ENGINEERING TOMORROW

Danfoss

Service Guide
VLT® FC Series, F-size Enclosures

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VLT® THE REAL DRIVE

Contents

1 Introduction

1.1 Purpose

This guide is intended to be used by a qualified technician to identify faults and perform repairs on 6-pulse and 12-pulse frequency converters in F-sized enclosures.

The guide provides the following information:

- Data for the different enclosure types
- Description of user interfaces and internal processing
- Troubleshooting and test instructions
- Assembly and disassembly instructions

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1.2 Additional Resources

Additional resources are available to understand advanced frequency converter functions and programming.

- The *VLT® HVAC Drive FC 102 Programming Guide* provides greater detail on working with parameters and heating/air conditioning application examples.
- The *VLT® AQUA Drive FC 202 Programming Guide* provides greater detail on working with parameters and water and waste water application examples.
- The *VLT® AutomationDrive FC 301/FC 302 Programming Guide* provides greater detail on working with parameters and automation application examples.
- The *VLT® HVAC Drive FC 102, 110–1400 kW Design Guide* provides detailed capabilities and functionality to design motor control systems for heating/air conditioning applications.
- The *VLT® AQUA Drive FC 202, 110–1400 kW Design Guide* provides detailed capabilities and functionality to design motor control systems for water and waste water applications.
- The *VLT® AutomationDrive FC 302, 90–1200 kW Design Guide* provides detailed capabilities and functionality to design motor control systems for automation applications.
- The *VLT® HVAC Drive FC 102, 315–1400 kW Operating Instructions* provide information required to install and commission the 6-pulse frequency converter for heating/air conditioning applications.
- The *VLT® AQUA Drive FC 202, 110–1400 kW Operating Instructions* provide information required to install and commission the 6-pulse frequency converter for water and waste water applications.
- The *VLT® AutomationDrive FC 302, 90–1200 kW Operating Instructions* provide information required to install and commission the 6-pulse frequency converter for automation applications.
- The *VLT® HVAC Drive FC 100 12-Pulse Operating Instructions* provides information required to install and commission the 12-pulse frequency converter for heating/air conditioning applications.
- The *VLT® AQUA Drive FC 202 12-Pulse Operating Instructions* provides information required to install and commission the 12-pulse frequency converter for water and waste water applications.
- The *VLT® AutomationDrive FC 302 12-Pulse Operating Instructions* provides information required to install and commission the 12-pulse frequency converter for automation applications.
- Literature for various options available with the F-sized enclosures are found on *vlt-drives.danfoss.com/Support/Technical-Documentation/*.

1.3 Abbreviations

AC	Alternating current
AEO	Automatic energy optimization
ACP	Application control processor
AWG	American wire gauge
AMA	Automatic motor adaptation
°C	Degrees Celsius
DC	Direct current
EEPROM	Electrically erasable programmable read-only memory
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ETR	Electronic thermal relay
$f_{M,N}$	Nominal motor frequency
FC	Frequency converter
IP	Ingress protection
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 frequency converter
L_d	Motor d-axis inductance
L_q	Motor q-axis inductance
LCP	Local control panel
MCP	Motor control processor
N.A.	Not applicable
$P_{M,N}$	Nominal motor power
PCB	Printed circuit board
PE	Protective earth
PELV	Protective extra low voltage
PWM	Pulse width modulated
R_s	Stator resistance
Regen	Regenerative terminals
RPM	Revolutions per minute
RFI	Radio frequency interference
SCR	Silicon controlled rectifier
SMPS	Switch mode power supply
T_{LIM}	Torque limit
$U_{M,N}$	Nominal motor voltage
X_h	Motor main reactance

Table 1.1 Abbreviations

1.4 Conventions

- Numbered lists indicate procedures.
- Bullet lists indicate other information.
- Italicized text indicates the following:
  - Cross reference
  - Link
  - Parameter name
  - Parameter option
  - Parameter group name
- All dimensions are in mm (inch).
- An asterisk (*) indicates default setting of a parameter.

1.5 Tools Required

Item	Description
ESD protection kit	Wrist strap and mat
Metric socket set	7–19 mm
Socket extensions	100–150 mm (4 inch and 6 inch)
Magnetic sockets	–
Ratchet wrench	–
Torque wrench	Torque range 0.5–19 Nm (6–170 in-lb)
Torx driver set	T10–T50
Needle nose pliers	–
Screwdrivers	Standard and Phillips

Table 1.2 Tools Required for Service of Frequency Converter

Item	Description
Digital volt-ohm meter (PWM compatible)	• Rated for true RMS • Supports diode mode • Rated for the mains voltage of the frequency converter
Analog voltmeter	–
Oscilloscope	–
Clamp-on ammeter	Clamp-on ammeter rated for true RMS
Split bus supply	p/n 130B3146
Signal test board	p/n 176F8437
Signal test board extension	p/n 130B3147
Test cable	p/n 176F8766

Table 1.3 Instruments Recommended for Testing of Frequency Converter

1.6 General Torque Tightening Values

Use a torque wrench to ensure that correct torques are applied. Too low or too high torque can cause electrical connection problems. For fastening hardware described in this guide, use the values described in *Table 1.4*.

NOTICE

TORQUE VALUES

The values in *Table 1.4* are not intended for SCR, diode, or IGBT fasteners. Refer to the instructions included with those replacement parts for correct values.

Shaft size	Torx/hex drives size	Class A Nm (in-lb)	Class B Nm (in-lb)
M4	T20/7 mm	1.2 (10)	0.8 (7)
M5	T25/8 mm	2.3 (20)	1.2 (10)
M6	T30/10 mm	3.9 (35)	2.3 (20)
M8	T40/13 mm	9.6 (85)	3.9 (35)
M10	T50/17 mm	19 (169)	9.6 (85)
M12	–/18 or 19 mm	19 (169)	–

Table 1.4 Torque Values Standard Thread

Shaft size	Torx drives size	Class A Nm (in-lb)	Class B Nm (in-lb)
M4.8	T25	5.7 (50)	3.1 (27)
M5	T25	1.7 (15)	–

Table 1.5 Torque Values for Thread Cutting into Metal

Shaft size	Torx drives size	Class A Nm (in-lb)	Class B Nm (in-lb)
M4	T20	2.8 (24)	2.8 (24)
M5	T25	5.1 (45)	4.0 (35)

Table 1.6 Torque Values for Thread Forming into Plastic

Class A: *Clamping metal*
Class B: *Clamping PCA or plastic*

2 Safety

This section describes requirements to personnel and safe practices to observe when performing service and maintenance procedures.

2.1 Safety Symbols

The following symbols are used in this manual:

WARNING

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

CAUTION

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

NOTICE

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

2.2 Qualified Personnel

Correct and reliable transport, storage, installation, operation, and maintenance are required for the trouble-free and safe operation of the frequency converter. Only qualified personnel are allowed to install or operate this equipment.

Qualified personnel are defined as trained staff, who are authorized to install, commission, and maintain equipment, systems, and circuits in accordance with pertinent laws and regulations. Also, the qualified personnel must be familiar with the instructions and safety measures described in these operating instructions.

Authorized personnel
Authorized personnel are qualified personnel, trained by Danfoss to service Danfoss products.

2.3 Safety Precautions

WARNING

HIGH VOLTAGE

Frequency converters 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.**

WARNING

UNINTENDED START

When the frequency converter is connected to AC mains, DC power supply, or load sharing, the motor may start at any time. Unintended start during programming, service, or repair work can result in death, serious injury, or property damage. The motor can start by means of an external switch, a serial bus 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.
To prevent unintended motor start:

- **Disconnect the frequency converter from the mains.**
- **Press [Off/Reset] on the LCP before programming parameters.**
- **The frequency converter, motor, and any driven equipment must be fully wired and assembled when the frequency converter is connected to AC mains, DC power supply, or load sharing.**

WARNING

DISCHARGE TIME

The frequency converter contains DC-link capacitors, which can remain charged even when the frequency converter is not powered. High voltage can be present even when the warning LED indicator lights are off. Failure to wait the specified time after power has been removed before performing service or repair work can result in death or serious injury.

