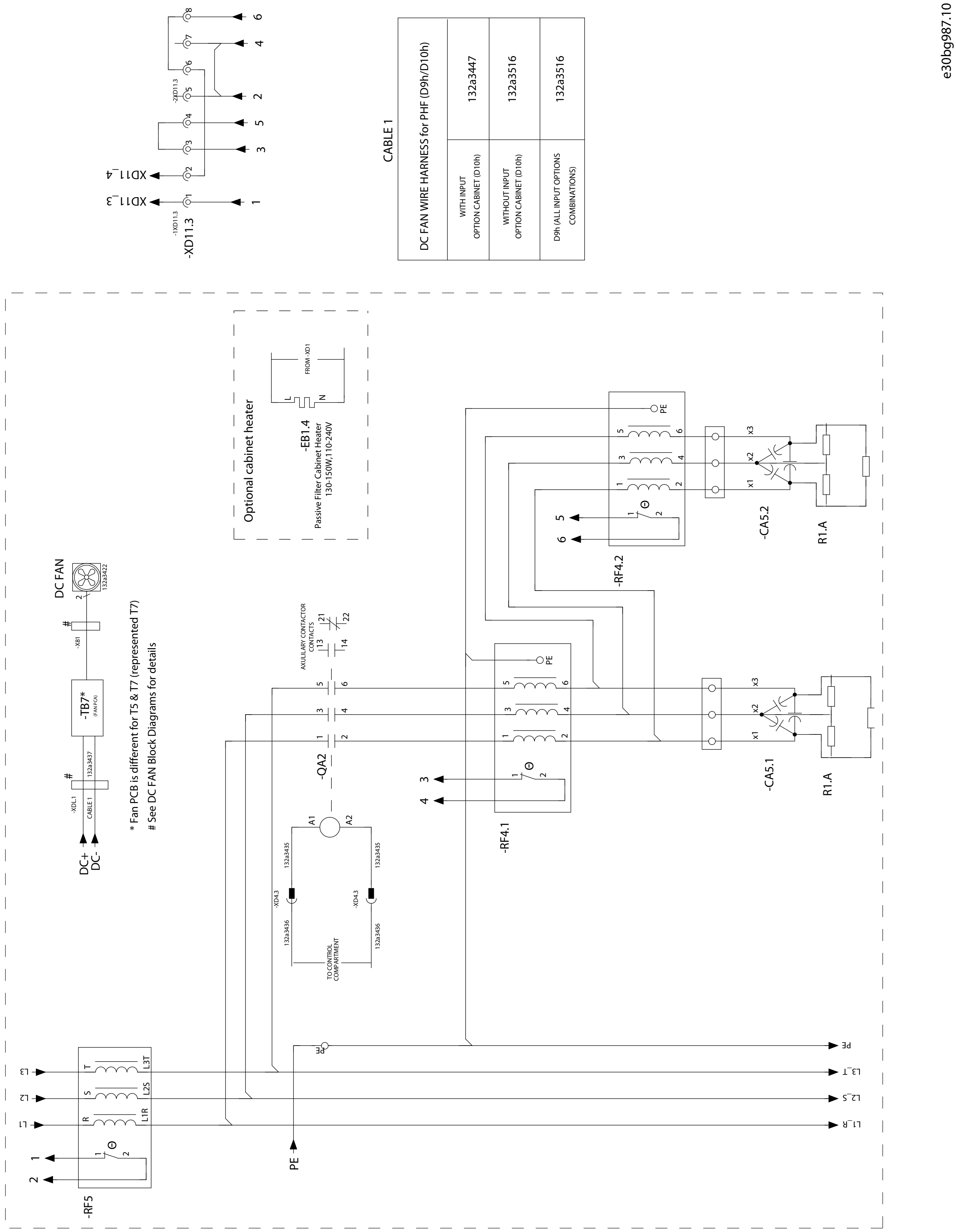


Illustration 108: PHF 1 Block Diagram for D9h–D10h

11.3 Passive Harmonic Filter 2 for E5h–E6h

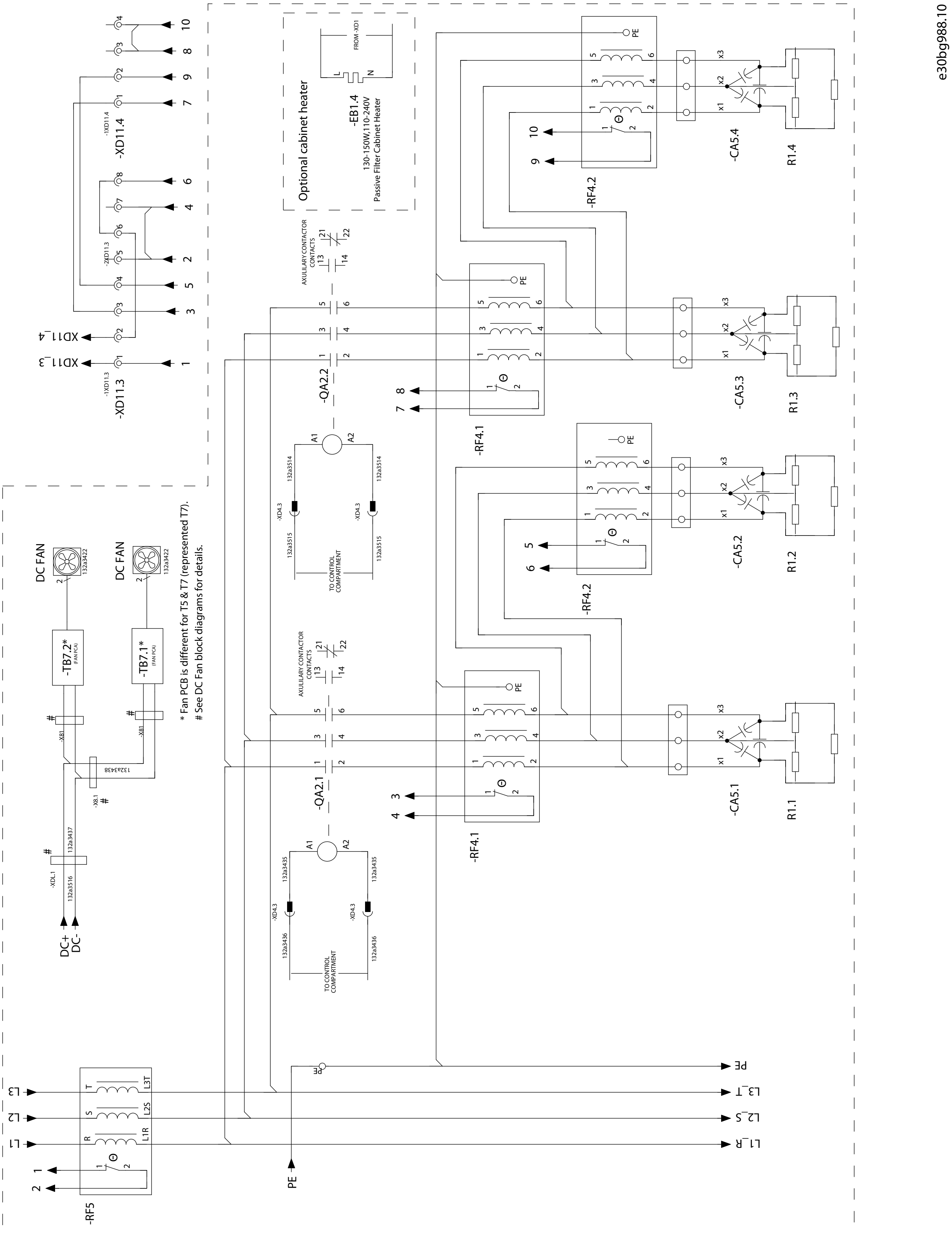


Illustration 109: PHF 2 Block Diagram for E5h–E6h

11.4 Drive Module

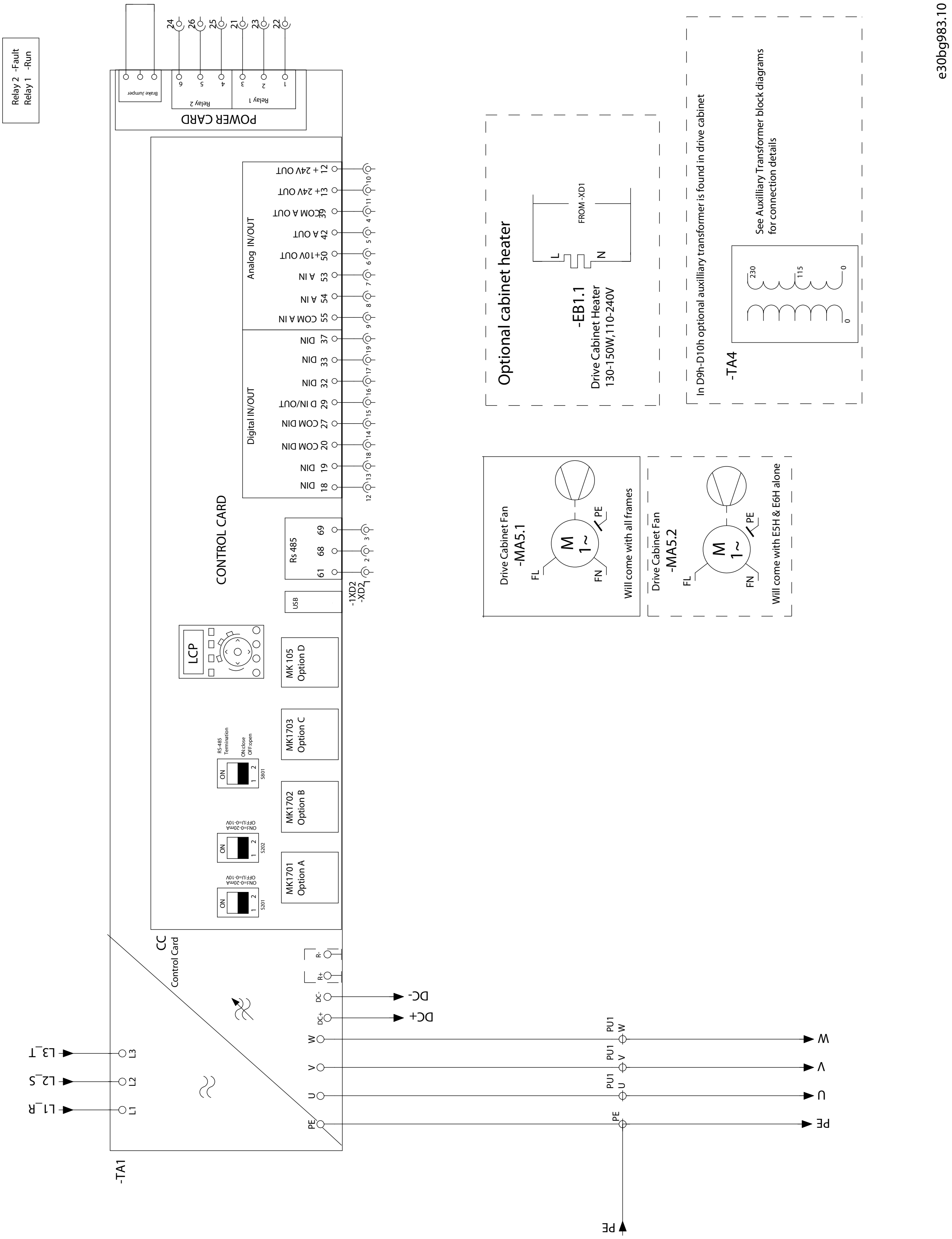


Illustration 110: Drive Module Block Diagram for D9h-D10h/E5h-E6h

11.5 dU/dt Filter for D9h–D10h

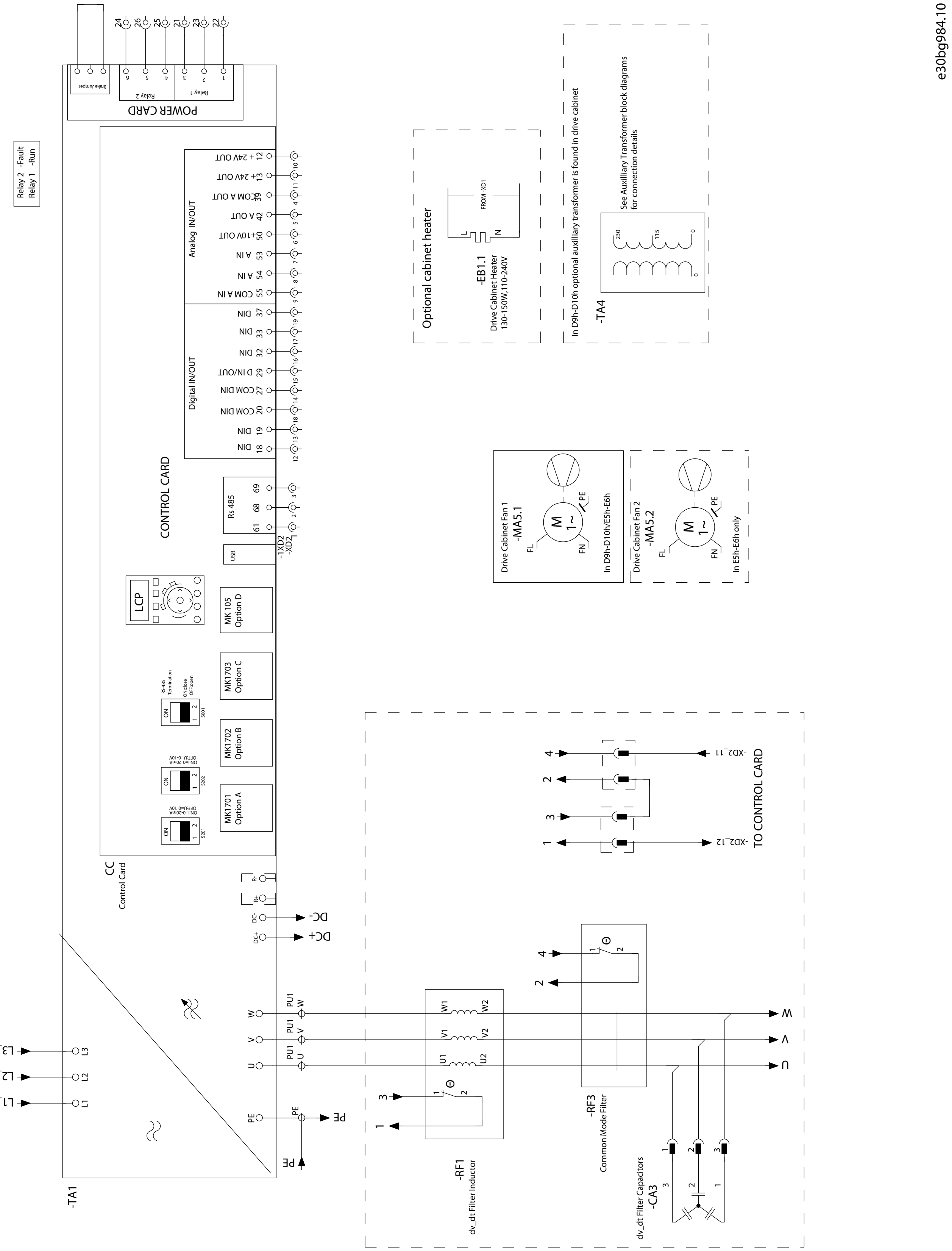


Illustration 111: dU/dt Filter Block Diagram for D9h–D10h (with Drive Module)