1. **Stop the motor.**
2. **Disconnect AC mains and remote DC-link power supplies, including battery back-ups, UPS, and DC-link connections to other frequency converters.**
3. **Disconnect or lock PM motor.**
4. **Wait for the capacitors to discharge fully. The minimum duration of waiting time is specified in *Table 2.1*.**
5. **Before performing any service or repair work, use an appropriate voltage measuring device to make sure that the capacitors are fully discharged.**

Voltage [V]	Power range [kW (hp)]	Minimum waiting time (minutes)
380–480	315–1000 (450–1350)	40
380–500	250–800 (350–1200)	40
525–690	355–1400 (400–1400)	40

Table 2.1 Discharge Time

WARNING

LEAKAGE CURRENT HAZARD

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

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

WARNING

EQUIPMENT HAZARD

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.

WARNING

UNINTENDED MOTOR ROTATION WINDMILLING

Unintended rotation of permanent magnet motors creates voltage and can charge the unit, resulting in death, serious injury, or equipment damage.

- Ensure that permanent magnet motors are blocked to prevent unintended rotation.

WARNING

SHOCK HAZARD AND RISK OF INJURY

For dynamic test procedures, mains input power is required, and all devices and supplies connected to mains are energized at rated voltage. Contact with powered components can result in death or serious injury.

- Do not touch energized parts of the frequency converter when connected to mains.

CAUTION

INTERNAL FAILURE HAZARD

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

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

WARNING

SHOCK HAZARD

The frequency converter can cause a DC current in the PE conductor and thus result in death or serious injury.

- When a residual current-operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is permitted on the supply side.

Failure to follow the recommendation means that the RCD cannot provide the intended protection.

CAUTION

RISK OF INJURY OR PROPERTY DAMAGE

Do not assume that a motor is wired properly after completed service of the frequency converter.

Check for:

- Loose connections.
- Improper programming.
- Added equipment.

Failure to perform these checks can result in personal injury, property damage, or less than optimal performance.

NOTICE

LIFTING - EQUIPMENT DAMAGE RISK

Incorrect lifting can result in equipment damage.

- Use lifting lugs where provided.
- Prevent uncontrolled rotation.

⚠WARNING

SHOCK HAZARD AND INJURY RISK

Even with the circuit breaker or disconnect in the OFF position, mains voltage is still present in the following options:

- **Door interlock**
- **Space heater**
- **Cabinet light and outlet**
- **RCD monitor**
- **IRM monitor**
- **Emergency stop**
- **24 V DC customer supply**

2.4 Electrostatic Discharge (ESD)

NOTICE

When performing service, use proper ESD procedures to prevent damage to sensitive components.

NOTICE

Do not touch components on the circuit boards. Hold circuit boards by the corners and edges only.

Many electronic components within the frequency converter are sensitive to static electricity. Voltages so low that they cannot be felt, seen, or heard can reduce the life, affect performance, or completely destroy sensitive electronic components.

3 Product Overview

VLT® HVAC Drive series frequency converters are designed for the HVAC markets. They operate in variable torque mode or constant torque down to 15 Hz and include special features and options designed for fan and pump applications.

VLT® AQUA Drive series frequency converters are designed for water and waste water markets. They can operate in either constant torque or variable torque with limited overload capabilities. Included are specific features and options for use on various water pumping and processing applications.

VLT® AutomationDrive series frequency converters are fully programmable for either constant torque or variable torque industrial applications. They operate various applications and incorporate a wide range of control and communication options.

These models are available in IP21 (NEMA 1), and IP54 (NEMA 12) enclosures.

3.1 Service Report

Report the serial number of the frequency converter when requesting support, or preparing the service report. The serial number is listed on the nameplate. Refer to *Illustration 3.1* for more details.

3.2 Enclosure Size Identification

Enclosure size is used throughout this guide whenever procedures or components differ between frequency converters based on physical size.

Find the enclosure size using the following steps:

1. Obtain the following information from the type code on the nameplate. Refer to *Illustration 3.1*.
    - 1a Product group and frequency converter series (characters 1–6)
    - 1b Power rating (characters 7–10)
    - 1c Voltage rating (phases and mains) (characters 11–12)
    - 1d Type of frequency converter (16th character)
2. Find the appropriate voltage rating table for the product group and frequency converter series. Refer to *Table 3.1–Table 3.4*.
   For example, T4 for FC 102 and FC 202
3. Within the table, find the power rating (for example, P500), and look up the type of frequency converter (for example, H for a 6-pulse unit).
4. Each power rating lists 2 enclosure sizes. The enclosures are identical except for an options cabinet added to the second enclosure.

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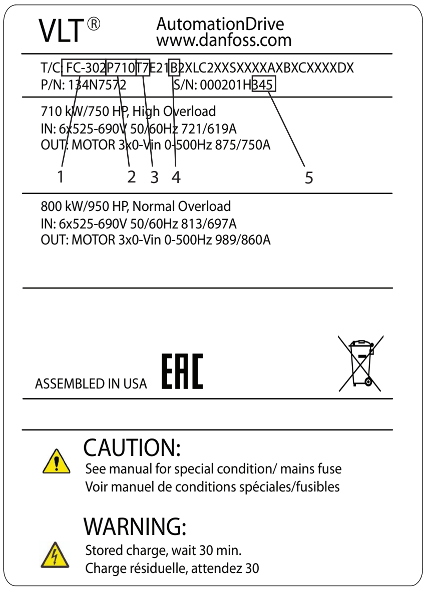


1	Product group and frequency converter series
2	Power rating
3	Voltage rating (phases and mains)
4	FC type: H = 6-pulse frequency converter B = 12-pulse frequency converter
5	Build date (wwy, where ww = the week and y = last digit of the year). For example, 345 = week 34 of 2015.

Illustration 3.1 Using the Nameplate to Find the Enclosure Size

3.2.1 T4 (380–480 V AC) Voltage Rating

Power rating	FC type	Enclosure size	Enclosure size with options cabinet
P315	B	F8	F9
P355	B	F8	F9
P400	B	F8	F9
P450	B	F8	F9
P500	H	F1	F3
P500	B	F10	F11
P560	H	F1	F3
P560	B	F10	F11
P630	H	F1	F3
P630	B	F10	F11
P710	H	F1	F3
P710	B	F10	F11
P800	H	F2	F4
P800	B	F12	F13
P1M0	H	F2	F4
P1M0	B	F12	F13

Table 3.1 T4 (380–480 V AC) Voltage Rating for VLT® HVAC Drive FC 102 and VLT® AQUA Drive FC 202

3.2.2 T5 (380–500 V AC) Voltage Rating

Power rating	FC type	Enclosure size	Enclosure size with options cabinet
P250	B	F8	F9
P315	B	F8	F9
P355	B	F8	F9
P400	B	F8	F9
P450	H	F1	F3
P450	B	F10	F11
P500	H	F1	F3
P500	B	F10	F11
P560	H	F1	F3
P560	B	F10	F11
P630	H	F1	F3
P630	B	F10	F11
P710	H	F2	F4
P710	B	F12	F13
P800	H	F2	F4
P800	B	F12	F13

Table 3.2 T5 (380–500 V AC) Voltage Rating for VLT® AutomationDrive FC 302

3.2.3 T7 (525–690 V AC) Voltage Rating

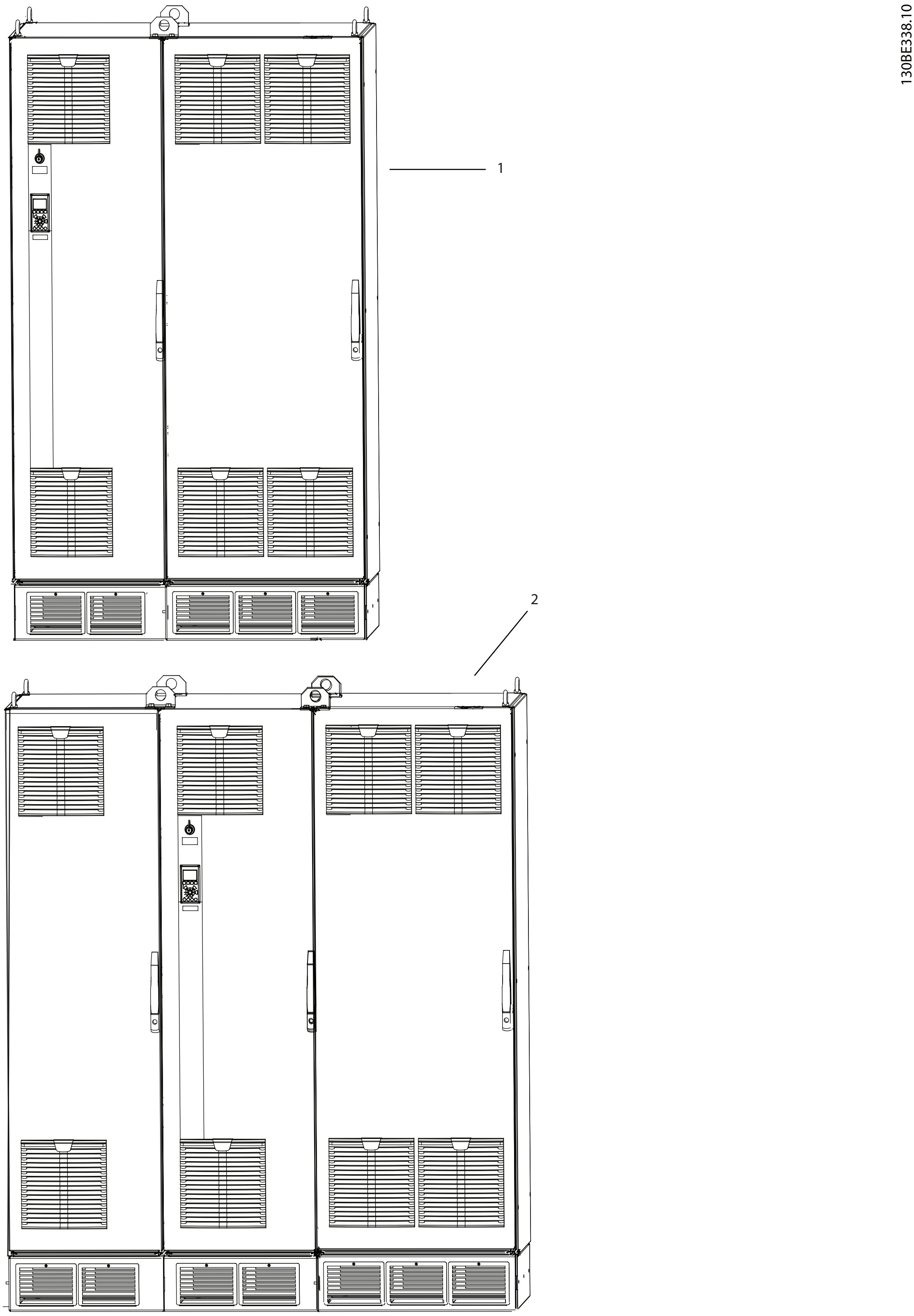
Power rating	FC type	Enclosure size	Enclosure size with options cabinet
P450	B	F8	F9
P500	B	F8	F9
P560	B	F8	F9
P630	B	F8	F9
P710	H	F1	F3
P710	B	F10	F11
P800	H	F1	F3
P800	B	F10	F11
P900	H	F1	F3
P900	B	F10	F11
P1M0	H	F2	F4
P1M0	B	F12	F13
P1M2	H	F2	F4
P1M2	B	F12	F13
P1M4	H	F2	F4
P1M4	B	F12	F13

Table 3.3 T7 (525–690 V AC) Voltage Rating for VLT® HVAC Drive FC 102 and VLT® AQUA Drive FC 202

Power rating	FC type	Enclosure size	Enclosure size with options cabinet
P355	B	F8	F9
P400	B	F8	F9
P500	B	F8	F9
P560	B	F8	F9
P630	H	F1	F3
P630	B	F10	F11
P710	H	F1	F3
P710	B	F10	F11
P800	H	F1	F3
P800	B	F10	F11
P900	H	F2	F4
P900	B	F12	F13
P1M0	H	F2	F4
P1M0	B	F12	F13
P1M2	H	F2	F4
P1M2	B	F12	F13

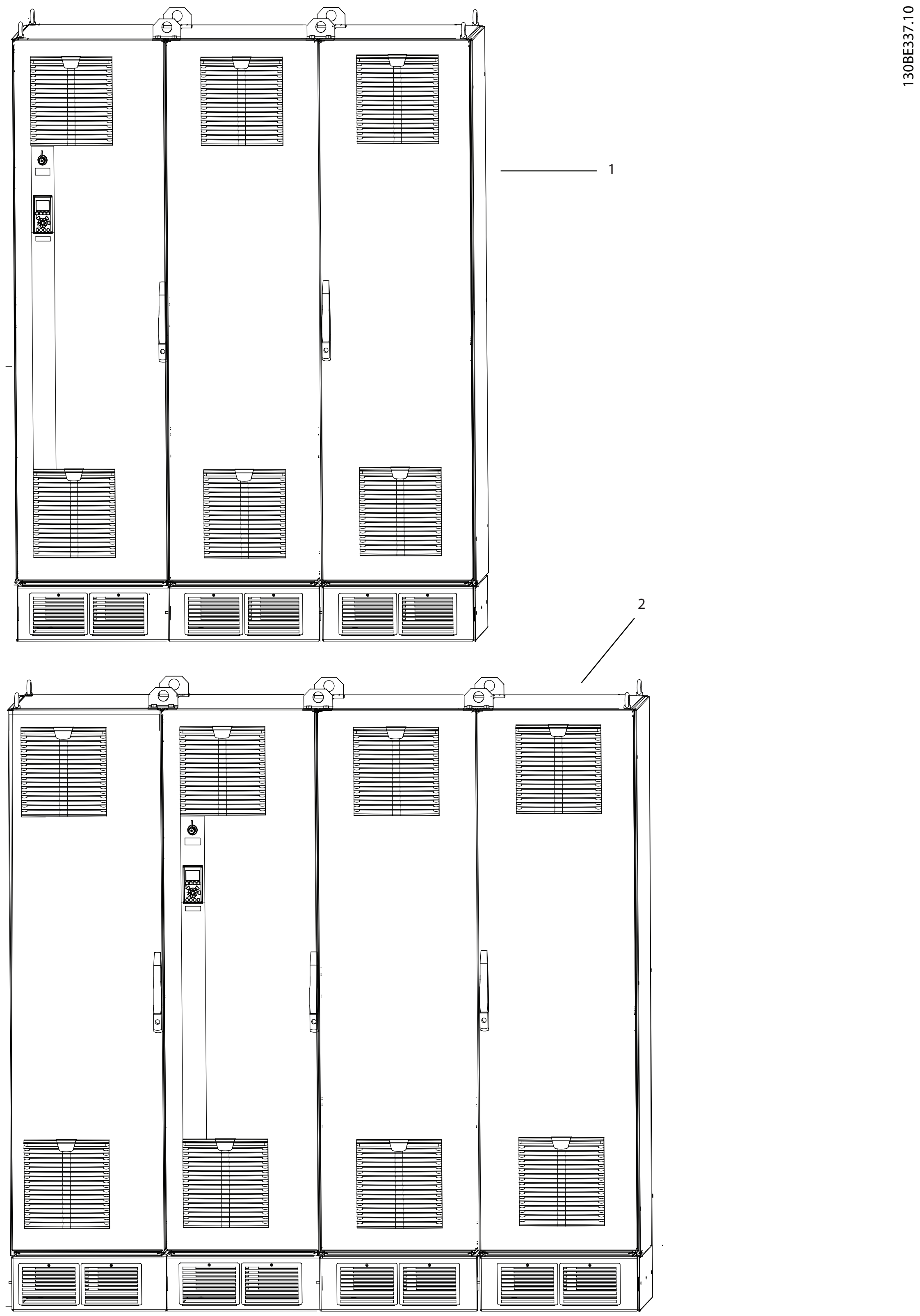
Table 3.4 T7 (525–690 V AC) Voltage Rating for VLT® AutomationDrive FC 302