11.6 dU/dt Filter for E5h–E6h

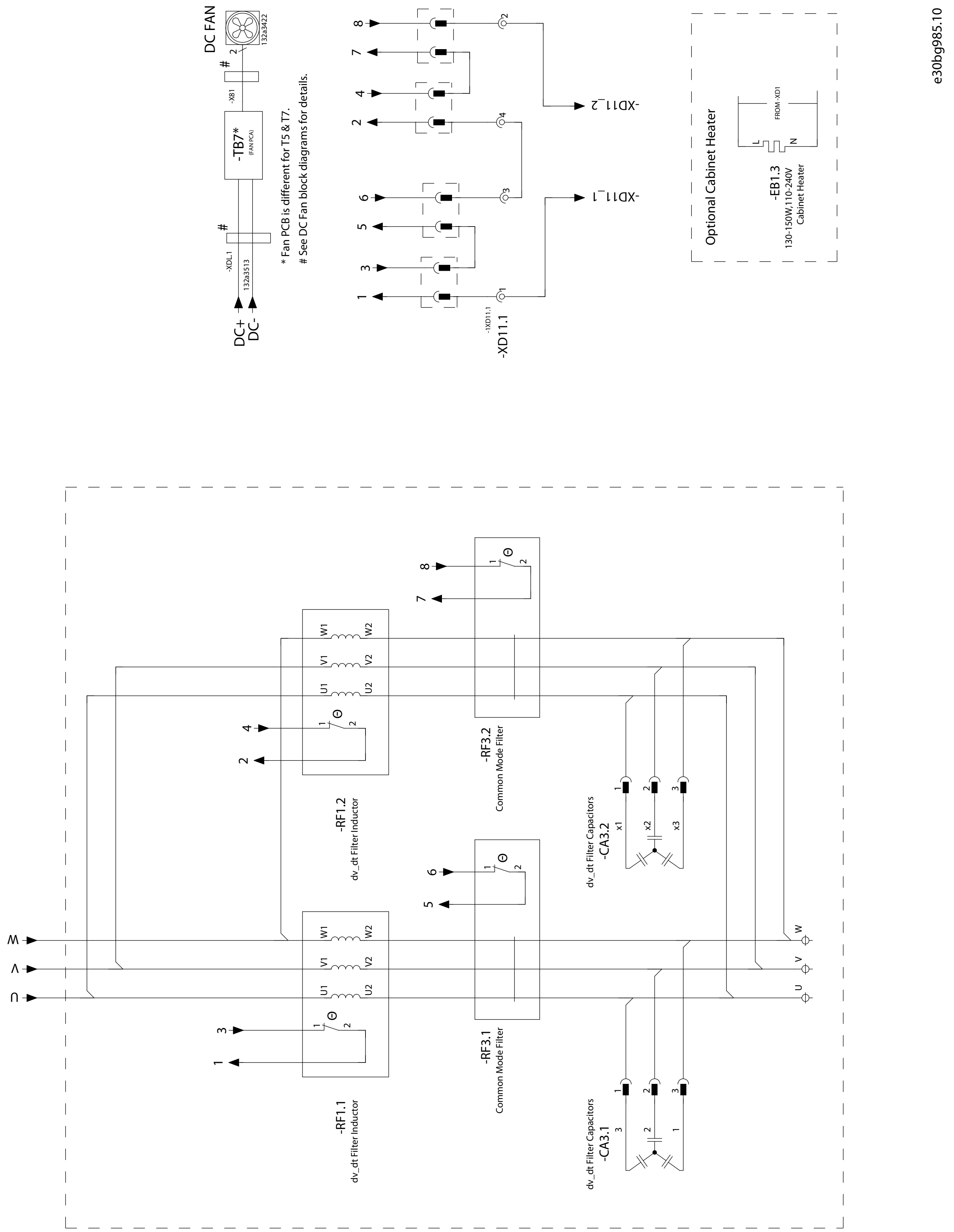


Illustration 112: dU/dt Filter Block Diagram for E5h–E6h

11.7 Sine-wave Filter for D9h–D10h

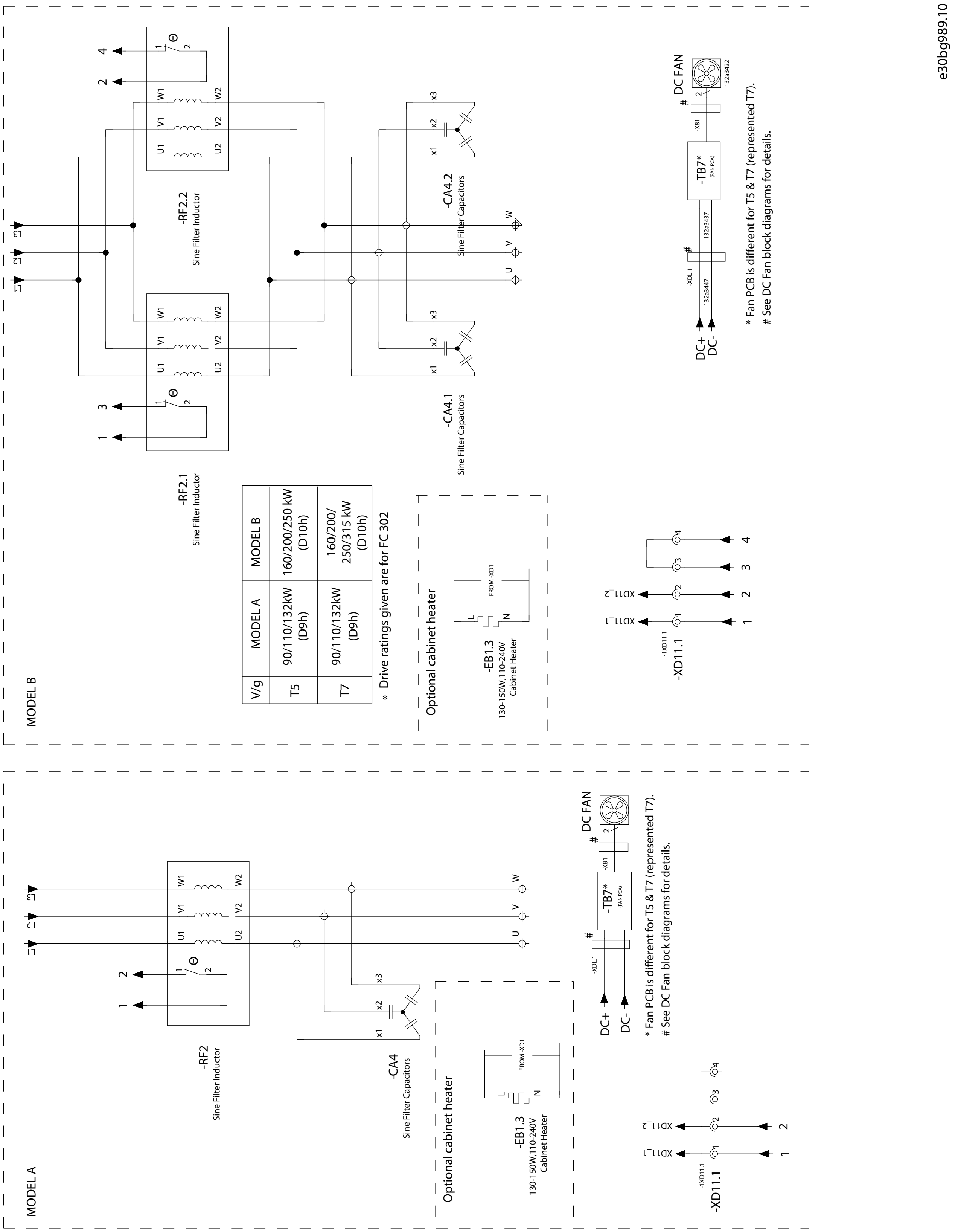


Illustration 113: Sine-wave Filter Block Diagram for D9h–D10h

11.8 Sine-wave Filter for E5h–E6h

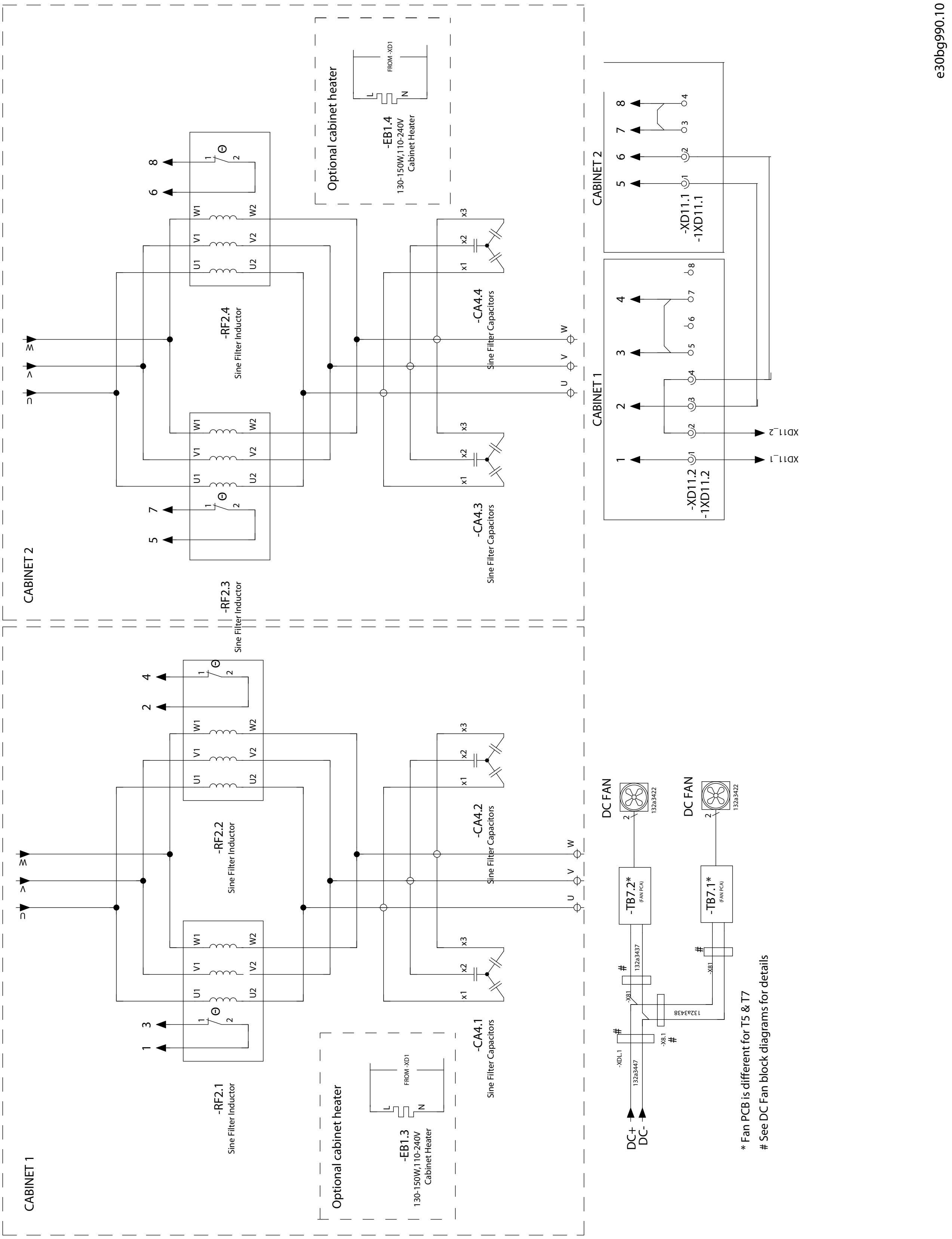


Illustration 114: Sine-wave Filter Block Diagram for E5h–E6h

11.9 DC Fan 1

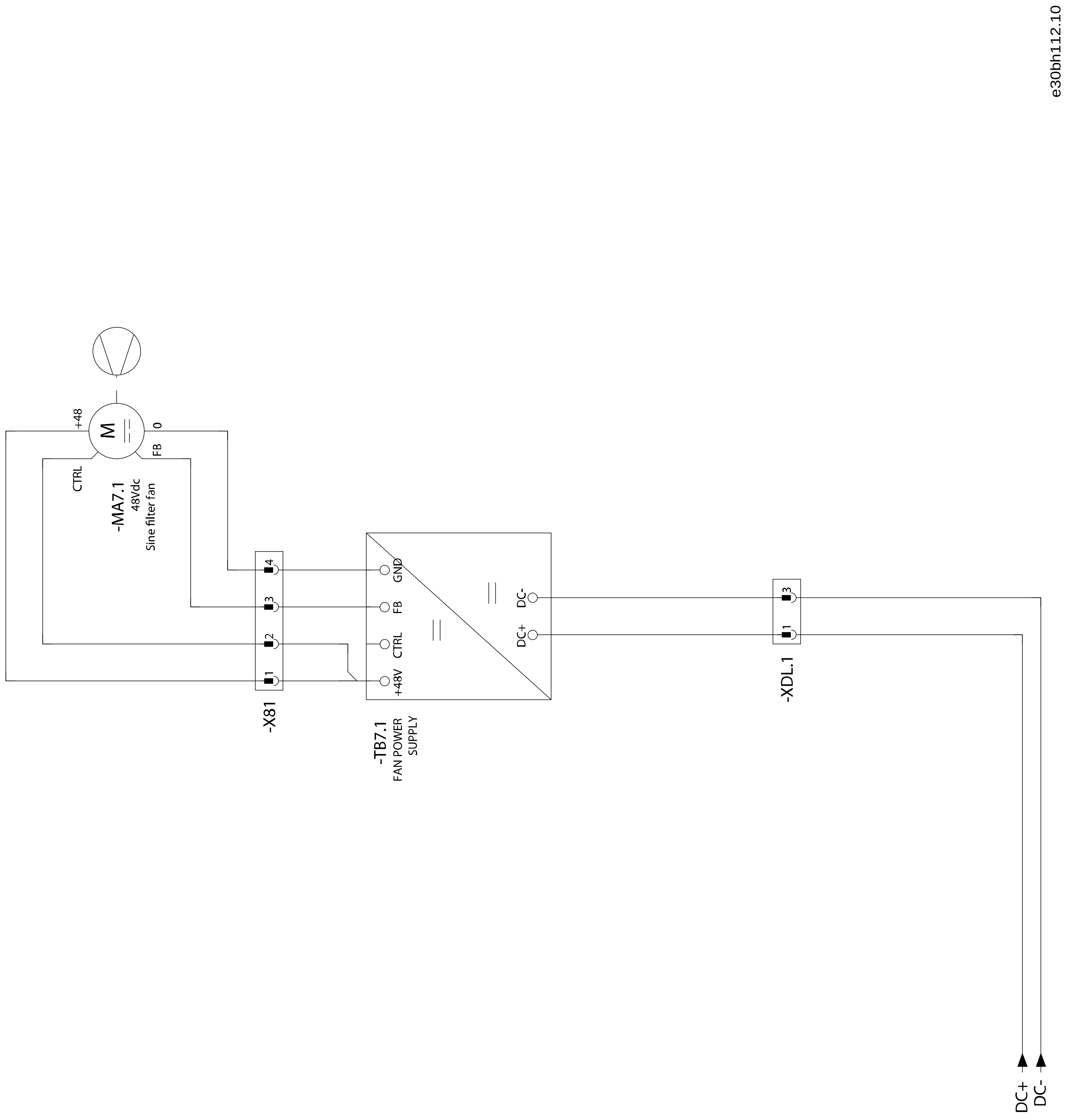


Illustration 115: DC Fan 1 Block Diagram for D9h-D10h/E5h/E6h

11.10 DC Fan 2

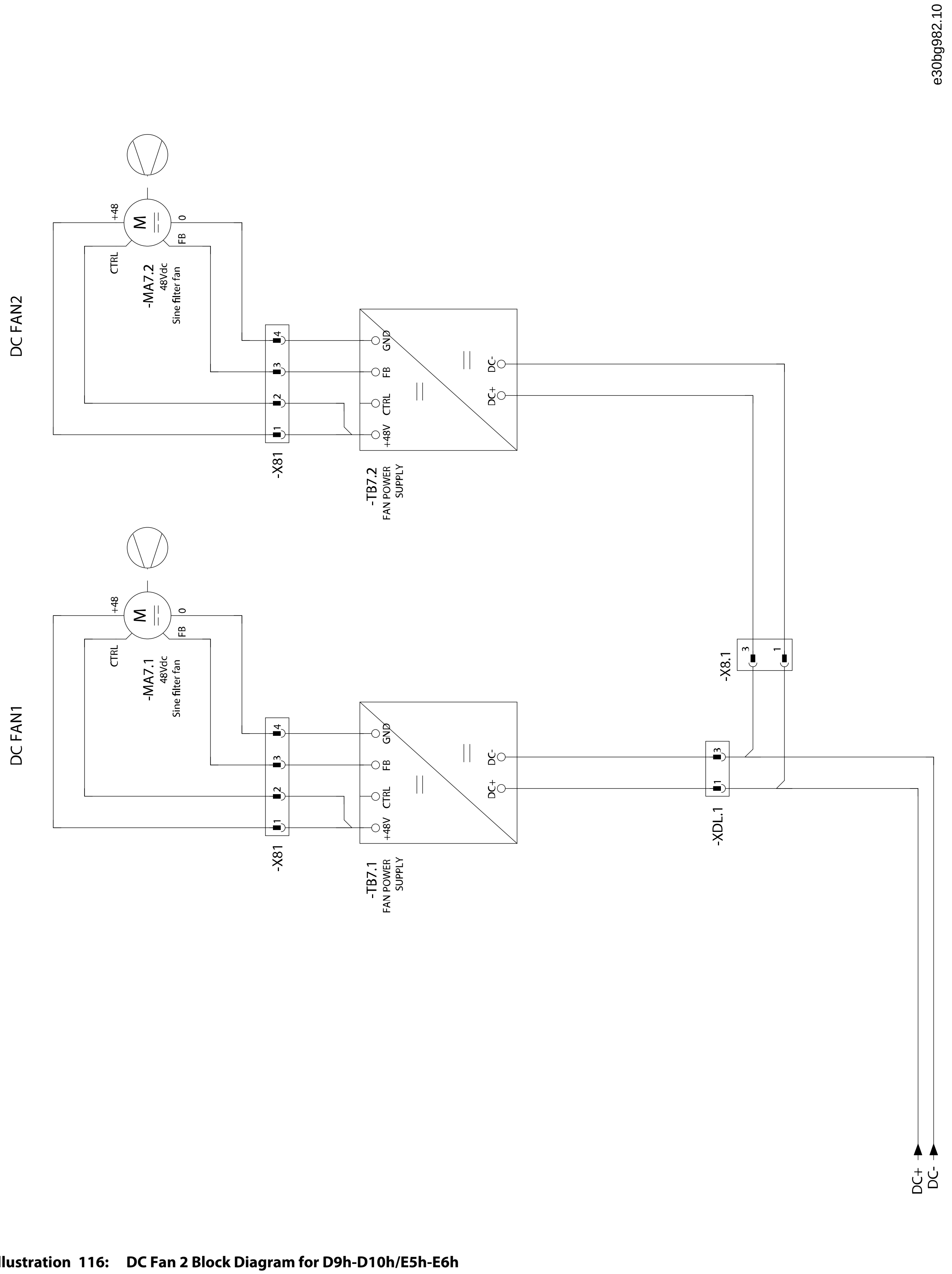


Illustration 116: DC Fan 2 Block Diagram for D9h-D10h/E5h-E6h

11.11 Control Option Overview

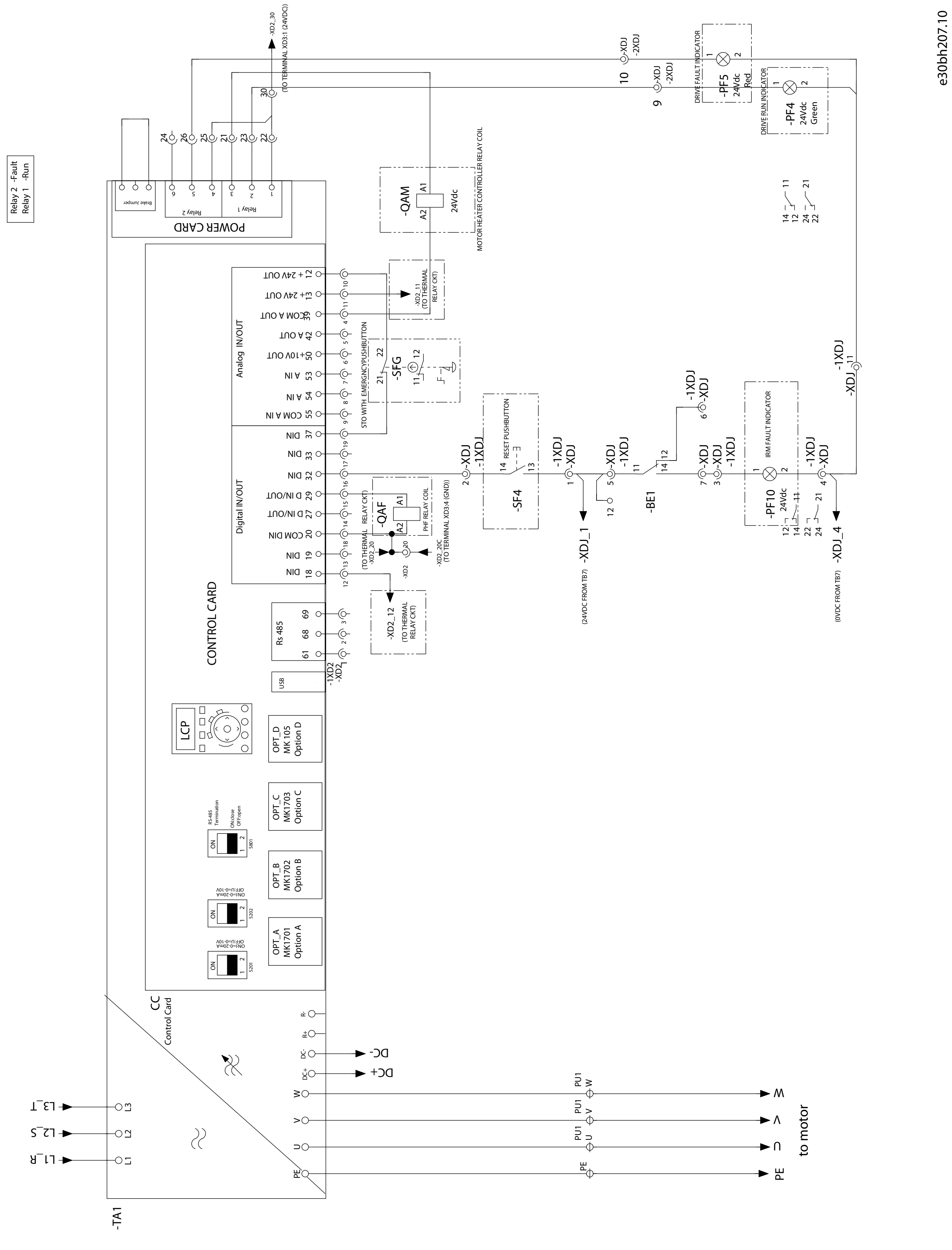


Illustration 117: Control Option Overview Block Diagram for D9h–D10h/E5h–E6h

11.12 Customer Terminals for 230/115 V AC Input