3.3 Exploded Views, F1–F4 Enclosures



1	F1 enclosure (rectifier and inverter cabinets)	2	F3 enclosure (options, rectifier, and inverter cabinets)

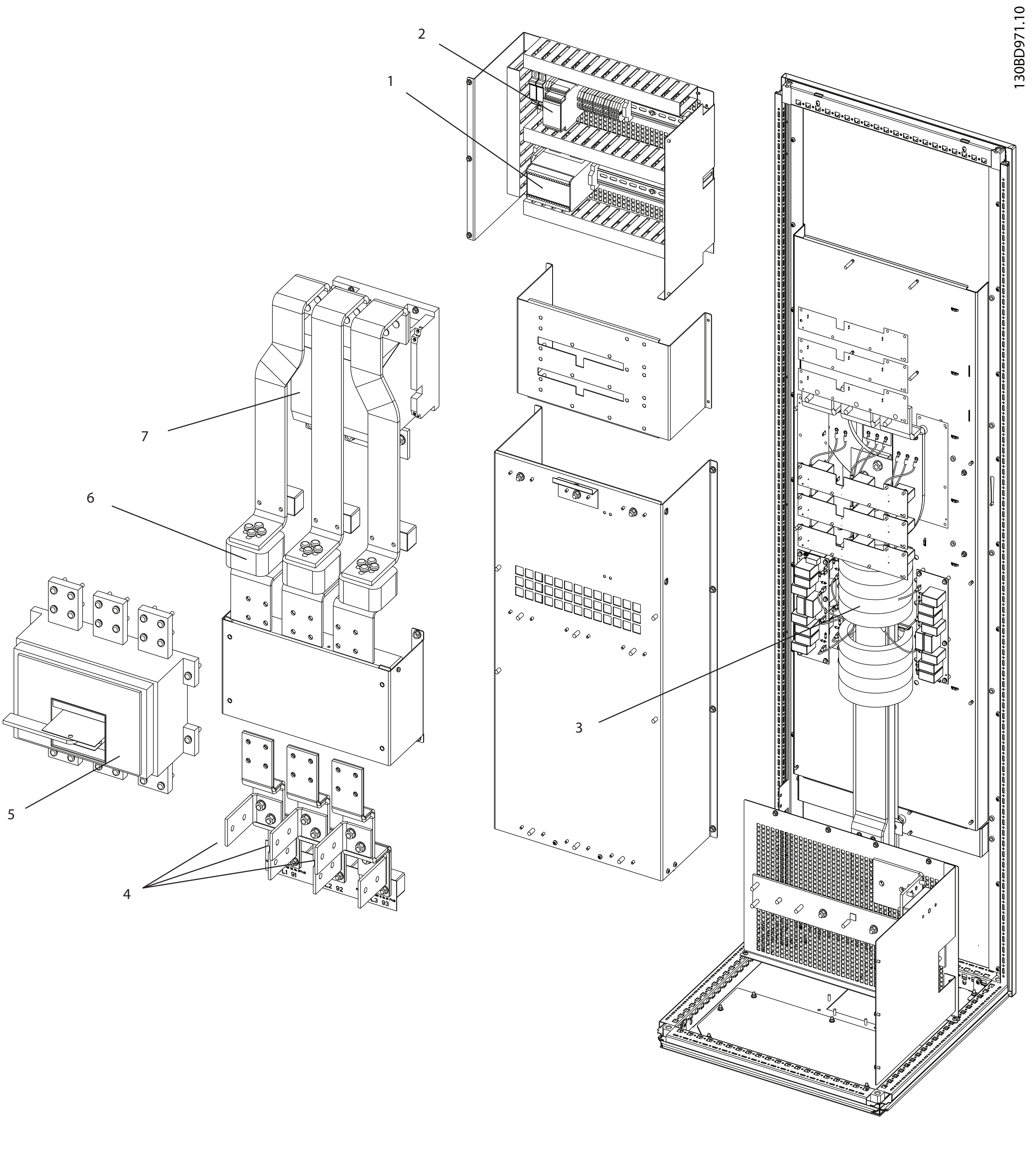
Illustration 3.2 Exterior View, F1/F3 Enclosure



1	F2 enclosure (rectifier and 2-door inverter cabinet)	2	F4 enclosure (options, rectifier, and 2-door inverter cabinet)

Illustration 3.3 Exterior View, F2/F4 Enclosure

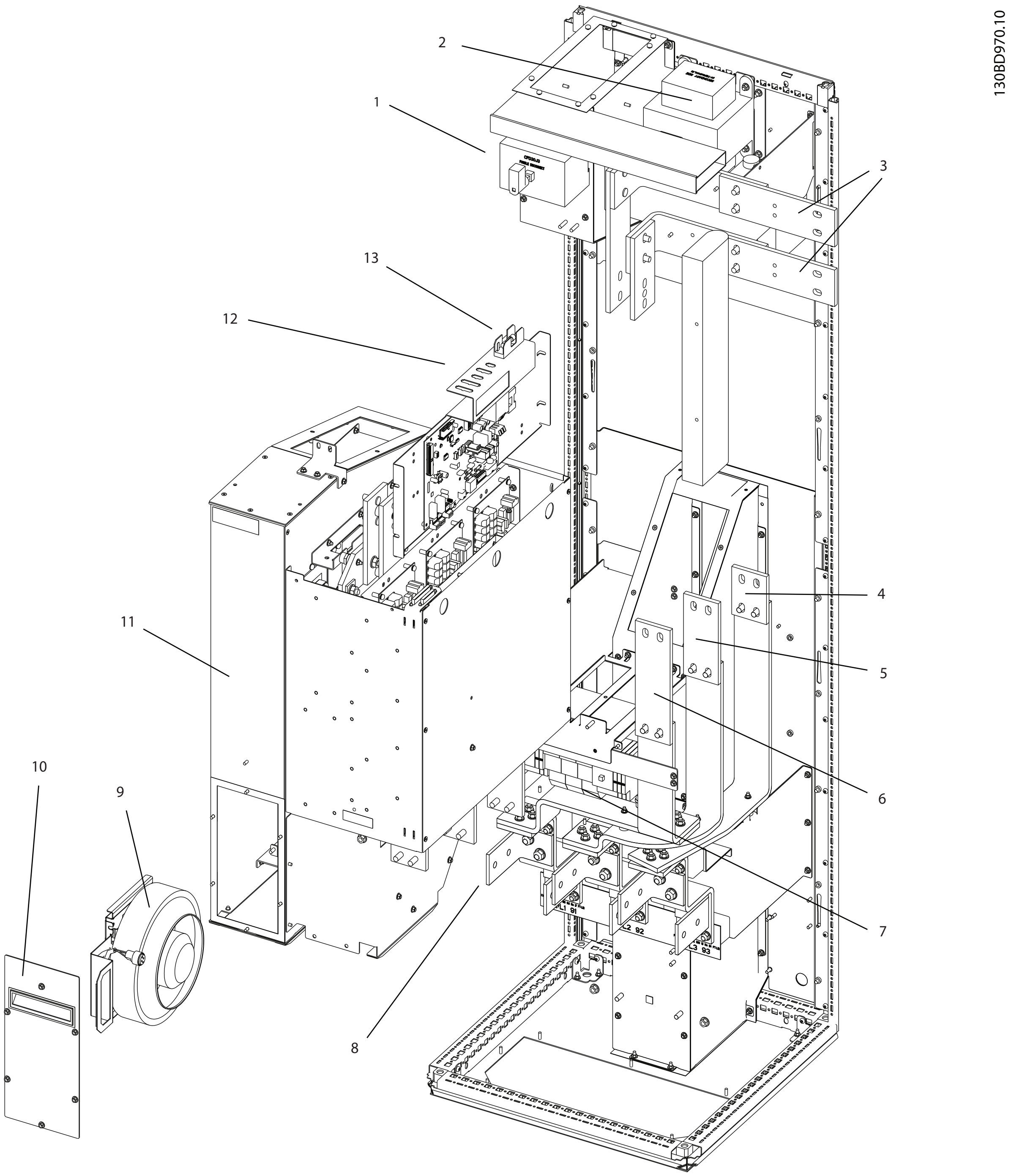
3.3.1 Options Cabinet



1	RCD/IRM	5	Mains circuit breaker or disconnect
2	Pilz relay	6	Mains fuses
3	RFI filter	7	Contactor
4	Mains input terminals		