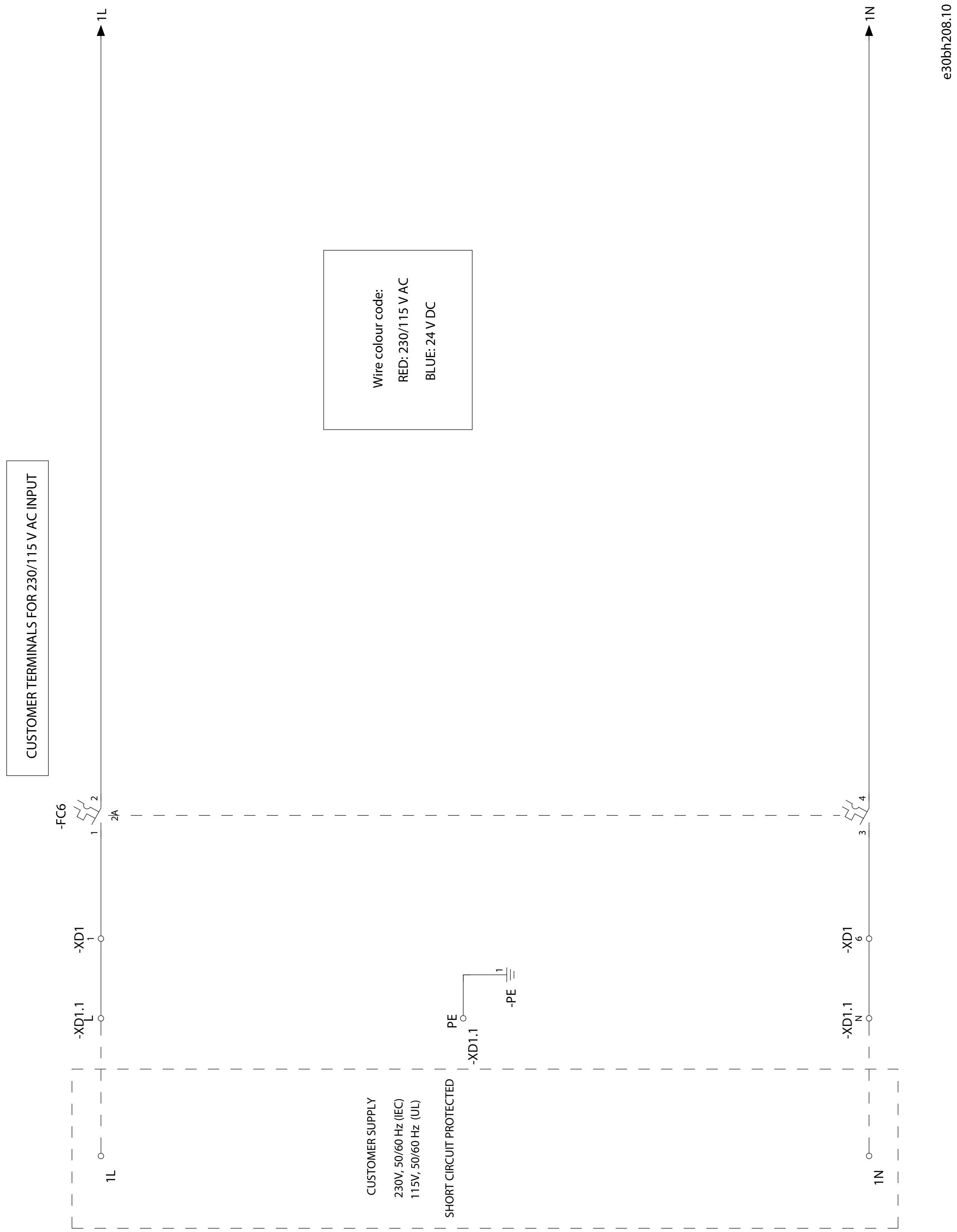


Illustration 118: Customer Terminals for 230/115 V AC Input Block Diagram

11.13 Auxiliary Transformer 120 V AC for 380–480/500 Voltage

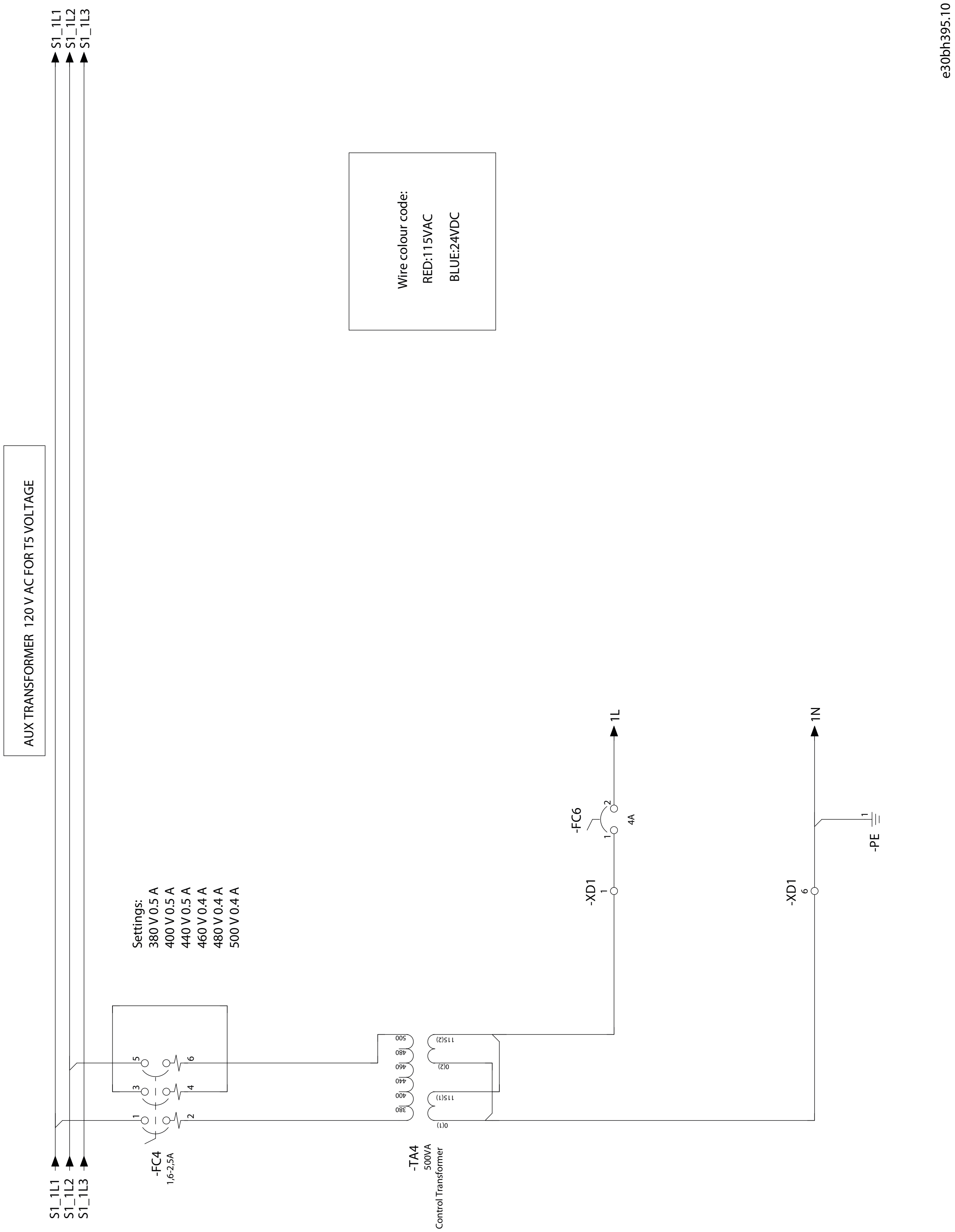


Illustration 119: Auxiliary Transformer 120 V AC for 380–480/500 (T5) Voltage Block Diagram

11.14 Auxiliary Transformer 230 V AC for 380–480/500 Voltage

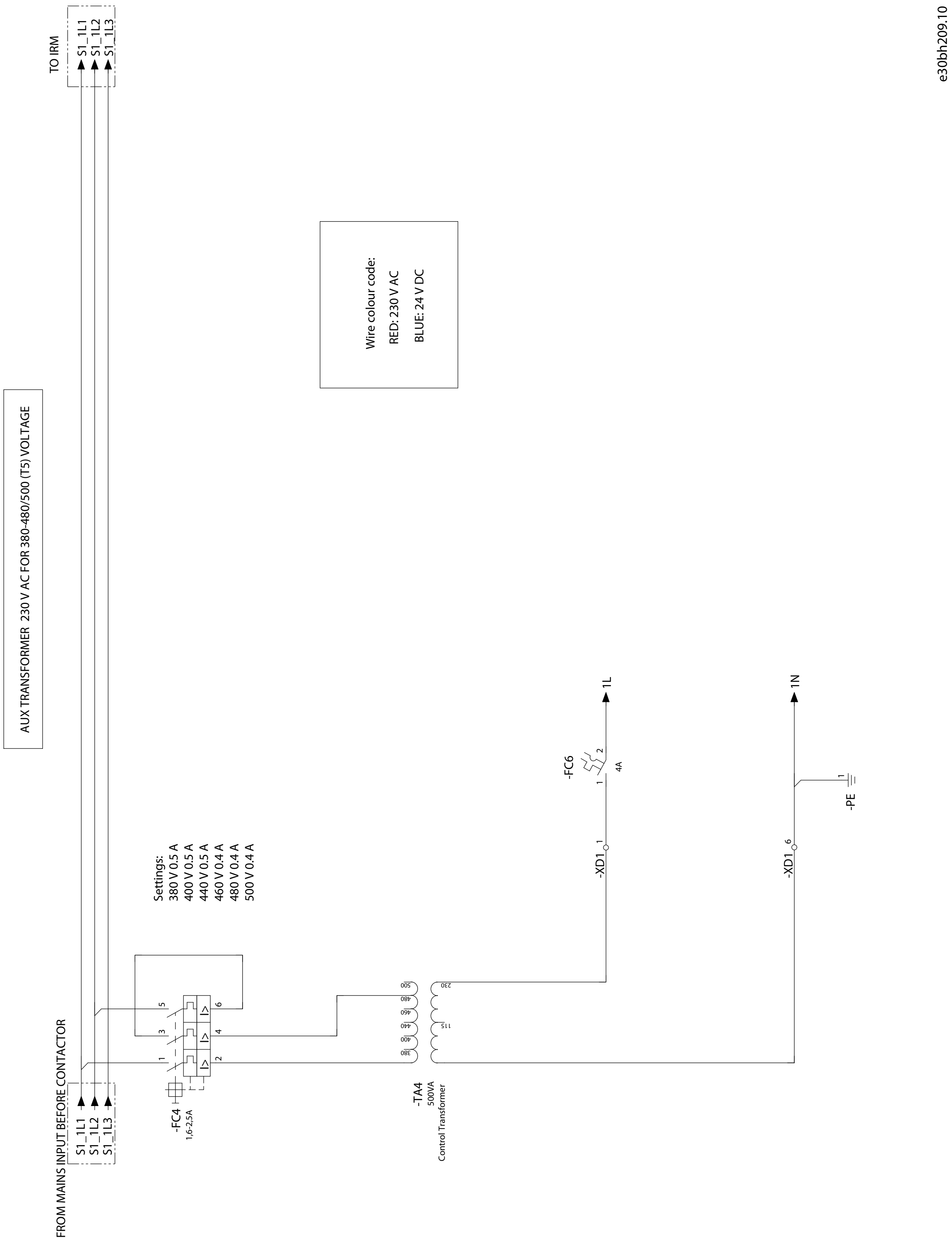


Illustration 120: Auxiliary Transformer 230 V AC for 380–480/500 (T5) Voltage Block Diagram

11.15 Auxiliary Transformer 120 V AC for 525–690 Voltage

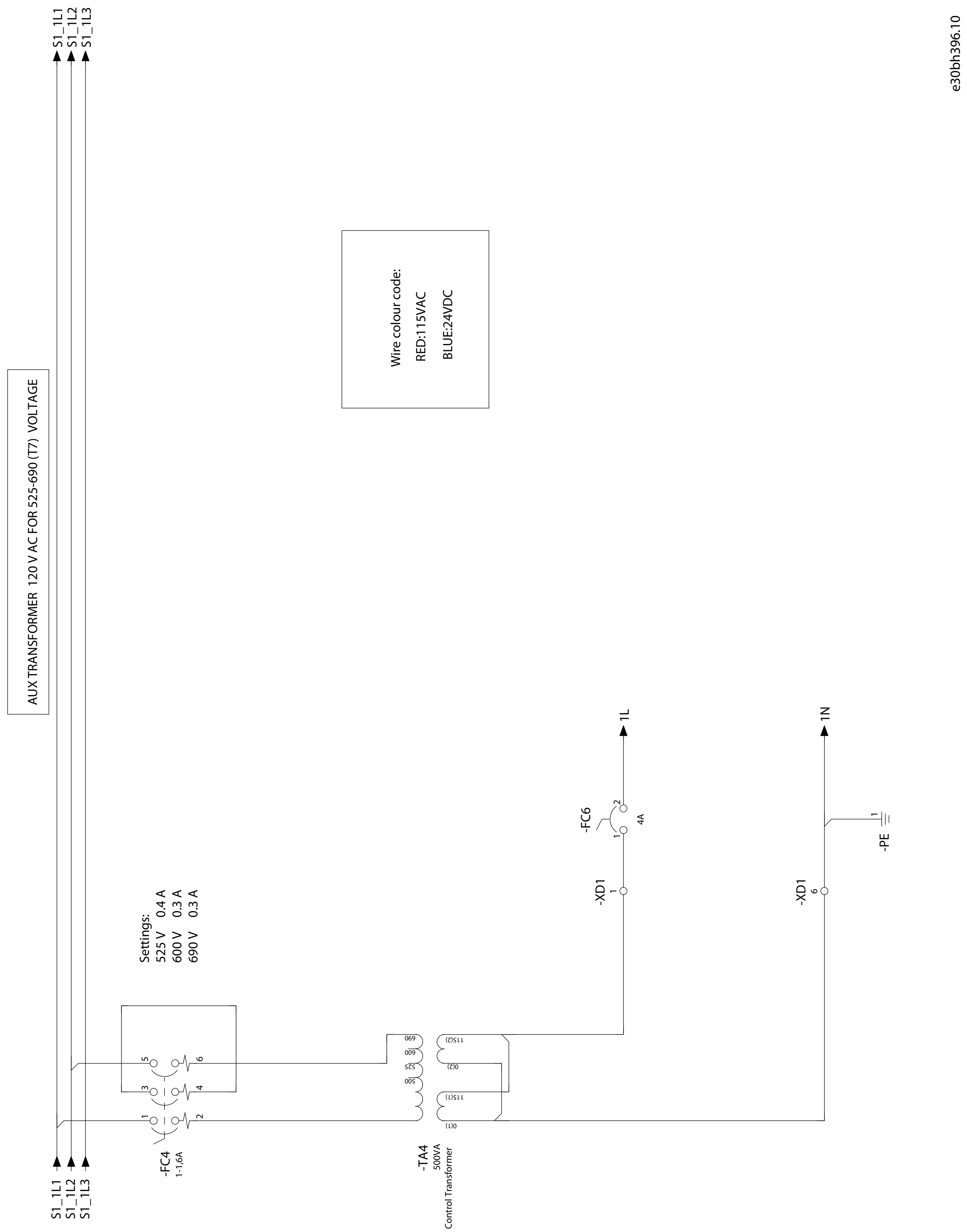


Illustration 121: Auxiliary Transformer 120 V AC for 525–690 (T7) Voltage Block Diagram

11.16 Auxiliary Transformer 230 V AC for 525–690 Voltage

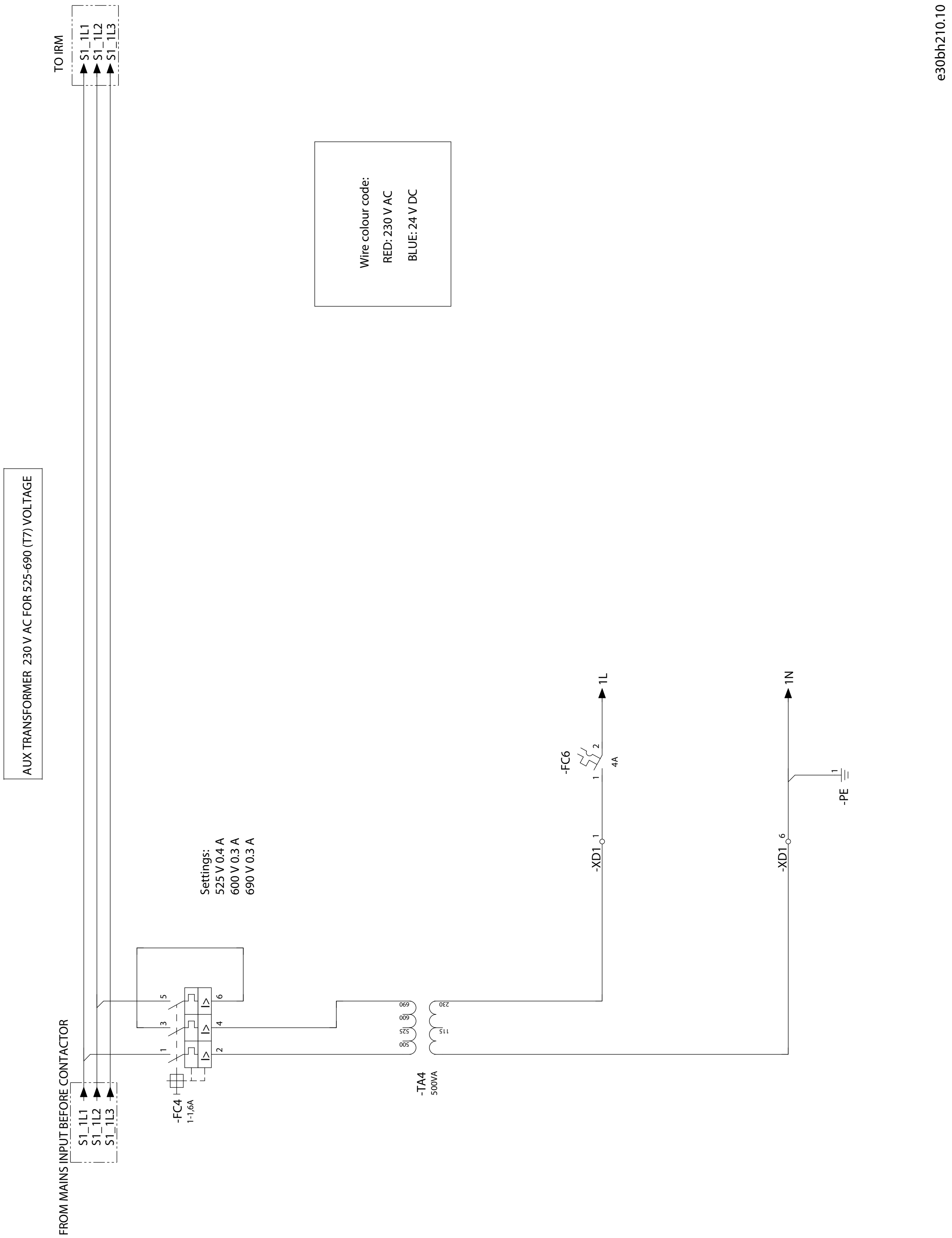


Illustration 122: Auxiliary Transformer 230 V AC for 525–690 (T7) Voltage Block Diagram