Illustration 3.4 Options Cabinet, F3 or F4 Enclosure

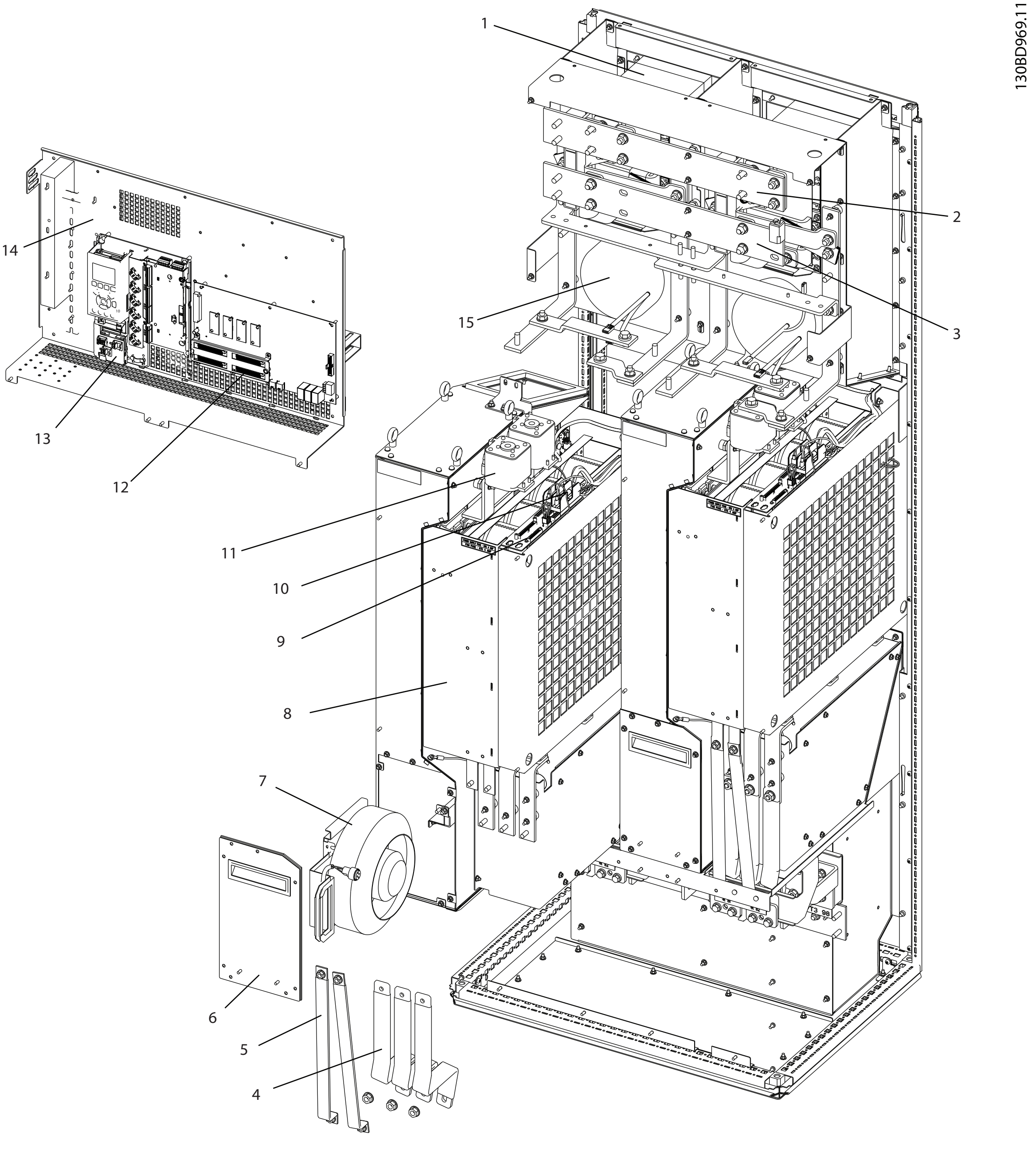
3.3.2 Rectifier Cabinet



1	Optional equipment power disconnect – option	8	Mains input terminals, if unit does not contain an options cabinet
2	Optional equipment control power transformer – option	9	Module heat sink fan
3	DC bus bar	10	Fan door cover
4	AC mains fuse (T phase) – option	11	Rectifier module
5	AC mains fuse (S phase) – option	12	Signal wiring connectors
6	AC mains fuse (R phase) – option	13	Power card supply fuse
7	Manual motor starter – option		

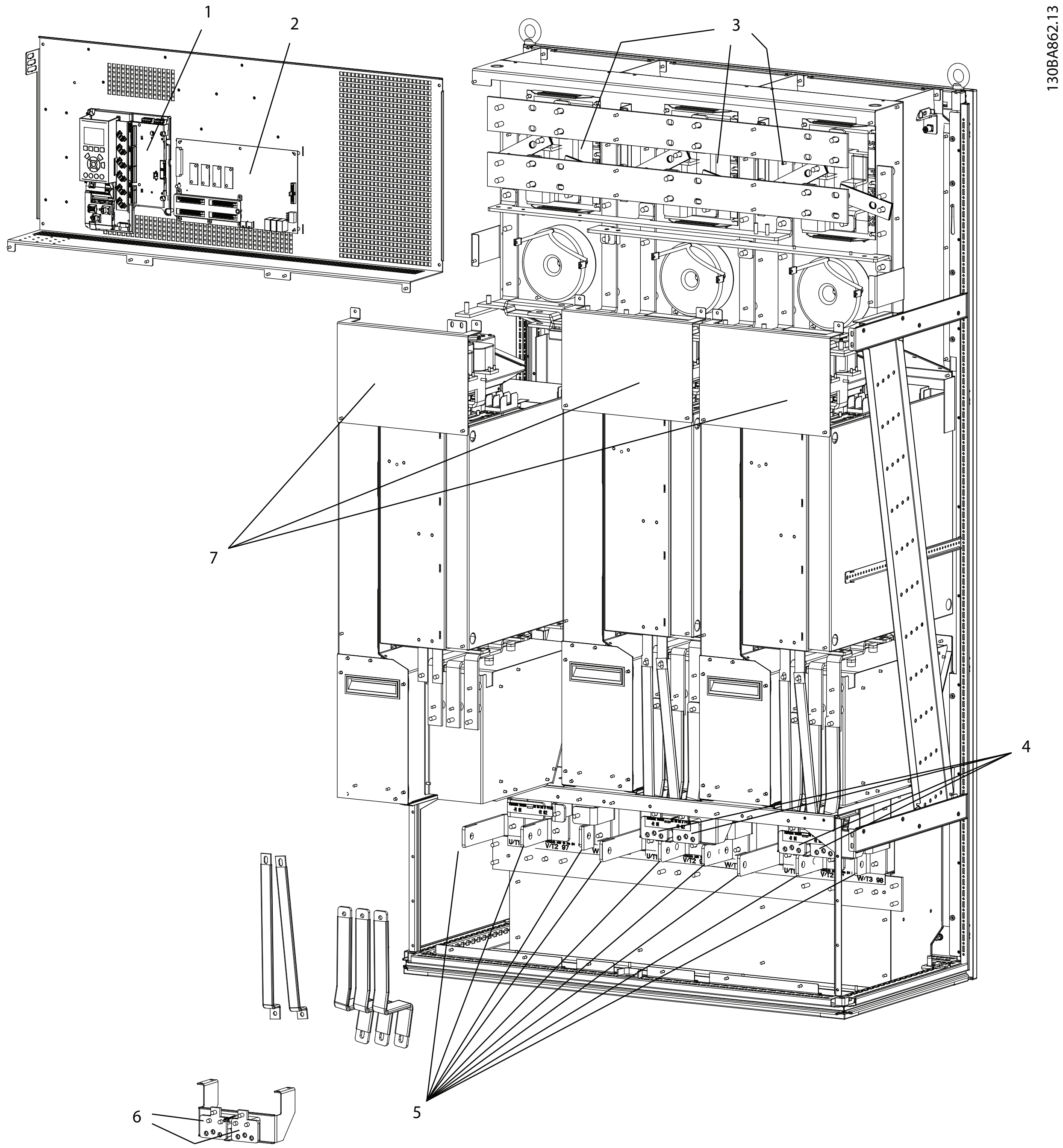
Illustration 3.5 Rectifier Cabinet, F1–F4 Enclosure