11.17 Motor Heater Controller and Cabinet Heater

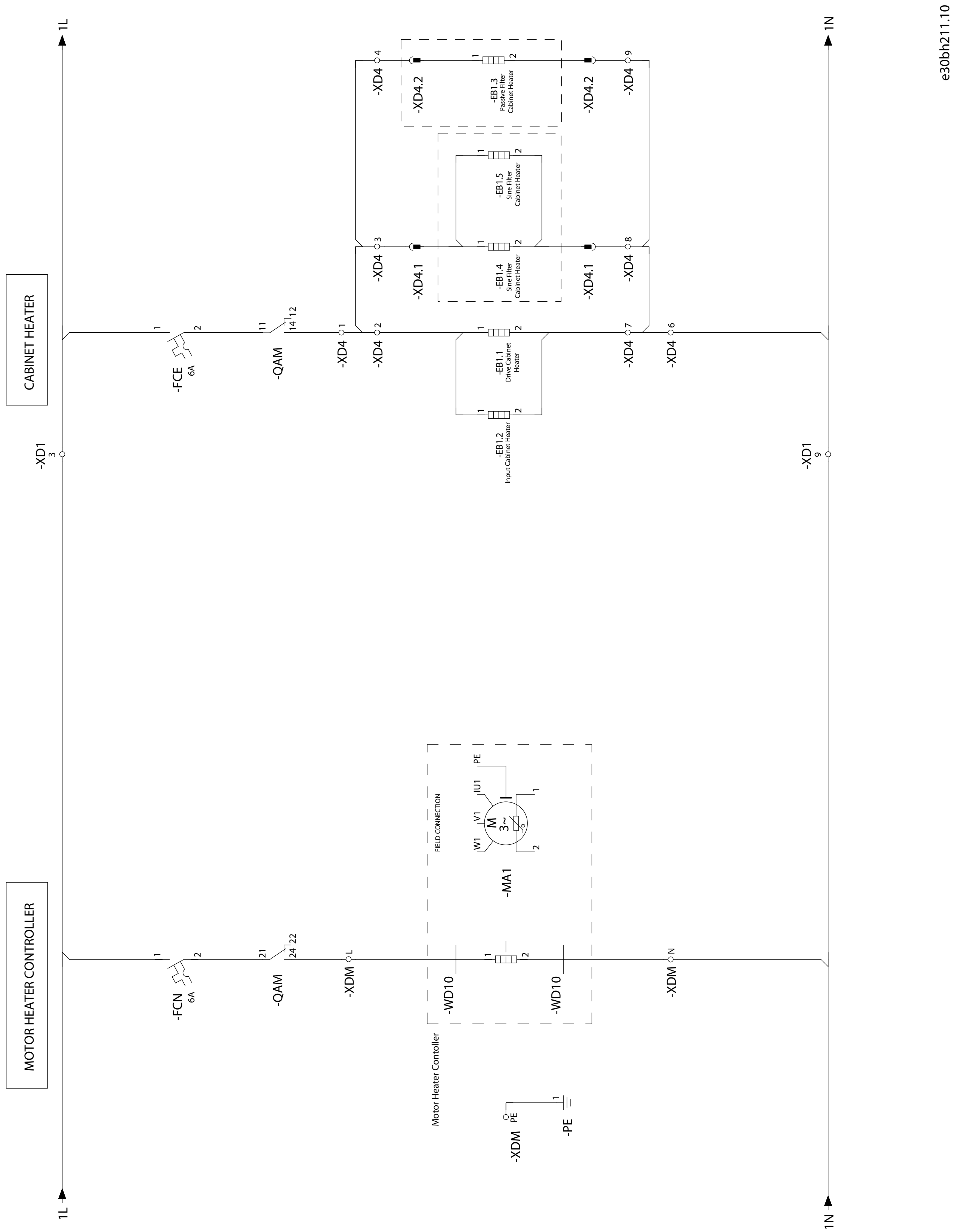


Illustration 123: Motor Heater Controller and Cabinet Heater Block Diagram

11.18 24 V DC Power Supply and PHF Contactor Relay

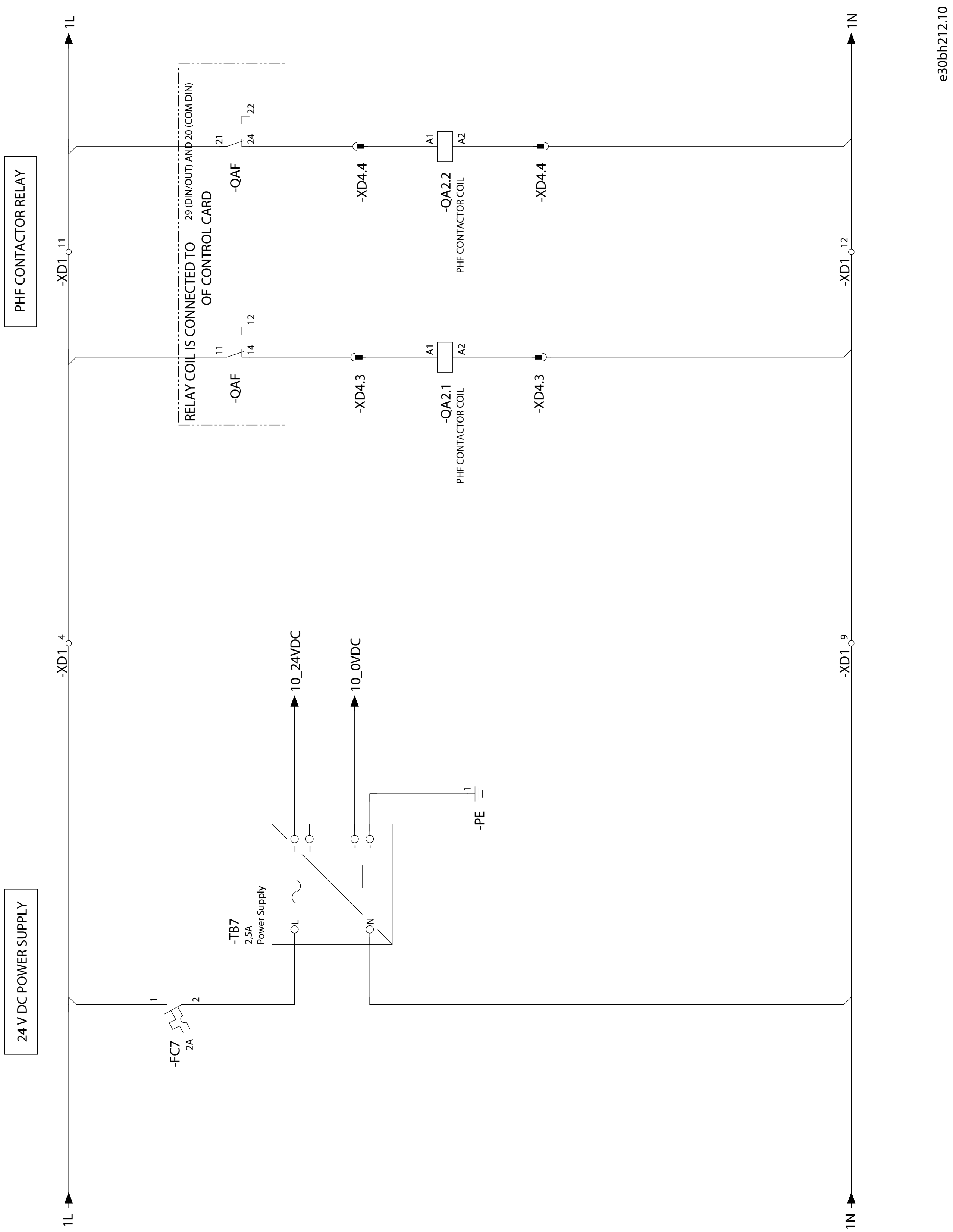


Illustration 124: 24 V DC Power Supply and PHF Contactor Relay Block Diagram

11.19 Customer Socket (UL) and Cabinet Light (UL)

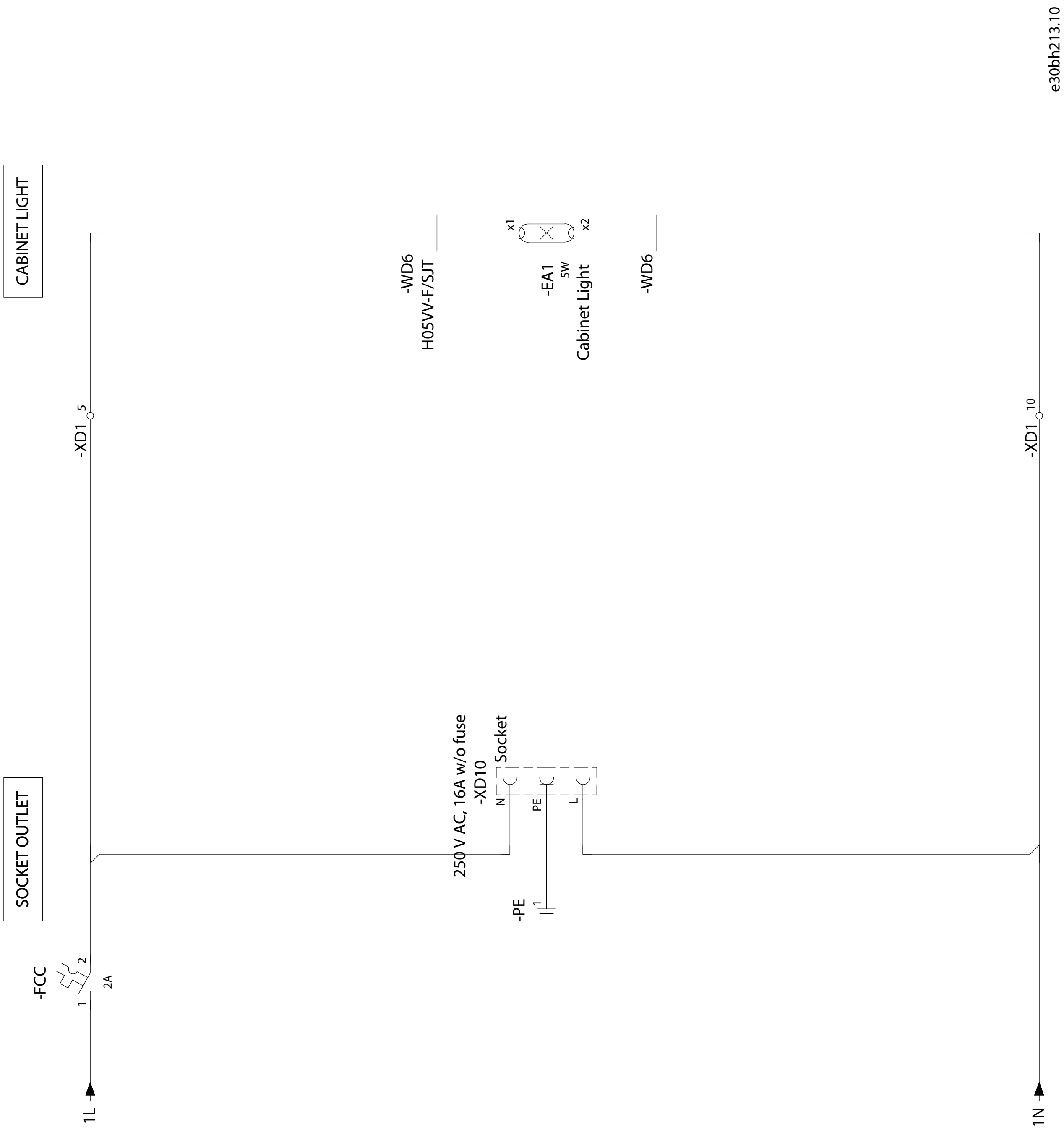


Illustration 125: Customer Socket (UL) and Cabinet Light (UL) Block Diagram

11.20 Customer Socket (IEC) and Cabinet Light (IEC)

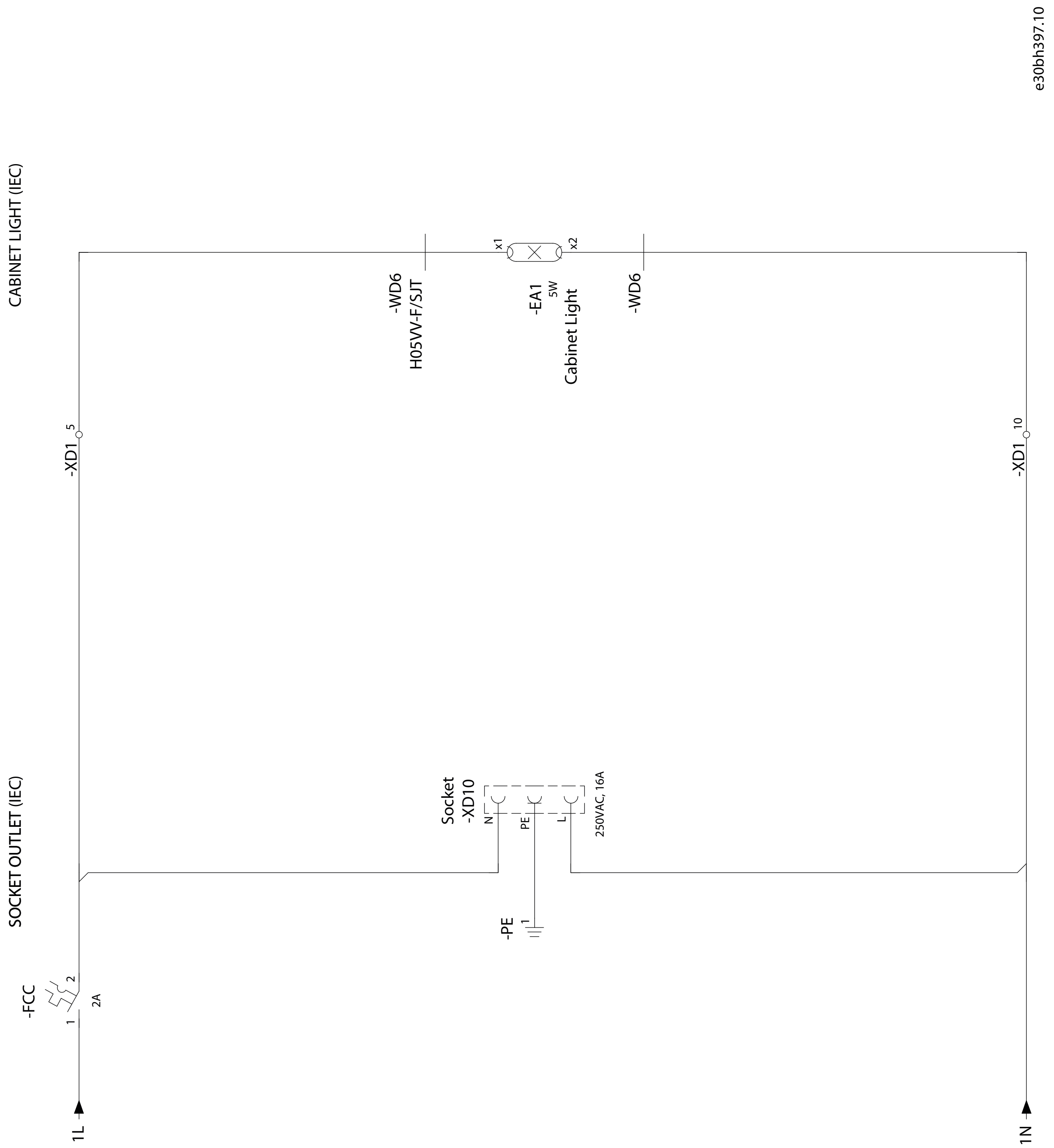


Illustration 126: Customer Socket (IEC) and Cabinet Light (IEC) Block Diagram

11.21 Door Fan 1

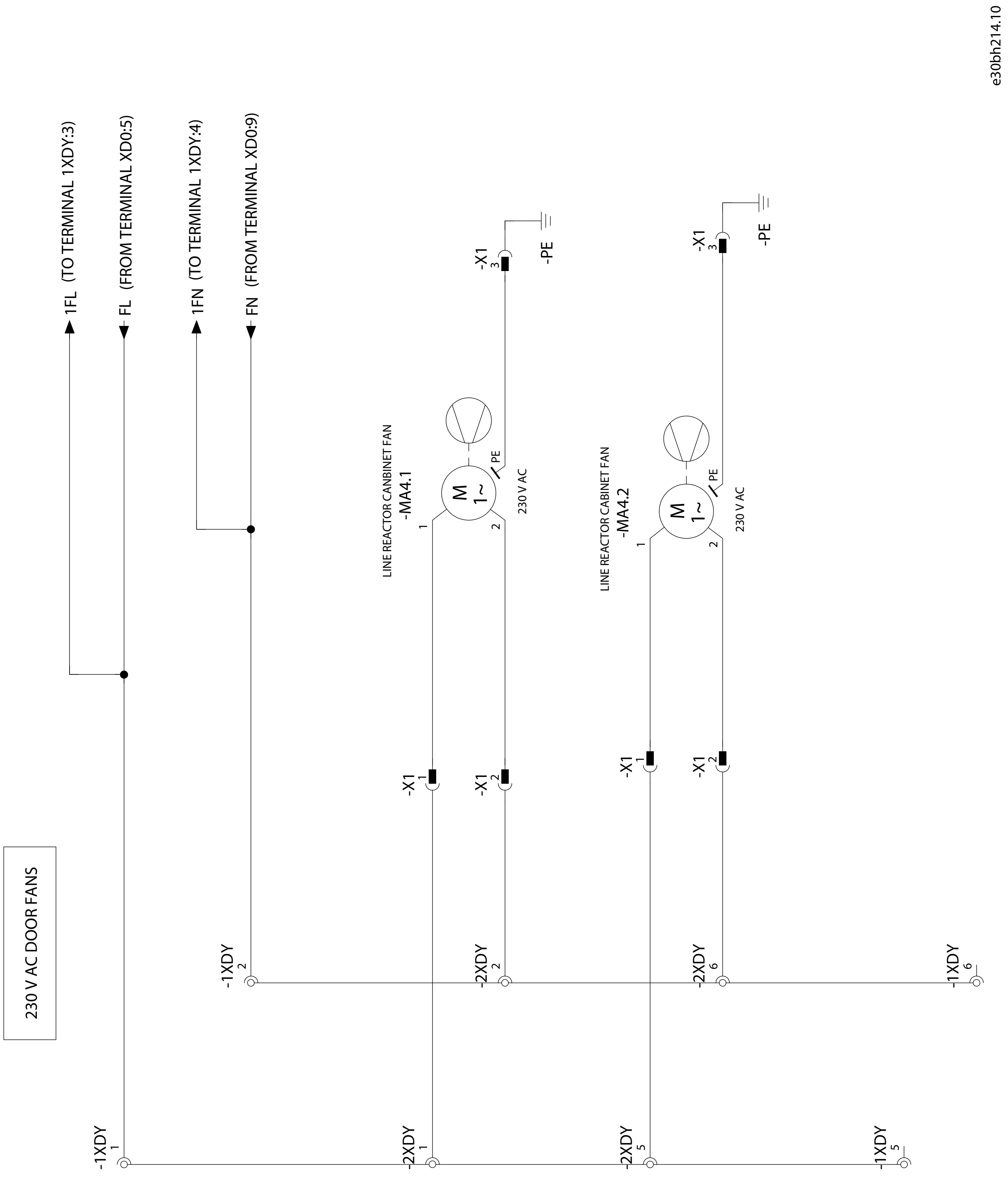


Illustration 127: Door Fan 1 Block Diagram

11.22 Door Fan 2

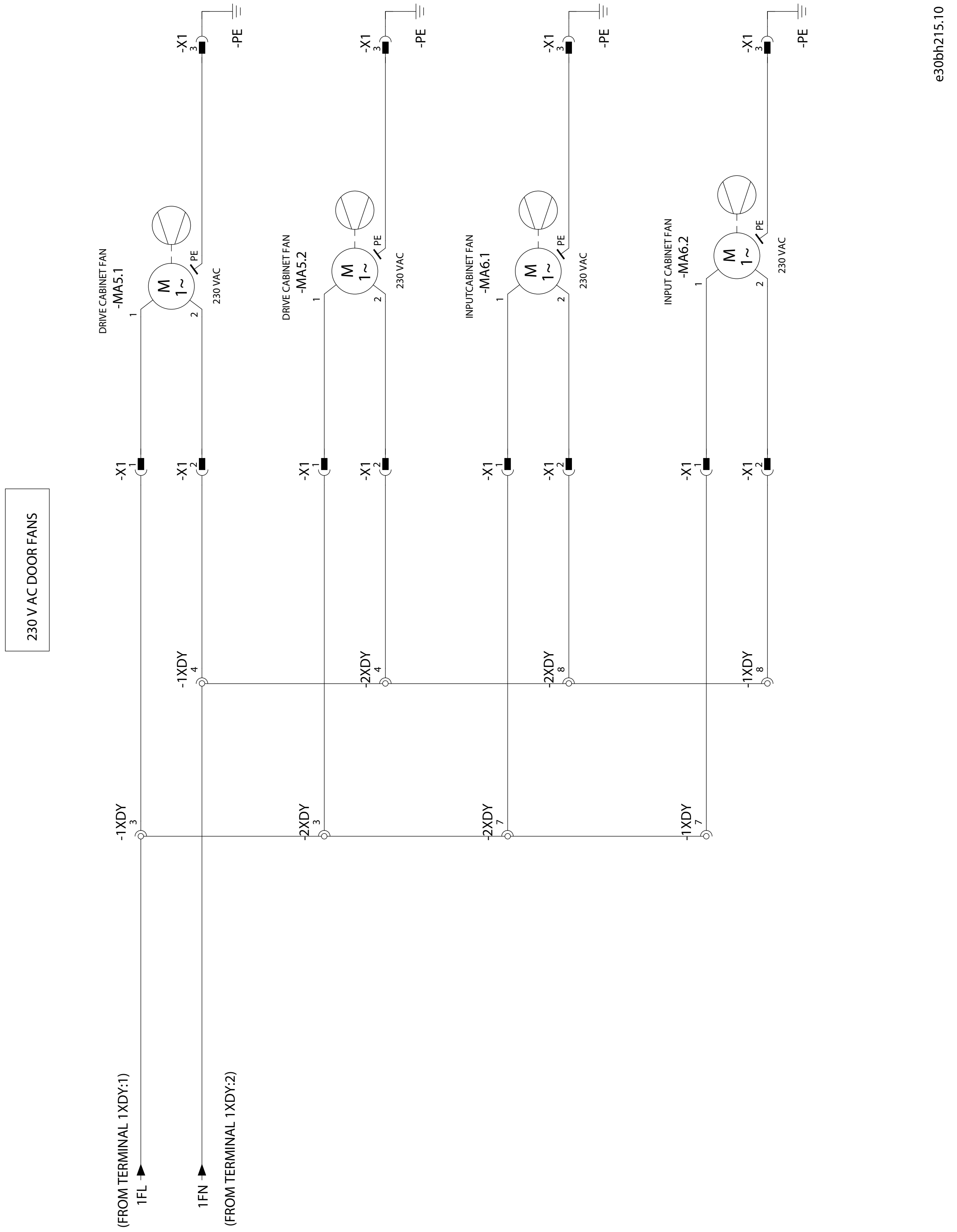


Illustration 128: Door Fan 2 Block Diagram

11.23 Insulation Monitor

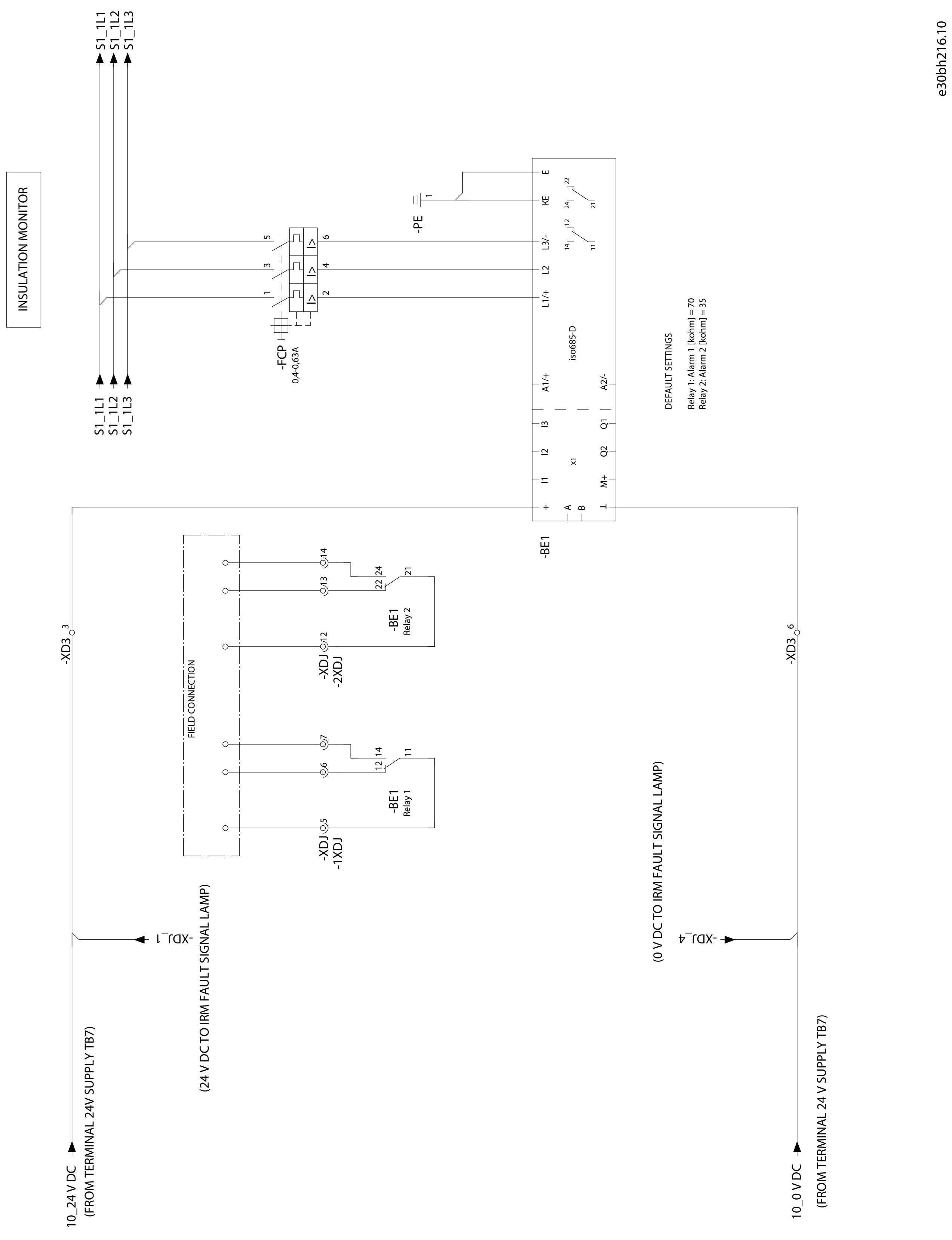


Illustration 129: Insulation Monitor Block Diagram

11.24 Thermal Relay Connections

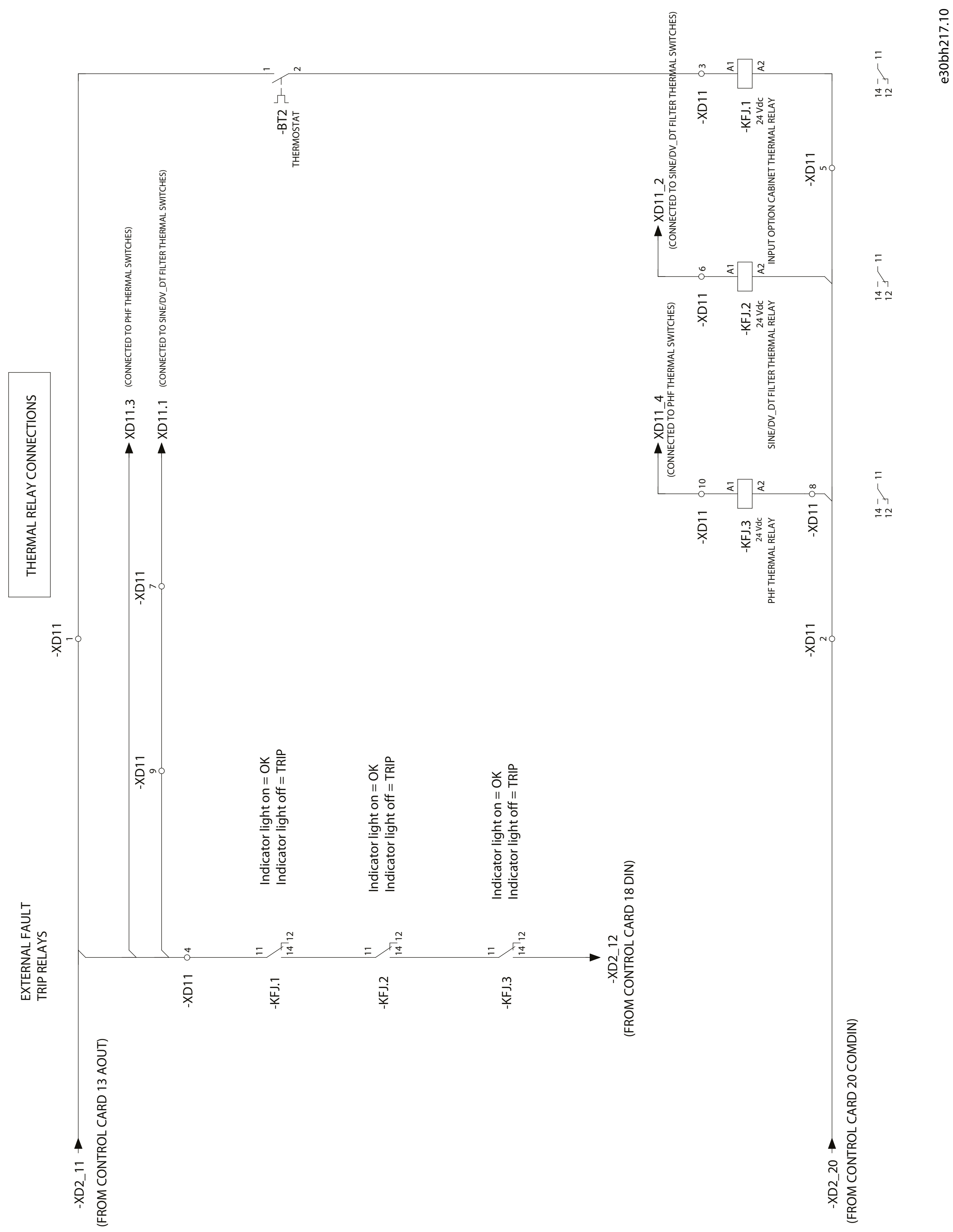


Illustration 130: Thermal Relay Connections Block Diagram

11.25 24 V DC Terminal Connection

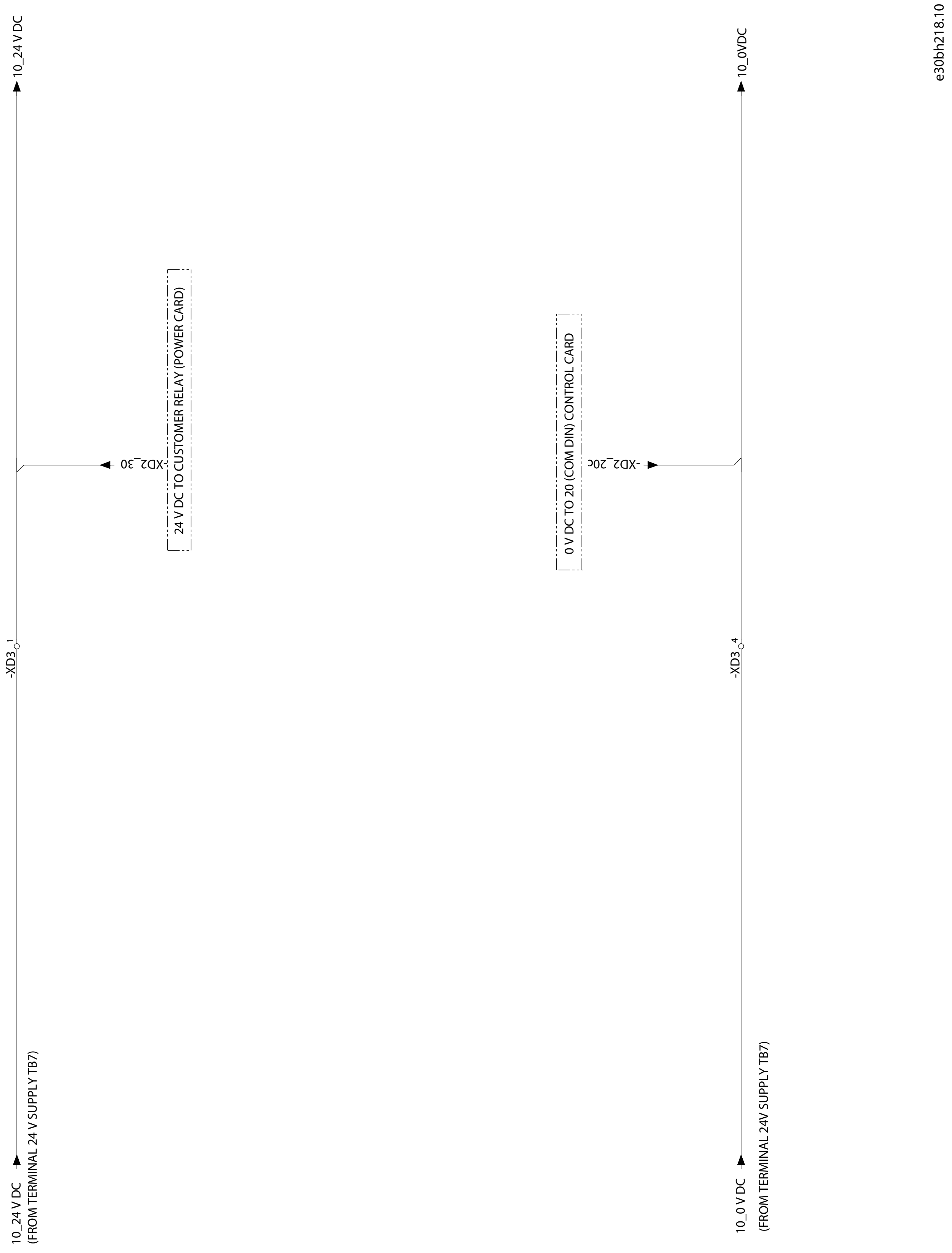


Illustration 131: 24 V DC Terminal Connection Block Diagram

11.26 Door Fan Input

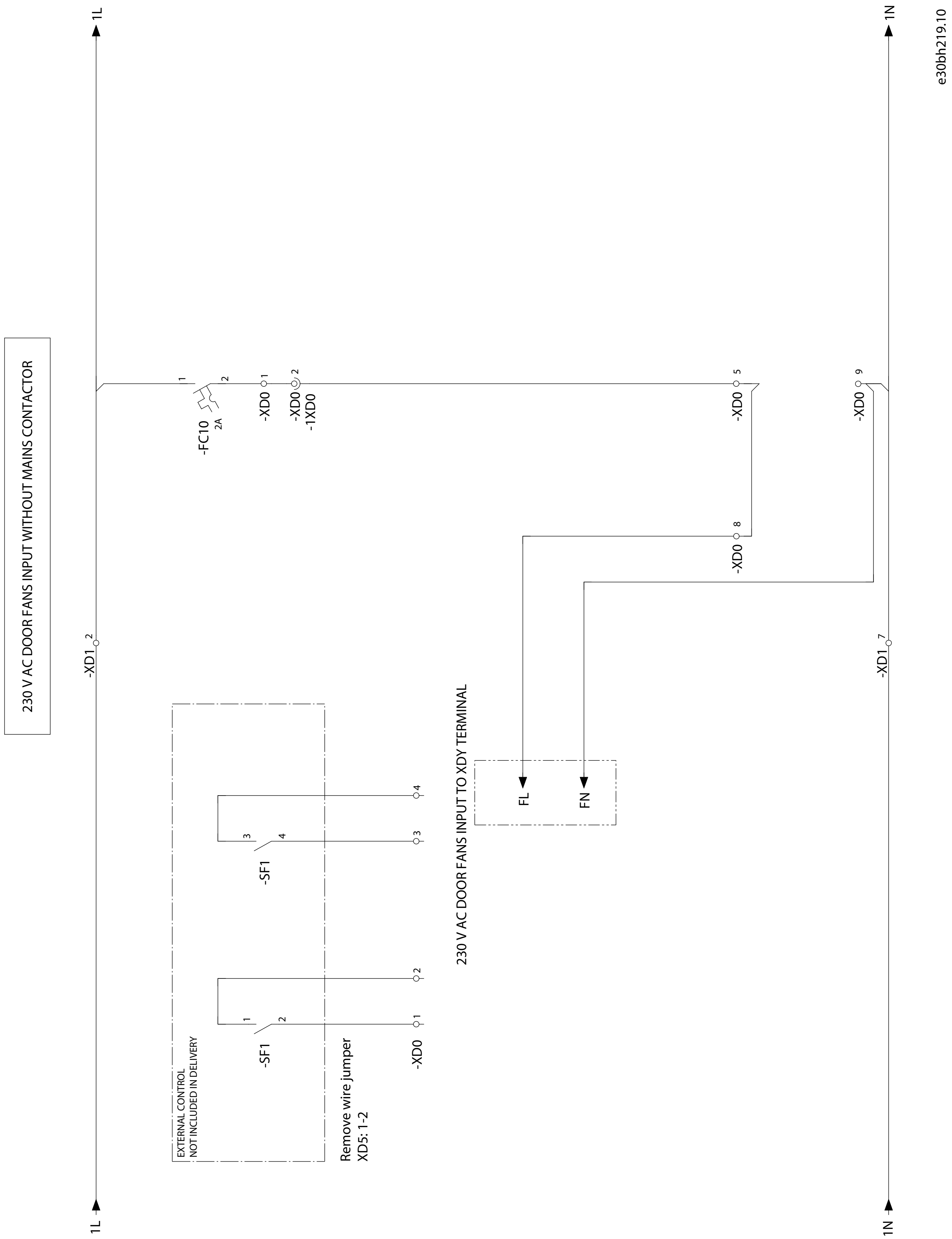


Illustration 132: Door Fan Input (without Mains Contactor) Block Diagram

11.27 Mains Contactor

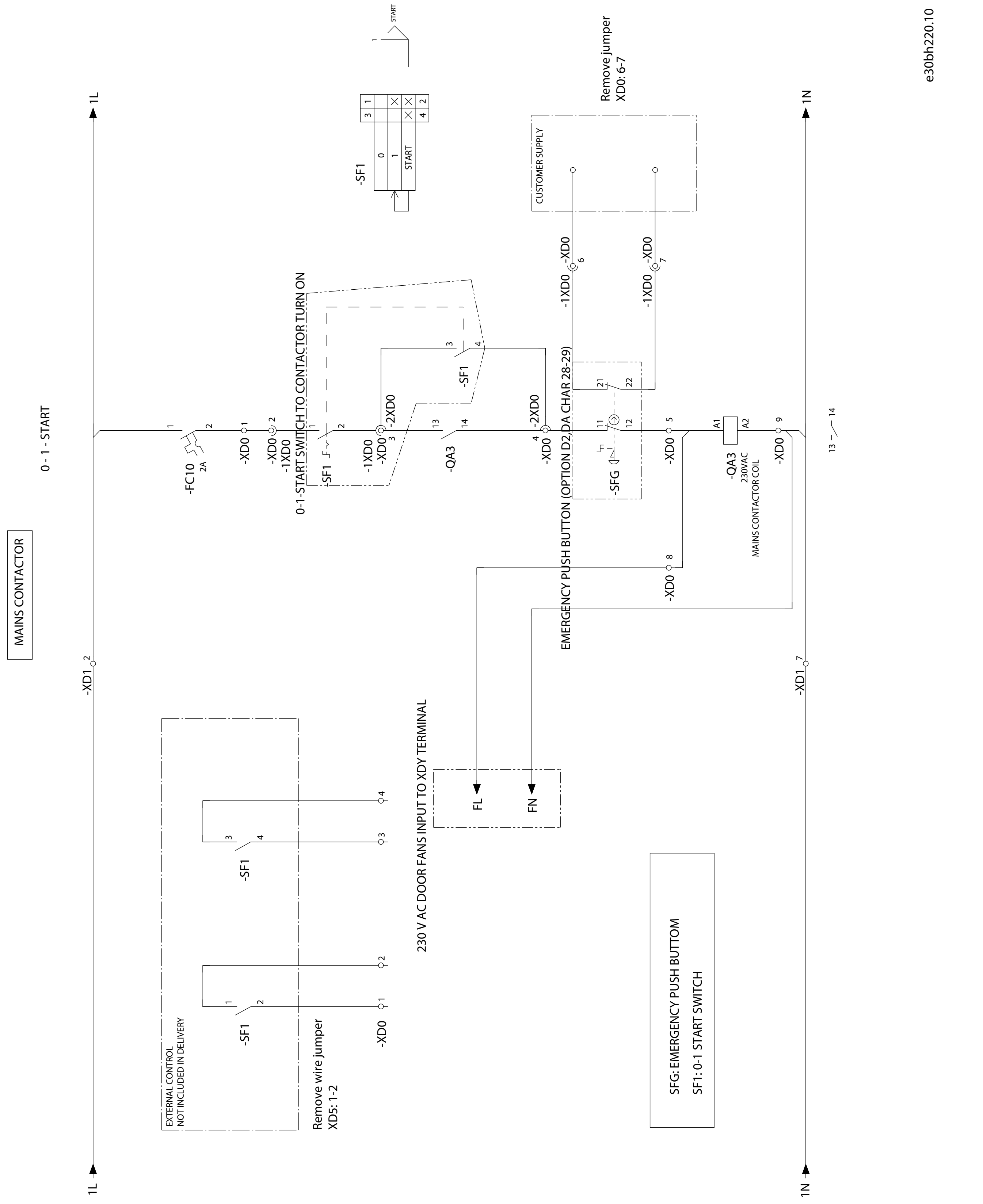


Illustration 133: Mains Contactor Block Diagram

12 Spare Parts

12.1 Spare Parts D9h-D10h/E5h-E6h Enclosed Drives

Table 92: Spare Parts List, D9h-D10h/E5h-E6h Enclosed Drives

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	Fusible Disconnect (Fused Disconnector)				
181n0458	Fused Disconnector, 400A, IEC	302	380–500, 525–690	I	90, 110, 132
	Fused Disconnector, 400A, IEC	103, 102, 202	380–480, 525–690	I	110, 132, 160
181n0443	Fused Disconnector, 630A, IEC	302	380–500	I	160, 200, 250
	Fused Disconnector, 630A, IEC	103, 102, 202	380–480, 380–500	I	200, 250, 315
	Fused Disconnector, 630A,IEC	302	525–690	I	160, 200, 250, 315, 355
	Fused Disconnector, 630A,IEC	103, 102, 202	525–690	I	200, 250, 315, 400
181n0459	Fused Disconnector, 1250A, IEC	302	380–500	I	315, 355, 400, 450, 500
	Fused Disconnector, 1250A, IEC	103, 102, 202	380–480, 380–500	I	355, 400, 450, 500, 560
	Fused Disconnector, 1250A, IEC	302	525–690	I	400, 500, 560, 630, 710
	Fused Disconnector, 1250A, IEC	103, 102, 202	525–690	I	500, 560, 630, 710, 800
181n0460	Fused Disconnector, 400A, UL	302	380–500	U	90, 110, 132
	Fused Disconnector, 400A, UL	103, 102, 202	380–480	U	110, 132,160
	Fused Disconnector, 400A, UL	302	525–600	U	90, 110, 132,160, 200
	Fused Disconnector, 400A, UL	103, 102, 202	525–600	U	110, 132, 160, 200, 250
181n0462	Fused Disconnector, 600A, UL	302	380–500	U	160, 200, 250
	Fused Disconnector, 600A, UL	103, 102, 202	380–480	U	200, 250, 315
	Fused Disconnector, 600A, UL	302	525–600	U	250, 315, 355
	Fused Disconnector, 600A, UL	103, 102, 202	525–600	U	315, 400, 450
181n0461	Fused Disconnector, 800A, UL	302	380–500	U	315
	Fused Disconnector, 800A, UL	103, 102, 202	380–480	U	355
	Fused Disconnector, 800A, UL	302	525–600	U	400, 500, 560
	Fused Disconnector, 800A, UL	103, 102, 202	525–600	U	500, 560, 630
181n0463	Fused Disconnector, 1200A, UL	302	380–500	U	355, 400, 450, 500
	Fused Disconnector, 1200A, UL	103, 102, 202	380–480	U	400, 450, 500, 560
	Fused Disconnector, 1200A, UL	302	525–600	U	630, 710
	Fused Disconnector, 1200A, UL	103, 102, 202	525–600	U	710, 800
	Non-fusible Disconnect (Switch Disconnector)				
181n0464	Switch Disconnector, 400A, IEC	302	380–500, 525–690	I	90, 110, 132
	Switch Disconnector, 400A, IEC	103, 102, 202	380–480, 525–690	I	110, 132, 160
181n0465	Switch Disconnector, 630A, IEC	302	380–500	I	160, 200, 250
	Switch Disconnector, 630A, IEC	103, 102, 202	380–480	I	200, 250, 315

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	Switch Disconnector, 630A, IEC	302	525–690	I	160, 200, 250, 315, 355, 400
	Switch Disconnector, 630A, IEC	103, 102, 202	525–690	I	200, 250, 315, 400, 450, 500
181n0466	Switch Disconnector, 1000A, IEC	302	380–500	I	315, 355
	Switch Disconnector, 1000A, IEC	103, 102, 202	380–480	I	355, 400
	Switch Disconnector, 1000A, IEC	302	525–690	I	500, 560
	Switch Disconnector, 1000A, IEC	103, 102, 202	525–690	I	560, 630
181n0467	Switch Disconnector, 1250A, IEC	302	380–500	I	400, 450, 500
	Switch Disconnector, 1250A, IEC	103, 102, 202	380–480	I	450, 500, 560
	Switch Disconnector, 1250A, IEC	302	525–690	I	630, 710
	Switch Disconnector, 1250A, IEC	103, 102, 202	525–690	I	710, 800
181n0562	Switch Disconnector, 400A, UL	302	380–500, 525–600	U	90, 110, 132
	Switch Disconnector, 400A, UL	103, 102, 202	380–480, 525–600	U	110, 132, 160
181n0468	Switch Disconnector, 600A, UL	302	380–500	U	160, 200
	Switch Disconnector, 600A, UL	103, 102, 202	380–480	U	200, 250