3.3.3 Inverter Cabinet



1	DC link inductor	9	Signal wiring connectors
2	(-) DC bus bar	10	SMPS fuse and fan fuse
3	(+) DC bus bar	11	DC fuse
4	Motor output bus bar	12	MDCIC board
5	Brake output bus bar – option	13	Control card
6	Fan door cover	14	Control mounting plate
7	Module heat sink fan	15	Fan transformer
8	Inverter module		

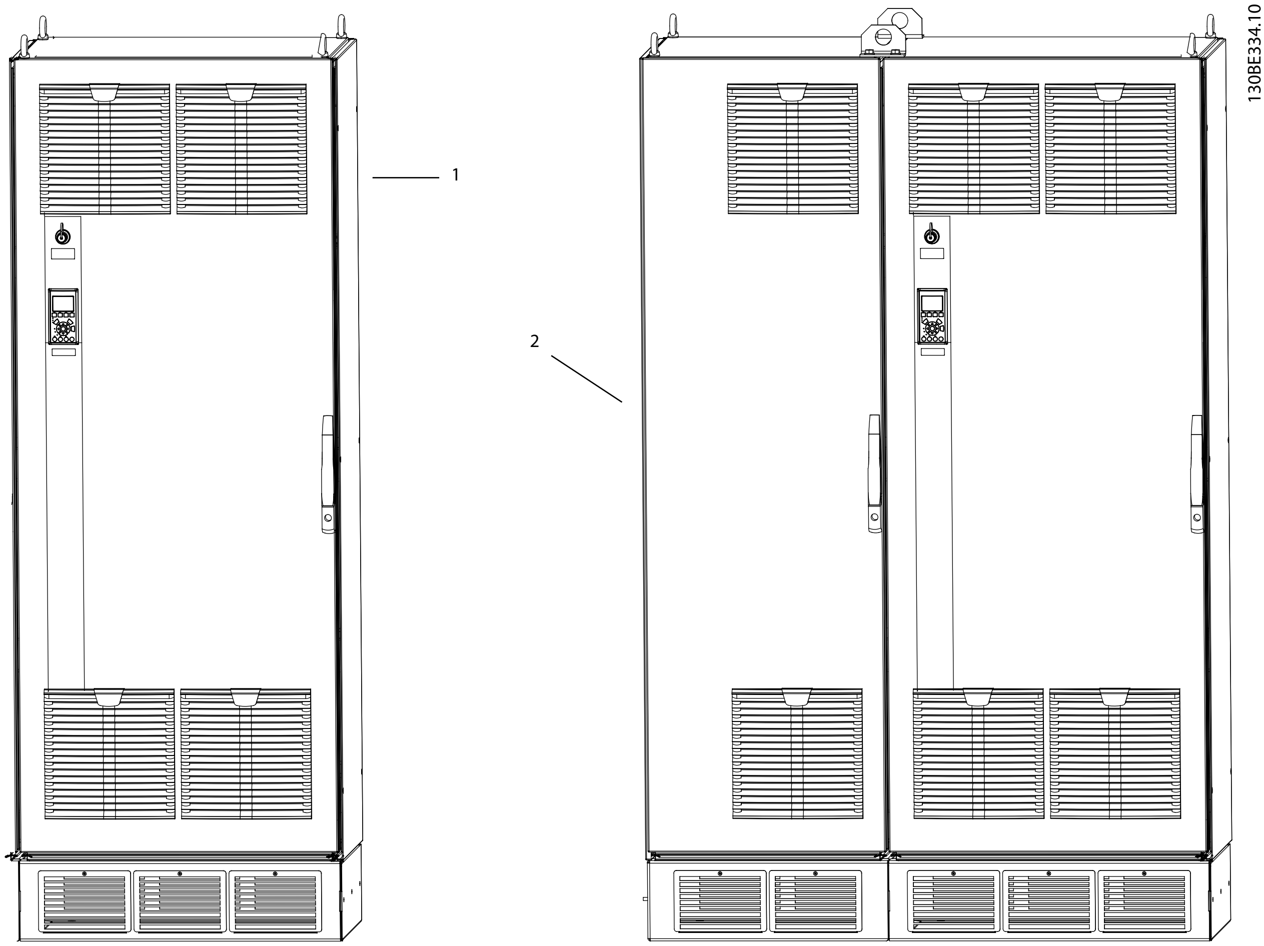
Illustration 3.6 Inverter Cabinet, F1 or F3 Enclosure



1	Control card and control card options	5	Motor terminals
2	MDCIC	6	Brake terminals – option
3	DC inductors	7	Safety covers
4	Brake terminals – option		