	Switch Disconnector, 600A, UL	302	525–600	U	160, 200, 250, 315, 355, 400
	Switch Disconnector, 600A, UL	103, 102, 202	525–600	U	200, 250, 315, 400, 450, 500
181n0469	Switch Disconnector, 800A,UL	302	380–500	U	250
	Switch Disconnector, 800A,UL	103, 102, 202	380–480	U	315
	Switch Disconnector, 800A,UL	302	525–600	U	500, 560
	Switch Disconnector, 800A,UL	103, 102, 202	525–600	U	560, 630
181n0470	Switch Disconnector, 1200A, UL	302	380–500	U	355, 400, 450, 500
	Switch Disconnector, 1200A, UL	103, 102, 202	380–480	U	400, 450, 500, 560
	Switch Disconnector, 1200A, UL	302	525–600	U	630, 710
	Switch Disconnector, 1200A, UL	103, 102, 202	525–600	U	710, 800
	Fuses				
181n0471	Mains Fuse, 250A,500V, IEC	302	380–500	I	90
	Mains Fuse, 250A,500V, IEC	103, 102, 202	380–480	I	110
181n0472	Mains Fuse, 315A,500V, IEC	302	380–500	I	110
	Mains Fuse, 315A,500V, IEC	103, 102, 202	380–480	I	132
181n0473	Mains Fuse, 355A,500V, IEC	302	380–500	I	132
	Mains Fuse, 355A,500V, IEC	103, 102, 202	380–480	I	160
181n0474	Mains Fuse, 425A,500V, IEC	302	380–500	I	160
	Mains Fuse, 425A,500V, IEC	103, 102, 202	380–480	I	200
181n0475	Mains Fuse, 630A,500V, IEC	302	380–500	I	200, 250
	Mains Fuse, 630A,500V, IEC	103, 102, 202	380–480	I	250, 315
181n0476	Mains Fuse, 250A,690V, IEC	302	525–690	I	90, 110, 132

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	Mains Fuse, 250A,690V, IEC	103, 102, 202	525–690	I	110, 132, 160
181n0477	Mains Fuse, 315A,690V, IEC	302	525–690	I	160
	Mains Fuse, 315A,690V, IEC	103, 102, 202	525–690	I	200
181n0479	Mains Fuse, 355A,690V, IEC	302	525–690	I	200
	Mains Fuse, 355A,690V, IEC	103, 102, 202	525–690	I	250
181n0478	Mains Fuse, 425A,690V, IEC	302	525–690	I	250
	Mains Fuse, 425A,690V, IEC	103, 102, 202	525–690	I	315
181n0444	Mains Fuse, 500A,690V,IEC	302	525–690	I	315, 355
	Mains Fuse, 500A,690V,IEC	103, 102, 202	525–690	I	400, 450
181n0480	Mains Fuse, 800A,500V, IEC	302	380–500	I	315
	Mains Fuse, 800A,500V, IEC	103, 102, 202	380–480	I	355
181n0481	Mains Fuse, 1000A,500V, IEC	302	380–500	I	355, 400, 450
	Mains Fuse, 1000A,500V, IEC	103, 102, 202	380–480	I	400, 450, 500
181n0482	Mains Fuse, 1250A,500V, IEC	302	380–500	I	500
	Mains Fuse, 1250A,500V, IEC	103, 102, 202	380–480	I	560
181n0483	Mains Fuse, 630A, 690V,IEC	302	525–690	I	400
	Mains Fuse, 630A, 690V,IEC	103, 102, 202	525–690	I	500
181n0484	Mains Fuse, 800A, 690V,IEC	302	525–690	I	500, 560
	Mains Fuse, 800A, 690V,IEC	103, 102, 202	525–690	I	560, 630
181n0485	Mains Fuse, 1000A, 690V,ABB	302	525–690	I	630, 710
	Mains Fuse, 1000A, 690V,ABB	103, 102, 202	525–690	I	710, 800
181n0486	Mains Fuse, A4J300,300A,600V,UL,UL	302	380–500	U	90
	Mains Fuse, A4J300,300A,600V,UL,UL	103, 102, 202	380–480	U	110
181n0487	Mains Fuse, A4J350,350A,600V,UL,UL	302	380–500	U	110
	Mains Fuse, A4J350,350A,600V,UL,UL	103, 102, 202	380–480	U	132
	Mains Fuse, A4J350,350A,600V,UL,UL	302	525–600	U	160
	Mains Fuse, A4J350,350A,600V,UL,UL	103, 102, 202	525–600	U	200
181n0488	Mains Fuse, A4J400,400A,600V,UL,UL	302	380–500	U	132
	Mains Fuse, A4J400,400A,600V,UL,UL	103, 102, 202	380–480	U	160
	Mains Fuse, A4J400,400A,600V,UL,UL	302	525–600	U	200
	Mains Fuse, A4J400,400A,600V,UL,UL	103, 102, 202	525–600	U	250
181n0489	Mains Fuse, A4J500,500A,600V,UL,UL	302	380–500	U	160
	Mains Fuse, A4J500,500A,600V,UL,UL	103, 102, 202	380–480	U	200
	Mains Fuse, A4J500,500A,600V,UL,UL	302	525–600	U	250
	Mains Fuse, A4J500,500A,600V,UL,UL	103, 102, 202	525–600	U	315
181n0491	Mains Fuse, A4BY750,750A,600V,UL	302	380–500	U	250

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	Mains Fuse, A4BY750,750A,600V,UL	103, 102, 202	380–480	U	315
	Mains Fuse, A4BY750,750A,600V,UL	302	525–600	U	500
	Mains Fuse, A4BY750,750A,600V,UL	103, 102, 202	525–600	U	560
181n0492	Mains Fuse, A4J175,175A,600V,UL	302	525–600	U	90
	Mains Fuse, A4J175 175A,600V,UL	103, 102, 202	525–600	U	110
181n0493	Mains Fuse, A4J200, 200A,600V,UL	302	525–600	U	110
	Mains Fuse, A4J200, 200A,600V,UL	103, 102, 202	525–600	U	132
181n0494	Mains Fuse, A4J250, 250A,600V,UL	302	525–600	U	132
	Mains Fuse, A4J250, 250A,600V,UL	103, 102, 202	525–600	U	160
181n0490	Mains Fuse, A4J600, 600A,600V,UL	302	380–500	U	200
	Mains Fuse, A4J600, 600A,600V,UL	103, 102, 202	380–480	U	250
	Mains Fuse, A4J600, 600A,600V,UL	302	525–600	U	315, 355
	Mains Fuse, A4J600, 600A,600V,UL	103, 102, 202	525–600	U	400, 450
181n0495	Mains Fuse, A4BY800, 800A,600V,UL	302	380–500	U	315
	Mains Fuse, A4BY800, 800A,600V,UL	103, 102, 202	380–480	U	355
	Mains Fuse, A4BY800, 800A,600V,UL	302	525–600	U	560
	Mains Fuse, A4BY800, 800A,600V,UL	103, 102, 202	525–600	U	630
181n0496	Mains Fuse, A4BY1000,1000A,600V,UL	302	380–500	U	355, 400, 450
	Mains Fuse, A4BY1000,1000A,600V,UL	103, 102, 202	380–480	U	400, 450, 500
	Mains Fuse, A4BY1000,1000A,600V,UL	302	525–600	U	630
	Mains Fuse, A4BY1000,1000A,600V,UL	103, 102, 202	525–600	U	710
181n0498	Mains Fuse, A4BY1200,1200A,600V,UL	302	380–500	U	500
	Mains Fuse, A4BY1200,1200A,600V,UL	103, 102, 202	380–480	U	560
181n0499	Mains Fuse, A4BY650, 650A,600V,UL	302	525–600	U	400
	Mains Fuse, A4BY650, 650A,600V,UL	103, 102, 202	525–600	U	500
181n0497	Mains Fuse, A4BY1100,1100A,600V,UL	302	525–600	U	710
	Mains Fuse, A4BY1100,1100A,600V,UL	103, 102, 202	525–600	U	800
	MCCB (Molded Case Circuit Breaker)				
181n0675	Circuit Breaker, T5L400, 600V, IEC	302	380–500, 525–690	I	90, 110, 132
	Circuit Breaker, T5L400, 600V, IEC	103, 102, 202	380–480, 525–690	I	110, 132, 160
181n0508	Circuit Breaker, T6L800, 600V, IEC	302	380–500	I	160, 200, 250
	Circuit Breaker, T6L800, 600V, IEC	103, 102, 202	380–480	I	200, 250, 315
181n0509	Circuit Breaker, T6L630, 600V, IEC	302	525–690	I	160, 200, 250, 315
	Circuit Breaker, T6L630, 600V, IEC	103, 102, 202	525–690	I	200, 250, 315, 400
181n0510	Circuit Breaker, T7L1000, 600V, IEC	302	380–500	I	315
	Circuit Breaker, T7L1000, 600V, IEC	103, 102, 202	380–480	I	355

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	Circuit Breaker T7L1000, 600V, IEC	302	525–690	I	355, 400, 500, 560
	Circuit Breaker, T7L1000, 600V, IEC	103, 102, 202	525–690	I	400, 450, 560, 630
181n0511	Circuit Breaker, T7L1250, 600V, IEC	302	380–500	I	355, 400, 450
	Circuit Breaker, T7L1250, 600V, IEC	103, 102, 202	380–480	I	400, 450, 500
	Circuit Breaker, T7L1250, 600V, IEC	302	525–690	I	630, 710
	Circuit Breaker, T7L1250, 600V, IEC	103, 102, 202	525–690	I	710, 800
181n0512	Circuit Breaker, T7L1600, 600V, IEC	302	380–500	I	500
	Circuit Breaker, T7L1600, 600V, IEC	103, 102, 202	380–480	I	560
181n0500	Circuit Breaker, T5L400BW UL/CSA PR221DS-LS	302	380–500, 525–600	U	90, 110, 132
	Circuit Breaker, T5L400BW UL/CSA PR221DS-LS	103, 102, 202	380–480,525–600	U	110, 132, 160
181n0501	Circuit Breaker, T6L600BW UL/CSA PR221DS-LS	302	380–500	U	160, 200
	Circuit Breaker, T6L600BW UL/CSA PR221DS-LS	103, 102, 202	380–480	U	200, 250
	Circuit Breaker, T6L600BW UL/CSA PR221DS-LS	302	525–600	U	160, 200, 250
	Circuit Breaker, T6L600BW UL/CSA PR221DS-LS	103, 102, 202	525–600	U	200, 250, 315
181n0502	Circuit Breaker, T6LQ600BW UL/CSA PR221DS-LS	302	525–600	U	315
	Circuit Breaker, T6LQ600BW UL/CSA PR221DS-LS	103, 102, 202	525–600	U	400
181n0503	Circuit Breaker, T6L 800 UL/CSA PR221DS-LS	302	380–500	U	250
	Circuit Breaker, T6L 800 UL/CSA PR221DS-LS	103, 102, 202	380–480	U	315
181n0506	Circuit Breaker, T7L 1000 UL PR231/P LS	302	525–600	U	355, 400
	Circuit Breaker, T7L 1000 UL PR231/P LS	103, 102, 202	525–600	U	400, 450
181n0504	Circuit Breaker, T7L 1200 UL PR231/P LS	302	380–500	U	315, 355, 400
	Circuit Breaker, T7L 1200 UL PR231/P LS	103, 102, 202	380–480	U	355, 400, 450
	Circuit Breaker, T7L 1200 UL PR231/P LS	302	525–600	U	500, 560, 630, 710
	Circuit Breaker, T7L 1200 UL PR231/P LS	103, 102, 202	525–600	U	560, 630, 710, 800
181n0505	Circuit Breaker, T8V1600, 600V, UL	302	525–600	U	450, 500
	Circuit Breaker, T8V1600, 600V, UL	103, 102, 202	525–600	U	500, 560

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	Mains Contactor				
181n0445	Contactor, 400A/400V/AC-3/2NO	302	380–500	I,U	90, 110, 132, 160, 200
	Contactor, 400A/400V/AC-3/2NO	103, 102, 202	380–480	I,U	110, 132, 160, 200, 250
	Contactor, 400A/400V/AC-3/2NO	302	525–600/690	I,U	90, 110, 132, 160, 200, 250, 315
	Contactor, 400A/400V/AC-3/2NO	103, 102, 202	525–600/690	I,U	110, 132, 160, 200, 250, 315, 400
181n0516	Contactor DILM500/22(RA250)	302	380–500	I	250
	Contactor DILM500/22(RA250)	103, 102, 202	380–480	I	315
181n0513	Contactor, 580A/600V/AC-3/2NO+2NC	302	380–500	I,U	315, 355, 400
	Contactor, 580A/600V/AC-3/2NO+2NC	103, 102, 202	380–480	I,U	355, 400, 450
	Contactor, 580A/600V/AC-3/2NO+2NC	302	525–600/690	I,U	355, 400, 500, 560
	Contactor, 580A/600V/AC-3/2NO+2NC	103, 102, 202	525–600/690	I,U	400, 450, 560, 630
181n0514	Contactor, 820A/600V/AC-3/2NO+2NC	302	380–500	I,U	450, 500
	Contactor, 820A/600V/AC-3/2NO+2NC	103, 102, 202	380–480	I,U	500, 560
	Contactor, 820A/600V/AC-3/2NO+2NC	302	525–600/690	I,U	710
	Contactor, 820A/600V/AC-3/2NO+2NC	103, 102, 202	525–600/690	I,U	800
181n0515	Contactor, 1000A/600V/AC-3/2NO +2NC	302	380–500	U	450, 500
	Contactor, 1000A/600V/AC-3/2NO +2NC	103, 102, 202	380–480	U	500, 560
	Contactor, 1000A/600V/AC-3/2NO +2NC	302	525–600	U	710
	Contactor, 1000A/600V/AC-3/2NO +2NC	103, 102, 202	525–600	U	800
	PHF Contactor				
181n0454	Contactor 690V/80A	302	525–690	–	90, 110
	Contactor 690V/80A	103, 102, 202	525–690	–	110, 132
	Contactor 690V/80A	302	380–500	–	90
	Contactor 690V/80A	103, 102, 202	380–480	–	110
181n0455	Contactor 690V/116A	302	525–690	–	132
	Contactor 690V/116A	103, 102, 202	525–690	–	160
	Contactor 690V/116A	302	380–500	–	110
	Contactor 690V/116A	103, 102, 202	380–480	–	132
181n0457	Contactor 1000V/146A	302	525–690	–	160
	Contactor 1000V/146A	103, 102, 202	525–690	–	200
	Contactor 1000V/146A	302	380–500	–	132, 160, 315, 355, 400
	Contactor 1000V/146A	103, 102, 202	380–480	–	160, 200, 355, 400, 450