Illustration 3.7 Inverter Cabinet, F2 or F4 Enclosure

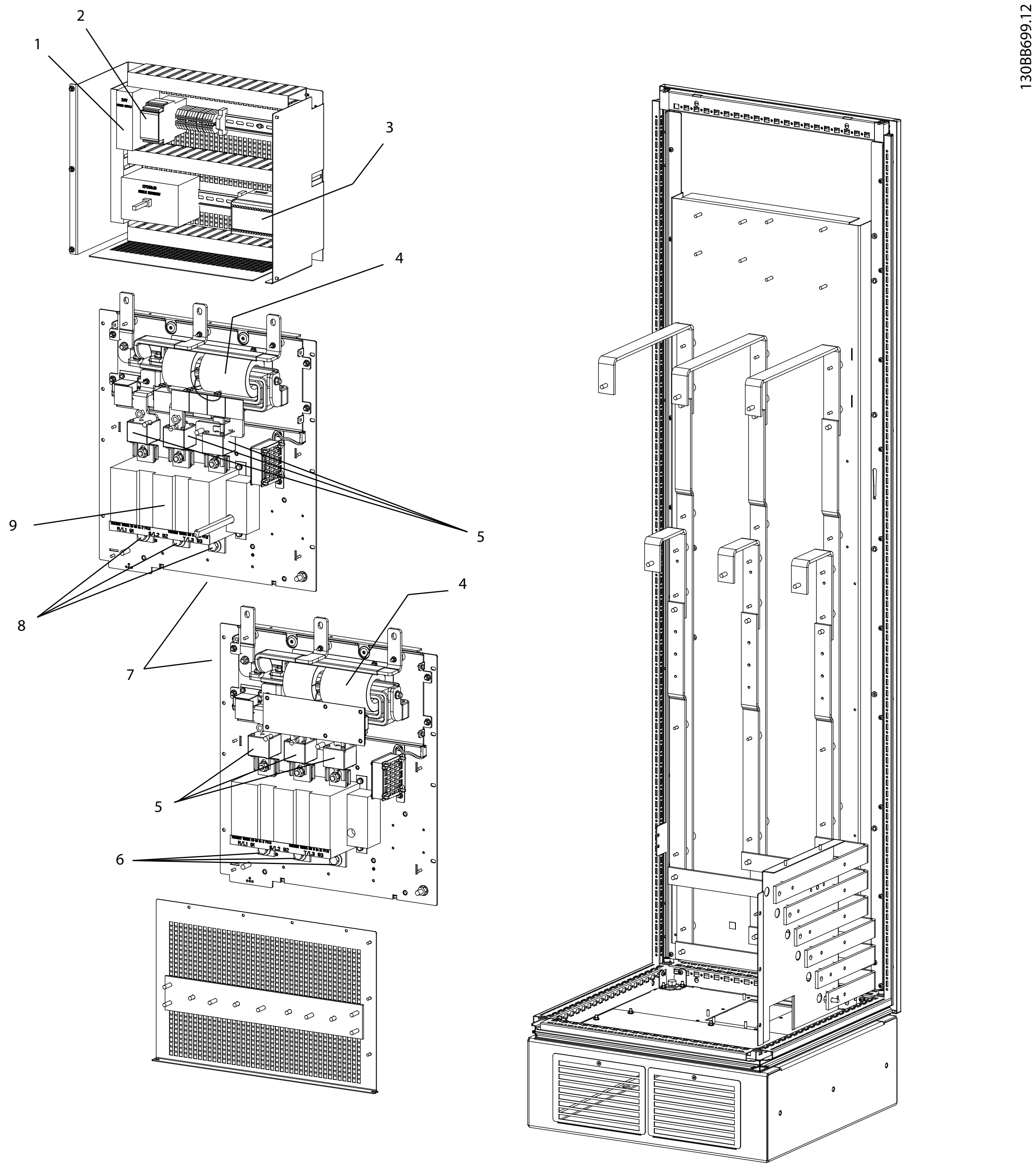
3.4 Exploded Views, F8–F9 Enclosures



1	F8 enclosure (rectifier/inverter cabinet)	2	F9 enclosure (options and rectifier/inverter cabinets)

Illustration 3.8 Exterior View, F8–F9 Enclosure

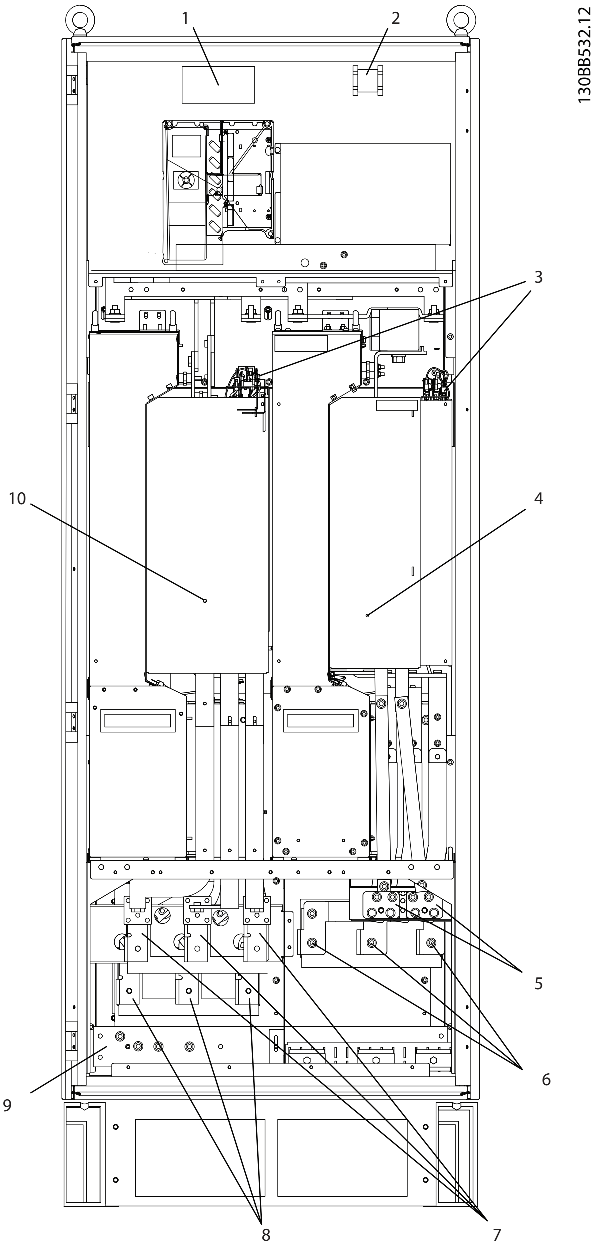
3.4.1 Options Cabinet



1	Safety relay coil fuse with Pilz relay – option	6	Mains input L12, L22, L32
2	Pilz relay terminal – option	7	Input plates
3	RCD or IRM terminal – option	8	Mains input L11, L21, L31
4	RFI filter – option	9	2x3-phase mains disconnect – option
5	Mains fuses – option		

Illustration 3.9 Options Cabinet, F9 Enclosure

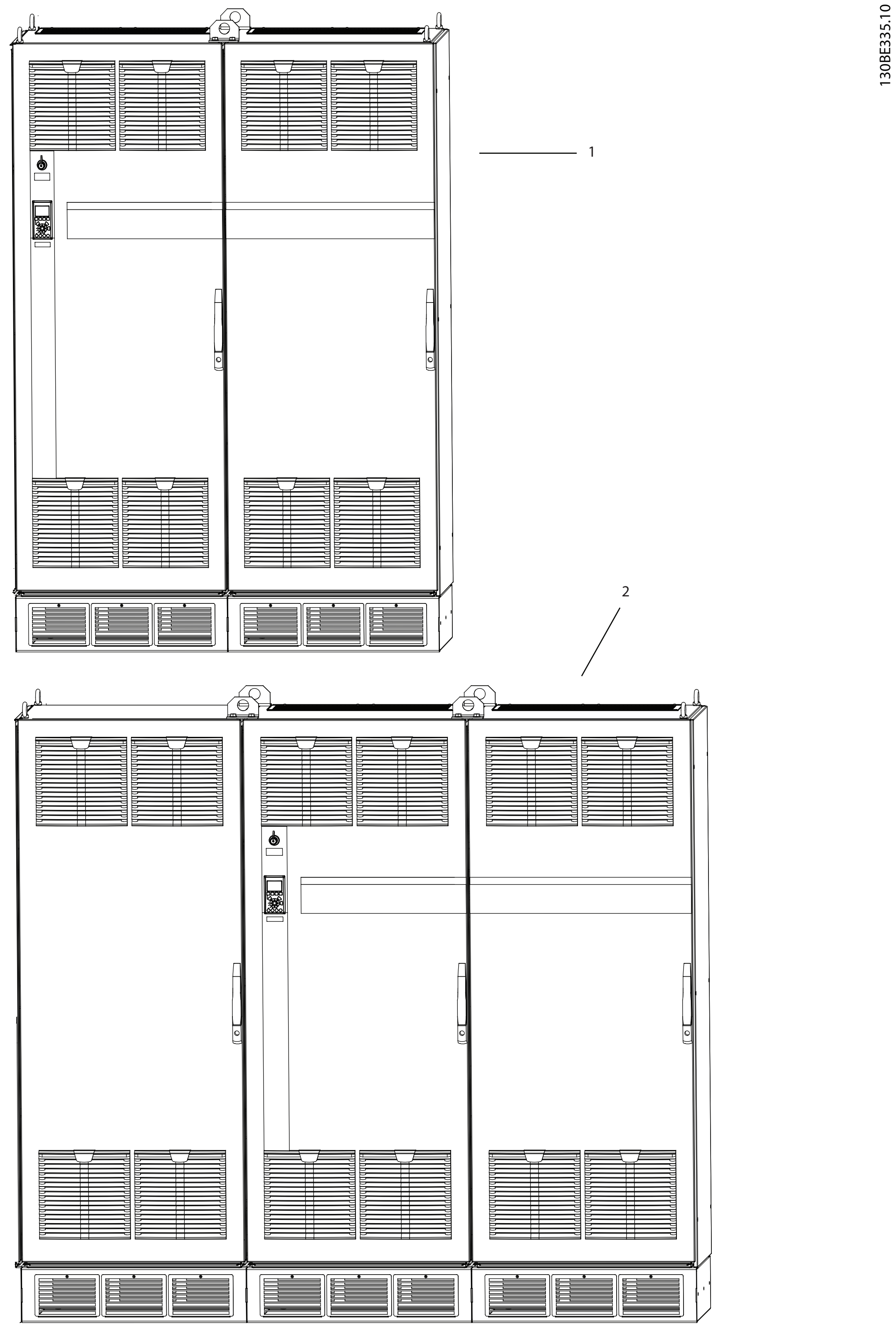
3.4.2 Rectifier/Inverter Cabinet



1	Auxiliary fan terminals (104, 106)	6	Motor terminals 96 (U), 97 (V), 98 (W)
2	Relay 1 (01, 02, 03), relay 2 (04, 05, 06)	7	Mains input L11, L21, L31
3	Signal wiring connectors	8	Mains input L12, L22, L32
4	Inverter module	9	Ground PE terminals
5	Brake terminals 81 (-R), 82 (+R) – option	10	12-pulse rectifier module