Code	Description	Drive Series	Voltage	UL/I	Power Rating
181n0456	Contactor 1000V/190A	302	525–690	–	250, 500, 560,630
	Contactor 1000V/190A	103, 102, 202	380–480	–	315
	Contactor 1000V/190A	302	380–500	–	200, 450, 500
	Contactor 1000V/190A	103, 102, 202	380–480	–	250, 500, 560
181n0437	Contactor /1000V/265A	302	525–690	–	315, 355, 400, 710
	Contactor /1000V/265A	103, 102, 202	525–690	–	400, 450, 500, 800
	Contactor /1000V/265A	302	380–500	–	250
	Contactor /1000V/265A	103, 102, 202	380–480	–	315
	dU/dt Filter Choke				
181n0554	dudt-filterchoke 34uH 261A 690V	302	380–500	–	90, 110
	dudt-filterchoke 34uH 261A 690V	103, 102, 202	380–480	–	110, 132
	dudt-filterchoke 34uH 261A 690V	302	525–690	–	110, 132
	dudt-filterchoke 34uH 261A 690V	103, 102, 202	525–690	–	132,160
181n0553	dudt-filterchoke 21uH 416A 690V	302	380–500	–	132, 160, 315, 355, 400
	dudt-filterchoke 21uH 416A 690V	103, 102, 202	380–480	–	160, 200, 355, 400, 450
	dudt-filterchoke 21uH 416A 690V	302	525–690	–	160, 200, 250, 315, 500, 560, 630
	dudt-filterchoke 21uH 416A 690V	103, 102, 202	525–690	–	200, 250, 315, 400, 560, 630, 710
181n0552	dudt-filterchoke 15uH 590A 690V	302	380–500	–	200, 250, 450, 500
	dudt-filterchoke 15uH 590A 690V	103, 102, 202	380–480	–	250, 315, 500, 560
	dudt-filterchoke 15uH 590A 690V	302	525–690	–	355, 400, 710
	dudt-filterchoke 15uH 590A 690V	103, 102, 202	525–690	–	450, 500, 800
181n0555	dudt-filterchoke 62uH 144A 690V	302	380–500	–	90
	dudt-filterchoke 62uH 144A 690V	103, 102, 202	380–480	–	110
	dU/dt Filter Capacitor Bank				
181n0558	du/dt-filter capacitor assy 68nF	302	380–500	–	90, 110
	du/dt-filter capacitor assy 68nF	103, 102, 202	380–480	–	110, 132
	du/dt-filter capacitor assy 68nF	302	525–690	–	110, 132
	du/dt-filter capacitor assy 68nF	103, 102, 202	525–690	–	132, 160
181n0557	du/dt-filter capacitor assy 94nF	302	380–500	–	132, 160, 315, 355, 400
	du/dt-filter capacitor assy 94nF	103, 102, 202	380–480	–	160, 200, 355, 400, 450
	du/dt-filter capacitor assy 94nF	302	525–690	–	160, 200, 250, 315, 500, 560, 630
	du/dt-filter capacitor assy 94nF	103, 102, 202	525–690	–	200, 250, 315,400, 560, 630, 710
181n0556	du/dt-filter capacitor assy 164nF	302	380–500	–	200, 250, 450, 500

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	du/dt-filter capacitor assy 164nF	103, 102, 202	380–480	–	250, 315, 500, 560
	du/dt-filter capacitor assy 164nF	302	525–690	–	355, 400, 710
	du/dt-filter capacitor assy 164nF	103, 102, 202	525–690	–	400, 450, 800
181n0559	du/dt-filter capacitor assy 33nF	302	380–500	–	90
	du/dt-filter capacitor assy 33nF	103, 102, 202	380–480	–	110
	Common-Mode Filter				
181n0407	CM-filter,Vacon100 Enclosed	302	380–500	–	90, 110, 132, 160, 200, 250, 315, 355, 400, 450, 500
	CM-filter,Vacon100 Enclosed	103, 102, 202	380–480	–	110, 132, 160, 200, 250, 315, 355, 400, 450, 500, 560
	CM-filter,Vacon100 Enclosed	302	525–690	–	90, 110, 132, 160, 200, 250, 315, 355, 400, 500, 560, 630, 710
	CM-filter,Vacon100 Enclosed	103, 102, 202	525–690	–	110, 132, 160, 200, 250, 315, 400, 450, 560, 630, 710, 800
	Sine-wave Filter Choke				
181n0522	Choke Sine-filt,359uH,212A,500V	302	380–500	–	90, 160, 315, 355, 400
	Choke Sine-filt,359uH,212A,500V	103, 102, 202	380–480	–	110, 200, 355, 400, 450
181n0526	Choke Sine-filt,237uH,315A,500V	302	380–500	–	110, 132, 200, 250, 450,500
	Choke Sine-filt,237uH,315A,500V	103, 102, 202	380–480	–	132, 160, 250, 315, 500, 560
181n0524	Choke Sine-filt,878uH,137A,690V	302	525–690	–	90, 160, 355, 400
	Choke Sine-filt,878uH,137A,690V	103, 102, 202	525–690	–	110, 200, 450,500
181n0528	Choke Sine-filter,549uH,222A,690V	302	380–500	–	110, 132
	Choke Sine-filter,549uH,222A,690V	103, 102, 202	380–480	–	132, 160
181n0528	Choke Sine-filter,549uH,222A,690V	302	525–690	–	200, 250, 315, 500, 560, 630, 710
	Choke Sine-filter,549uH,222A,690V	103, 102, 202	525–690	–	250, 315, 400, 560, 630, 710, 800
	Sine-wave Filter Capacitor Banks				
181n0523	Capacitor Sine-filter 212A/500V	302	380–500	–	90, 160, 315, 355, 400
	Capacitor Sine-filter 212A/500V	103, 102, 202	380–480	–	110, 200, 355, 400, 450
181n0527	Capacitor Sine-filter 315 500V	302	380–500	–	110, 132, 200, 250, 450, 500
	Capacitor Sine-filter 315 500V	103, 102, 202	380–480	–	132, 160, 250, 315, 500, 560
181n0525	Capacitor Sine-filt 137A 690V	302	525–690	–	90, 160, 355, 400
	Capacitor Sine-filt 137A 690V	103, 102, 202	525–690	–	110, 200, 400, 450
181n0529	Capacitor Sine-filt 222A 690V	302	525–690	–	110, 132, 200, 250, 315, 500, 560, 630, 710
	Capacitor for Sine-filt 222A 690V	103, 102, 202	525–690	–	132, 160, 250, 315, 400, 560, 630, 710, 800

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	Other Accessories				
181n0549	Lamp LED 025 Magnet Fixing	103, 102, 202, 302	–	–	–
181n0436	Heater 130–150W,Rittal 3105.370	103, 102, 202, 302	–	–	–
181n0450	Auxiliary relay	103, 102, 202, 302	–	–	–
181n0548	Modular socket,16A,250VAC,IEC	103, 102, 202, 302	–	I	–
181n0550	Modular Socket, 1P, 15A, 125VAC,UL	103, 102, 202, 302	–	U	–
181n0533	Pilot Light, Green, 24Vdc, 22 mm	103, 102, 202, 302	–	–	–
181n0532	Pilot Light,Red,24Vdc,22 mm	103, 102, 202, 302	–	–	–
181n0447	Terminal,4-cond thro doubledeck	103, 102, 202, 302	–	–	–
181n0448	Terminal,2-cond/2-pin,doubledeck	103, 102, 202, 302	–	–	–
181n0433	Terminal,2-cond thro doubledeck	103, 102, 202, 302	–	–	–
181n0430	Terminal,Wago 2004-1201_XDI	103, 102, 202, 302	–	–	–
181n0431	Terminal,1-conductor through,blue	103, 102, 202, 302	–	–	–
181n0432	Terminal,1-conductor through, PE	103, 102, 202, 302	–	–	–
181n0452	Terminal,1-cond/1-pin doubledeck	103, 102, 202, 302	–	–	–
181n0449	Terminal, 4-pin carrier	103, 102, 202, 302	–	–	–
181n0446	Emergency pushbutton,40 red	103, 102, 202, 302	–	–	–
181n0435	MCB,Mot Heater Ctrl, Cab Heater,IEC	103, 102, 202, 302	–	I	–
181n0544	MCB,Light,Socket,24VDC supply,Inp cont,IEC	103, 102, 202, 302	–	I	–
181n0434	MCB,Auxilliary supply terminals,IEC	103, 102, 202, 302	–	I	–
181n0542	MCB,Auxilliary Voltage Transformer,IEC	103, 102, 202, 302	–	I	–
181n0530	MCB,Mot Heater Ctrl, Cab Heater,UL	103, 102, 202, 302	–	U	–

Code	Description	Drive Series	Voltage	UL/I	Power Rating
181n0551	MCB,Light,Socket,24VDC supply,Inp cont,UL	103, 102, 202, 302	–	U	–
181n0546	MCB,Auxilliary supply terminals,UL	103, 102, 202, 302	–	U	–
181n0547	MCB,Auxilliary Voltage Transformer,UL	103, 102, 202, 302	–	U	–
181n0531	Insulation monitor	103, 102, 202, 302	–	–	–
181n0453	Fan Power Board 200V-500V	103, 102, 202, 302	380–480, 380–500	–	–
181n0438	Fan Power Board 525V-690V	103, 102, 202, 302	525–690	–	–
181n0535	RJ45/RJ45 Interface Module,Din	103, 102, 202, 302	–	–	–
181n0540	Aux transformer T5/115-230V,500VA	103, 102, 202, 302	380–480, 380–500	–	–
181n0543	Aux transformer T7/115-230V,500VA	103, 102, 202, 302	525–690	–	–
181n0537	Reset pushbutton,blue,1No contact	103, 102, 202, 302	–	–	–
181n0534	Blue pushbutton, 1 No contact	103, 102, 202, 302	–	–	–
181n0406	3pos Rotaryswitch,0-1-Start,22mm	103, 102, 202, 302	–	–	–
181n0541	Motor/Trafo Ckt Breaker 1.6-2.5A	103, 102, 202, 302	525–690	–	–
181n0539	Motor/Trafo Ckt Breaker 1-1.6A	103, 102, 202, 302	380–480, 380–500	–	–
181n0538	Motor/Trafo Ckt Breaker 0.4-0.63A	103, 102, 202, 302	–	–	–
181n0545	24VDC Power Supply 60W	103, 102, 202, 302	–	–	–
181n0405	Door Fan, 230V 50/60Hz, 400m^3/h	302	380–500	–	90, 110, 132, 160, 200, 250, 315, 355, 400, 450, 500
	Door Fan, 230V 50/60Hz, 400m^3/h	103, 102, 202	380–480	–	110, 132, 160, 200, 250, 315, 355, 400, 450, 500, 560
	Door Fan, 230V 50/60Hz, 400m^3/h	302	525–690	–	90, 110, 132, 160, 200, 250, 315, 355, 400, 500, 560, 630, 710
	Door Fan, 230V 50/60Hz, 400m^3/h	103, 102, 202	525–690	–	110, 132, 160, 200, 250, 315, 400, 450, 560, 630, 710, 800
181n0220	Internal Fan, 175 mm 48V DC	103, 102, 202, 302	–	–	–

Code	Description	Drive Series	Voltage	UL/I	Power Rating
181n0439	Assy,wire,PHF,Contactor1 to receptacle	103, 102, 202	380–480	–	110, 132, 160, 200, 250, 315, 355, 400, 450, 500, 560
	Assy,wire,PHF,Contactor1 to receptacle	103, 102, 202	525–690	–	110, 132, 160, 200, 250, 315, 400, 450, 560, 630, 710, 800
	Assy,wire,PHF,Contactor1 to receptacle	302	380–500	–	90, 110, 132, 160, 200, 250, 315, 355, 400, 450, 500
	Assy,wire,PHF,Contactor1 to receptacle	302	525–690	–	90, 110, 132, 160, 200, 250, 315, 355, 400, 500, 560, 630, 710
181n0518	Assy,wire,PHF,Contactor2 to receptacle	103, 102, 202	380–480	–	355, 400, 450, 500, 560
	Assy,wire,PHF,Contactor2 to receptacle	103, 102, 202	525–690	–	560, 630, 710, 800
	Assy,wire,PHF,Contactor2 to receptacle	302	380–500	–	315, 355, 400, 450, 500
	Assy,wire,PHF,Contactor2 to receptacle	302	525–690	–	500, 560, 630, 710
181n0440	Assy,wire,PHF,Cont recep-control comp1	103, 102, 202	380–480	–	110, 132, 160, 200, 250, 315, 355, 400, 450, 500, 560
	Assy,wire,PHF,Cont recep-control comp1	103, 102, 202	525–690	–	110, 132, 160, 200, 250, 315, 400, 450, 560, 630, 710, 800
	Assy,wire,PHF,Cont recep-control comp1	302	380–500	–	90, 110, 132, 160, 200, 250, 315, 355, 400, 450, 500
	Assy,wire,PHF,Cont recep-control comp1	302	525–690	–	90, 110, 132, 160, 200, 250, 315, 355, 400, 500, 560, 630, 710
181n0519	Assy,wire,PHF Cont Recept-Cont Comp2	103, 102, 202	380–480	–	355, 400, 450, 500, 560
	Assy,wire,PHF Cont Recept-Cont Comp2	103, 102, 202	525–690	–	560, 630, 710, 800
	Assy,wire,PHF Cont Recept-Cont Comp2	302	380–500	–	315, 355, 400, 450, 500
	Assy,wire,PHF Cont Recept-Cont Comp2	302	525–690	–	500, 560, 630, 710
181n0451	Assy,wire,E4H DC to PHF with options	103, 102, 202, 302	–	–	–
181n0517	Assy,wire,E4H DC to dvdt Fan pw supply	103, 102, 202, 302	–	–	–
181n0520	Assy,wire,E4H DC to PHF Fan	103, 102, 202, 302	–	–	–
181n0441	Assy,wire,Sine filter fan power	103, 102, 202, 302	–	–	–
181n0442	Assy,wire,Sine filter fan power harn extn	103, 102, 202, 302	–	–	–

Code	Description	Drive Series	Voltage	UL/I	Power Rating
181n0561	Assy,wire,D4h,Contactor Wire Set	302	380–500	–	90, 110, 132
	Assy,wire,D4h,Contactor Wire Set	103, 102, 202, 302	380–480	–	110, 132, 160
	Assy,wire,D4h,Contactor Wire Set	302	525–690	–	90, 110, 132,
	Assy,wire,D4h,Contactor Wire Set	103, 102, 202, 302	525–690	–	110, 132, 160
	Assy,wire,D4h,Contactor Wire Set	302	380–500	–	160, 200, 250
	Assy,wire,D4h,Contactor Wire Set	103, 102, 202, 302	380–480	–	200, 250, 315
	Assy,wire,D4h,Contactor Wire Set	302	525–690	–	160, 200, 250, 315
	Assy,wire,D4h,Contactor Wire Set	103, 102, 202, 302	525–690	–	200, 250, 315, 400
181n0560	Assy,wire,E Frame,Contactor Wire Set	302	380–500	–	315, 355, 400, 450, 500
	Assy,wire,E Frame,Contactor Wire Set	103, 102, 202, 302	380–480	–	355, 400, 450, 500, 560
	Assy,wire,E Frame,Contactor Wire Set	302	525–690	–	355, 400, 500, 560, 630, 710
	Assy,wire,E Frame,Contactor Wire Set	103, 102, 202, 302	525–690	–	450, 500, 560, 630, 710, 800
181n0676	Assy,wire,D4h options cab contactor wire set	302	380–500	–	160, 200, 250
	Assy,wire,D4h options cab contactor wire set	103, 102, 202, 302	380–480	–	200, 250, 315
	Assy,wire,D4h options cab contactor wire set	302	525–690	–	160, 200, 250, 315
	Assy,wire,D4h options cab contactor wire set	103, 102, 202, 302	525–690	–	200, 250, 315, 400
181n0521	Switch Disconnect Shaft12X280	103, 102, 202, 302	–	–	–
	PHF Line 008 T5 50Hz				
181n0563	PHF Line Choke 008 L0 200-500-50/50Hz	103, 102, 202	380–480	–	110
	PHF Line Choke 008 L0 260-500-50/50Hz	302	380–500	–	90
181n0564	PHF Line Choke 008 L0 305-500-50/50Hz	103, 102, 202	380–480	–	132
	PHF Line Choke 008 L0 385-500-50/50Hz	302	380–500	–	110
181n0565	PHF Line Choke 008 L0 480-500-50/50Hz	103, 102, 202	380–480	–	160
	PHF Line Choke 008 L0 550-500-50/50Hz	302	380–500	–	132

Code	Description	Drive Series	Voltage	UL/I	Power Rating
181n0566	PHF Line Choke 008 L0 650-500-50/50Hz	103, 102, 202	380–480	–	200
	PHF Line Choke 008 L0 740-500-50/50Hz	302	380–500	–	160
181n0567	PHF Line Choke 008 L0 830-500-50/50Hz	103, 102, 202	380–480	–	250
	PHF Line Choke 008 L0 920-500-50/50Hz	302	380–500	–	200
181n0568	PHF Line Choke 008 L0 1030-500-50/50Hz	103, 102, 202	380–480	–	315
	PHF Line Choke 008 L0 200-500-50/50Hz	302	380–500	–	250
181n0569	PHF Line Choke 008 L0 260-500-50/50Hz	103, 102, 202	380–480	–	355
	PHF Line Choke 008 L0 305-500-50/50Hz	302	380–500	–	315
181n0570	PHF Line Choke 008 L0 385-500-50/50Hz	103, 102, 202	380–480	–	400
	PHF Line Choke 008 L0 480-500-50/50Hz	302	380–500	–	355
181n0571	PHF Line Choke 008 L0 550-500-50/50Hz	103, 102, 202	380–480	–	450
	PHF Line Choke 008 L0 650-500-50/50Hz	302	380–500	–	400
181n0572	PHF Line Choke 008 L0 740-500-50/50Hz	103, 102, 202	380–480	–	500
	PHF Line Choke 008 L0 830-500-50/50Hz	302	380–500	–	450
181n0573	PHF Line Choke 008 L0 920-500-50/50Hz	103, 102, 202	380–480	–	560
	PHF Line Choke 008 L0 1030-500-50/50Hz	302	380–500	–	500
	PHF Line 005 T5 50Hz				
181n0574	PHF Line Choke 005 L0 200-500-50/50Hz	103, 102, 202	380–480	–	110
	PHF Line Choke 005 L0 260-500-50/50Hz	302	380–500	–	90
181n0575	PHF Line Choke 005 L0 305-500-50/50Hz	103, 102, 202	380–480	–	132
	PHF Line Choke 005 L0 385-500-50/50Hz	302	380–500	–	110
181n0576	PHF Line Choke 005 L0 480-500-50/50Hz	103, 102, 202	380–480	–	160

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	PHF Line Choke 005 L0 550-500-50/50Hz	302	380–500	–	132
181n0577	PHF Line Choke 005 L0 650-500-50/50Hz	103, 102, 202	380–480	–	200
	PHF Line Choke 005 L0 740-500-50/50Hz	302	380–500	–	160
181n0578	PHF Line Choke 005 L0 830-500-50/50Hz	103, 102, 202	380–480	–	250
	PHF Line Choke 005 L0 920-500-50/50Hz	302	380–500	–	200
181n0579	PHF Line Choke 005 L0 1030-500-50/50Hz	103, 102, 202	380–480	–	315
	PHF Line Choke 005 L0 200-500-50/50Hz	302	380–500	–	250
181n0580	PHF Line Choke 005 L0 260-500-50/50Hz	103, 102, 202	380–480	–	355
	PHF Line Choke 005 L0 305-500-50/50Hz	302	380–500	–	315
181n0581	PHF Line Choke 005 L0 385-500-50/50Hz	103, 102, 202	380–480	–	400
	PHF Line Choke 005 L0 480-500-50/50Hz	302	380–500	–	355
181n0582	PHF Line Choke 005 L0 550-500-50/50Hz	103, 102, 202	380–480	–	450
	PHF Line Choke 005 L0 650-500-50/50Hz	302	380–500	–	400
181n0583	PHF Line Choke 005 L0 740-500-50/50Hz	103, 102, 202	380–480	–	500
	PHF Line Choke 005 L0 830-500-50/50Hz	302	380–500	–	450
181n0584	PHF Line Choke 005 L0 920-500-50/50Hz	103, 102, 202	380–480	–	560
	PHF Line Choke 005 L0 1030-500-50/50Hz	302	380–500	–	500
	PHF Line 008 T7 50Hz				
181n0585	PHF Line Choke 008 L0 120-690-50/50Hz	103, 102, 202	525–690	–	110
	PHF Line Choke 008 L0 150-690-50/50Hz	302	525–690	–	90
181n0586	PHF Line Choke 008 L0 190-690-50/50Hz	103, 102, 202	525–690	–	132
	PHF Line Choke 008 L0 240-690-50/50Hz	302	525–690	–	110

Code	Description	Drive Series	Voltage	UL/I	Power Rating
181n0587	PHF Line Choke 008 L0 290-690-50/50Hz	103, 102, 202	525–690	–	160
	PHF Line Choke 008 L0 360-690-50/50Hz	302	525–690	–	132
181n0588	PHF Line Choke 008 L0 450-690-50/50Hz	103, 102, 202	525–690	–	200
	PHF Line Choke 008 L0 510-690-50/50Hz	302	525–690	–	160
181n0589	PHF Line Choke 008 L0 575-690-50/50Hz	103, 102, 202	525–690	–	250
	PHF Line Choke 008 L0 650-690-50/50Hz	302	525–690	–	200
181n0590	PHF Line Choke 008 L0 720-690-50/50Hz	103, 102, 202	525–690	–	315
	PHF Line Choke 008 L0 830-690-50/50Hz	302	525–690	–	250
181n0591	PHF Line Choke 008 L0 960-690-50/50Hz	103, 102, 202	525–690	–	400
	PHF Line Choke 008 L0 120-690-50/50Hz	302	525–690	–	315
181n0592	PHF Line Choke 008 L0 150-690-50/50Hz	103, 102, 202	525–690	–	450
	PHF Line Choke 008 L0 190-690-50/50Hz	302	525–690	–	355
181n0593	PHF Line Choke 008 L0 240-690-50/50Hz	103, 102, 202	525–690	–	500
	PHF Line Choke 008 L0 290-690-50/50Hz	302	525–690	–	400
181n0594	PHF Line Choke 008 L0 360-690-50/50Hz	103, 102, 202	525–690	–	560
	PHF Line Choke 008 L0 450-690-50/50Hz	302	525–690	–	500
181n0595	PHF Line Choke 008 L0 510-690-50/50Hz	103, 102, 202	525–690	–	630
	PHF Line Choke 008 L0 575-690-50/50Hz	302	525–690	–	560
181n0596	PHF Line Choke 008 L0 650-690-50/50Hz	103, 102, 202	525–690	–	710
	PHF Line Choke 008 L0 720-690-50/50Hz	302	525–690	–	630
181n0597	PHF Line Choke 008 L0 830-690-50/50Hz	103, 102, 202	525–690	–	800
	PHF Line Choke 008 L0 960-690-50/50Hz	302	525–690	–	710

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	PHF Line 005 T7 50Hz				
181n0598	PHF Line Choke 005 L0 120-690-50/50Hz	103, 102, 202	525–690	–	110
	PHF Line Choke 005 L0 150-690-50/50Hz	103, 102, 202	525–690	–	90
181n0599	PHF Line Choke 005 L0 190-690-50/50Hz	103, 102, 202	525–690	–	132
	PHF Line Choke 005 L0 240-690-50/50Hz	103, 102, 202	525–690	–	110
181n0600	PHF Line Choke 005 L0 290-690-50/50Hz	103, 102, 202	525–690	–	160
	PHF Line Choke 005 L0 360-690-50/50Hz	103, 102, 202	525–690	–	132
181n0601	PHF Line Choke 005 L0 450-690-50/50Hz	103, 102, 202	525–690	–	200
	PHF Line Choke 005 L0 510-690-50/50Hz	103, 102, 202	525–690	–	160
181n0602	PHF Line Choke 005 L0 7-50/50Hz	103, 102, 202	525–690	–	250
	PHF Line Choke 005 L0 650-690-50/50Hz	103, 102, 202	525–690	–	200
181n0603	PHF Line Choke 005 L0 720-690-50/50Hz	103, 102, 202	525–690	–	315
	PHF Line Choke 005 L0 830-690-50/50Hz	103, 102, 202	525–690	–	250
181n0604	PHF Line Choke 005 L0 960-690-50/50Hz	103, 102, 202	525–690	–	400
	PHF Line Choke 005 L0 120-690-50/50Hz	103, 102, 202	525–690	–	315
181n0605	PHF Line Choke 005 L0 150-690-50/50Hz	103, 102, 202	525–690	–	450
	PHF Line Choke 005 L0 190-690-50/50Hz	103, 102, 202	525–690	–	355
181n0606	PHF Line Choke 005 L0 240-690-50/50Hz	103, 102, 202	525–690	–	500
	PHF Line Choke 005 L0 290-690-50/50Hz	103, 102, 202	525–690	–	400
181n0607	PHF Line Choke 005 L0 360-690-50/50Hz	103, 102, 202	525–690	–	560
	PHF Line Choke 005 L0 450-690-50/50Hz	103, 102, 202	525–690	–	500
181n0608	PHF Line Choke 005 L0 510-690-50/50Hz	103, 102, 202	525–690	–	630

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	PHF Line Choke 005 L0 575-690-50/50Hz	103, 102, 202	525–690	–	560
181n0609	PHF Line Choke 005 L0 650-690-50/50Hz	103, 102, 202	525–690	–	710
	PHF Line Choke 005 L0 720-690-50/50Hz	103, 102, 202	525–690	–	630
181n0610	PHF Line Choke 005 L0 830-690-50/50Hz	103, 102, 202	525–690	–	800
	PHF Line Choke 005 L0 960-690-50/50Hz	103, 102, 202	525–690	–	710
	PHF Line 005/008 T5 50Hz,60Hz				
181n0611	PHF Filter Choke 80T5-50/60Hz	103, 102, 202	380–480	–	110
	PHF Filter Choke 94T5-50/60Hz	302	380–500	–	90
181n0612	PHF Filter Choke 122T5-50/60Hz	103, 102, 202	380–480	–	132
	PHF Filter Choke 143T5-50/60Hz	302	380–500	–	110
181n0613	PHF Filter Choke 180T5-50/60Hz	103, 102, 202	380–480	–	160
	PHF Filter Choke 218T5-50/60Hz	302	380–500	–	132
181n0614	PHF Filter Choke 244T5-50/60Hz	103, 102, 202	380–480	–	200
	PHF Filter Choke 286T5-50/60Hz	302	380–500	–	160
181n0615	PHF Filter Choke 360T5-50/60Hz	103, 102, 202	380–480	–	250
	PHF Filter Choke 436T5-50/60Hz	302	380–500	–	200
181n0616	PHF Filter Choke 80T5-50/60Hz	103, 102, 202	380–480	–	315
	PHF Filter Choke 94T5-50/60Hz	302	380–500	–	250
181n0617	PHF Filter Choke 122T5-50/60Hz	103, 102, 202	380–480	–	355, 400
	PHF Filter Choke 143T5-50/60Hz	302	380–500	–	315
181n0618	PHF Filter Choke 180T5-50/60Hz	103, 102, 202	380–480	–	450
	PHF Filter Choke 218T5-50/60Hz	302	380–500	–	355, 400
181n0619	PHF Filter Choke 244T5-50/60Hz	103, 102, 202	380–480	–	500
	PHF Filter Choke 286T5-50/60Hz	302	380–500	–	450
181n0620	PHF Filter Choke 360T5-50/60Hz	103, 102, 202	380–480	–	560
	PHF Filter Choke 436T5-50/60Hz	302	380–500	–	500
	PHF Line 005/008 T7 50Hz,60Hz				
181n0621	PHF Filter Choke 44T7-50/60Hz	103, 102, 202	525–690	–	110
	PHF Filter Choke 55T7-50/60Hz	302	525–690	–	90
181n0622	PHF Filter Choke 68T7-50/60Hz	103, 102, 202	525–690	–	132
	PHF Filter Choke 94T7-50/60Hz	302	525–690	–	110
181n0623	PHF Filter Choke 122T7-50/60Hz	103, 102, 202	525–690	–	160
	PHF Filter Choke 155T7-50/60Hz	302	525–690	–	132

Code	Description	Drive Series	Voltage	UL/I	Power Rating
181n0624	PHF Filter Choke 190T7-50/60Hz	103, 102, 202	525–690	–	200
	PHF Filter Choke 218T7-50/60Hz	302	525–690	–	160
181n0625	PHF Filter Choke 244T7-50/60Hz	103, 102, 202	525–690	–	250
	PHF Filter Choke 310T7-50/60Hz	302	525–690	–	200
181n0626	PHF Filter Choke 380T7-50/60Hz	103, 102, 202	525–690	–	315, 400
	PHF Filter Choke 44T7-50/60Hz	302	525–690	–	250
181n0627	PHF Filter Choke 55T7-50/60Hz	103, 102, 202	525–690	–	450
	PHF Filter Choke 68T7-50/60Hz	302	525–690	–	315, 355
181n0628	PHF Filter Choke 94T7-50/60Hz	103, 102, 202	525–690	–	500
	PHF Filter Choke 122T7-50/60Hz	302	525–690	–	400
181n0629	PHF Filter Choke 155T7-50/60Hz	103, 102, 202	525–690	–	560, 630
	PHF Filter Choke 190T7-50/60Hz	302	525–690	–	500
181n0630	PHF Filter Choke 218T7-50/60Hz	103, 102, 202	525–690	–	710
	PHF Filter Choke 244T7-50/60Hz	302	525–690	–	560, 630
181n0631	PHF Filter Choke 310T7-50/60Hz	103, 102, 202	525–690	–	800
	PHF Filter Choke 380T7-50/60Hz	302	525–690	–	710
	PHF Cap 008/005 T5 50Hz				
181n0674	PHF Capacitor Assy 150FT5-50Hz	103, 102, 202	380–480	–	110
	PHF Capacitor Assy 180FT5-50Hz	302	380–500	–	90
181n0633	PHF Capacitor Assy 225FT5-50Hz	103, 102, 202	380–480	–	132
	PHF Capacitor Assy 270FT5-50Hz	302	380–500	–	110
181n0634	PHF Capacitor Assy 360FT5-50Hz	103, 102, 202	380–480	–	160
	PHF Capacitor Assy 390FT5-50Hz	302	380–500	–	132
181n0635	PHF Capacitor Assy 450FT5-50Hz	103, 102, 202	380–480	–	200
	PHF Capacitor Assy 540FT5-50Hz	302	380–500	–	160
181n0636	PHF Capacitor Assy 720FT5-50Hz	103, 102, 202	380–480	–	250
	PHF Capacitor Assy 780FT5-50Hz	302	380–500	–	200
181n0637	PHF Capacitor Assy 150µFT5-50Hz	103, 102, 202	380–480	–	315
	PHF Capacitor Assy 180FT5-50Hz	302	380–500	–	250
181n0638	PHF Capacitor Assy 225FT5-50Hz	103, 102, 202	380–480	–	355, 400
	PHF Capacitor Assy 270FT5-50Hz	302	380–500	–	315
181n0639	PHF Capacitor Assy 360FT5-50Hz	103, 102, 202	380–480	–	450
	PHF Capacitor Assy 390FT5-50Hz	302	380–500	–	355, 400
181n0640	PHF Capacitor Assy 450FT5-50Hz	103, 102, 202	380–480	–	500
	PHF Capacitor Assy 540FT5-50Hz	302	380–500	–	450
181n0641	PHF Capacitor Assy 720FT5-50Hz	103, 102, 202	380–480	–	560

Code	Description	Drive Series	Voltage	UL/I	Power Rating
181n0674	PHF Capacitor Assy 780FT5-50Hz	103, 102, 203	380–480	–	110
	PHF Cap 008/005 T5 60Hz				
181n0642	PHF Capacitor Assy 106FT5-60Hz	103, 102, 202	380–480	–	110
	PHF Capacitor Assy 126FT5-60Hz	302	380–500	–	90
181n0643	PHF Capacitor Assy 159FT5-60Hz	103, 102, 202	380–480	–	132
	PHF Capacitor Assy 196FT5-60Hz	302	380–500	–	110
181n0644	PHF Capacitor Assy 270FT5-60Hz	103, 102, 202	380–480	–	160
	PHF Capacitor Assy 300FT5-60Hz	302	380–500	–	132
181n0645	PHF Capacitor Assy 318FT5-60Hz	103, 102, 202	380–480	–	200
	PHF Capacitor Assy 392FT5-60Hz	302	380–500	–	160
181n0646	PHF Capacitor Assy 540FT5-60Hz	103, 102, 202	380–480	–	250
	PHF Capacitor Assy 600FT5-60Hz	302	380–500	–	200
181n0647	PHF Capacitor Assy 106FT5-60Hz	103, 102, 202	380–480	–	315
	PHF Capacitor Assy 126FT5-60Hz	302	380–500	–	250
181n0648	PHF Capacitor Assy 159FT5-60Hz	103, 102, 202	380–480	–	355, 400
	PHF Capacitor Assy 196FT5-60Hz	302	380–500	–	315
181n0649	PHF Capacitor Assy 270FT5-60Hz	103, 102, 202	380–480	–	450
	PHF Capacitor Assy 300FT5-60Hz	302	380–500	–	355, 400
181n0650	PHF Capacitor Assy 318FT5-60Hz	103, 102, 202	380–480	–	500
	PHF Capacitor Assy 392FT5-60Hz	302	380–500	–	450
181n0651	PHF Capacitor Assy 540FT5-60Hz	103, 102, 202	380–480	–	560
	PHF Capacitor Assy 600FT5-60Hz	302	380–500	–	500
	PHF Cap 008/005 T7 50Hz				
181n0652	PHF Capacitor Assy 48FT7-50Hz	103, 102, 202	525–690	–	110
	PHF Capacitor Assy 60FT7-50Hz	302	525–690	–	90
181n0653	PHF Capacitor Assy 75FT7-50Hz	103, 102, 202	525–690	–	132
	PHF Capacitor Assy 96FT7-50Hz	302	525–690	–	110
181n0654	PHF Capacitor Assy 112FT7-50Hz	103, 102, 202	525–690	–	160
	PHF Capacitor Assy 150FT7-50Hz	302	525–690	–	132
181n0655	PHF Capacitor Assy 180FT7-50Hz	103, 102, 202	525–690	–	200
	PHF Capacitor Assy225FT7-50Hz	302	525–690	–	160
181n0656	PHF Capacitor Assy 224FT7-50Hz	103, 102, 202	525–690	–	250
	PHF Capacitor Assy 300FT7-50Hz	302	525–690	–	200
181n0657	PHF Capacitor Assy 360FT7-50Hz	103, 102, 202	525–690	–	315, 400
	PHF Capacitor Assy 48FT7-50Hz	302	525–690	–	250
181n0658	PHF Capacitor Assy 60FT7-50Hz	103, 102, 202	525–690	–	450

Code	Description	Drive Series	Voltage	UL/I	Power Rating
	PHF Capacitor Assy 75FT7-50Hz	302	525–690	–	315, 355
181n0659	PHF Capacitor Assy 96FT7-50Hz	103, 102, 202	525–690	–	500
	PHF Capacitor Assy 112FT7-50Hz	302	525–690	–	400
181n0660	PHF Capacitor Assy 150FT7-50Hz	103, 102, 202	525–690	–	560, 630
	PHF Capacitor Assy 180FT7-50Hz	302	525–690	–	500
181n0661	PHF Capacitor Assy225FT7-50Hz	103, 102, 202	525–690	–	710
	PHF Capacitor Assy 224FT7-50Hz	302	525–690	–	560, 630
181n0662	PHF Capacitor Assy 300FT7-50Hz	103, 102, 202	525–690	–	800
	PHF Capacitor Assy 360FT7-50Hz	302	525–690	–	710
	PHF Cap 008/005 T7 60Hz				
181n0663	PHF Capacitor Assy 37FT7-60Hz	103, 102, 202	525–690	–	110
	PHF Capacitor Assy 42FT7-60Hz	302	525–690	–	90
181n0664	PHF Capacitor Assy 54FT7-60Hz	103, 102, 202	525–690	–	132
	PHF Capacitor Assy 68FT7-60Hz	302	525–690	–	110
181n0665	PHF Capacitor Assy 84FT7-60Hz	103, 102, 202	525–690	–	160
	PHF Capacitor Assy 105FT7-60Hz	302	525–690	–	132
181n0666	PHF Capacitor Assy 126FT7-60Hz	103, 102, 202	525–690	–	200
	PHF Capacitor Assy 159FT7-60Hz	302	525–690	–	160
181n0667	PHF Capacitor Assy 168FT7-60Hz	103, 102, 202	525–690	–	250
	PHF Capacitor Assy 210FT7-60Hz	302	525–690	–	200
181n0668	PHF Capacitor Assy 252FT7-60Hz	103, 102, 202	525–690	–	315, 400
	PHF Capacitor Assy 37FT7-60Hz	302	525–690	–	250
181n0669	PHF Capacitor Assy 42FT7-60Hz	103, 102, 202	525–690	–	450
	PHF Capacitor Assy 54FT7-60Hz	302	525–690	–	315, 355
181n0670	PHF Capacitor Assy 68FT7-60Hz	103, 102, 202	525–690	–	500
	PHF Capacitor Assy 84FT7-60Hz	302	525–690	–	400
181n0671	PHF Capacitor Assy 105FT7-60Hz	103, 102, 202	525–690	–	560, 630
	PHF Capacitor Assy 126FT7-60Hz	302	525–690	–	500
181n0672	PHF Capacitor Assy 159FT7-60Hz	103, 102, 202	525–690	–	710
	PHF Capacitor Assy 168FT7-60Hz	302	525–690	–	560, 630
181n0673	PHF Capacitor Assy 210FT7-60Hz	103, 102, 202	525–690	–	800
	PHF Capacitor Assy 252FT7-60Hz	302	525–690	–	710

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