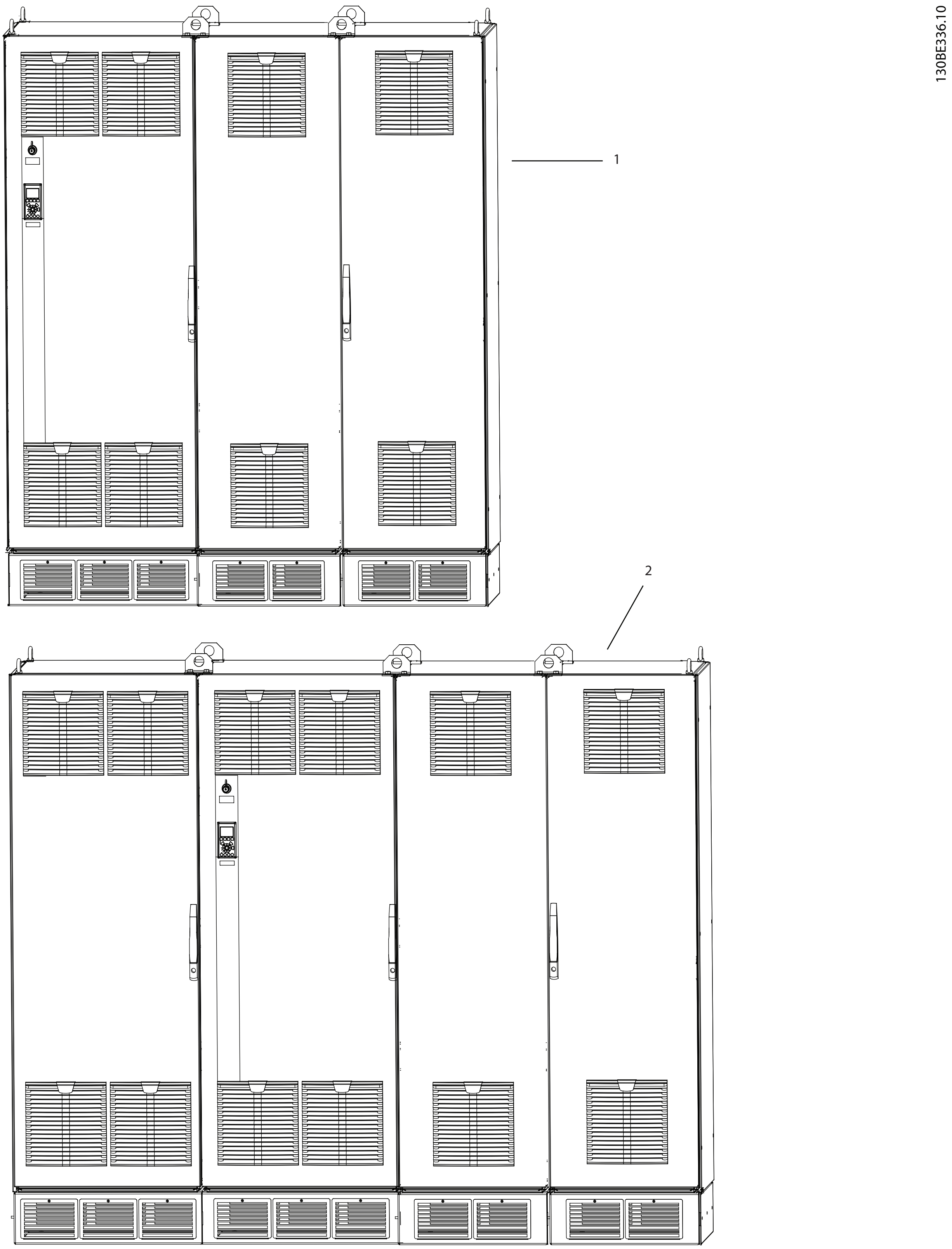
Illustration 3.10 Rectifier/Inverter Cabinet, F8 or F9 Enclosure

3.5 Exploded Views, F10–F13 Enclosures



1	F10 enclosure (rectifier and inverter cabinets)	2	F11 enclosure (options, rectifier, and inverter cabinets)

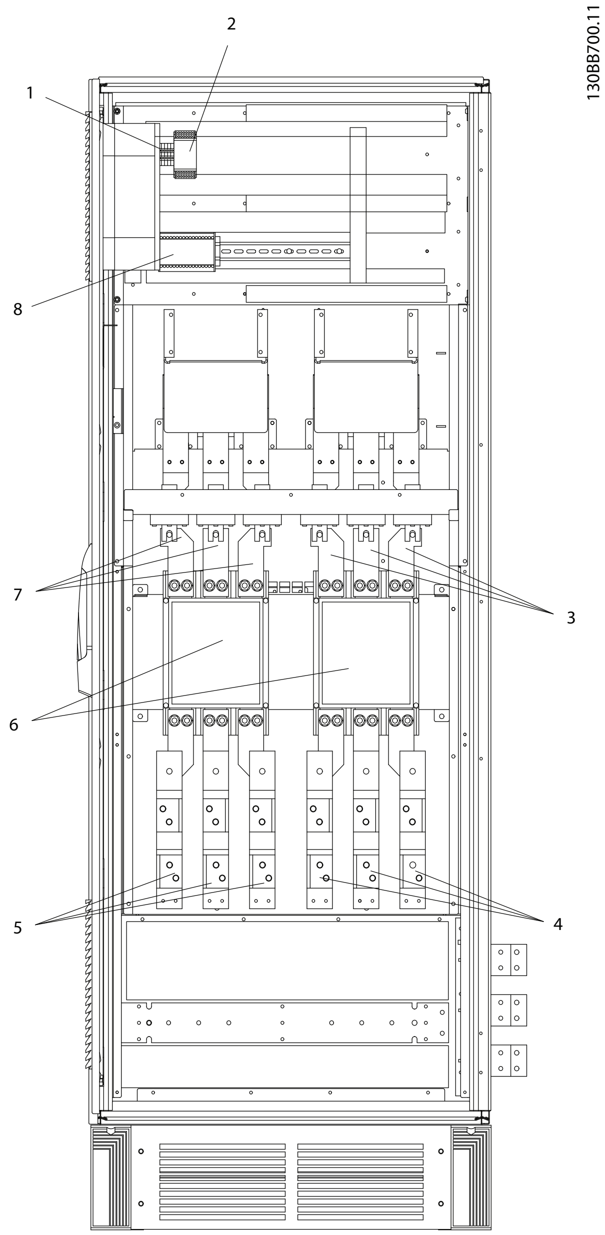
Illustration 3.11 Exterior View, F10–F11 Enclosure



1	F12 enclosure (rectifier and 2-door inverter cabinet)	2	F13 enclosure (options, rectifier, and 2-door inverter cabinet)

Illustration 3.12 Exterior View, F12–F13 Enclosure

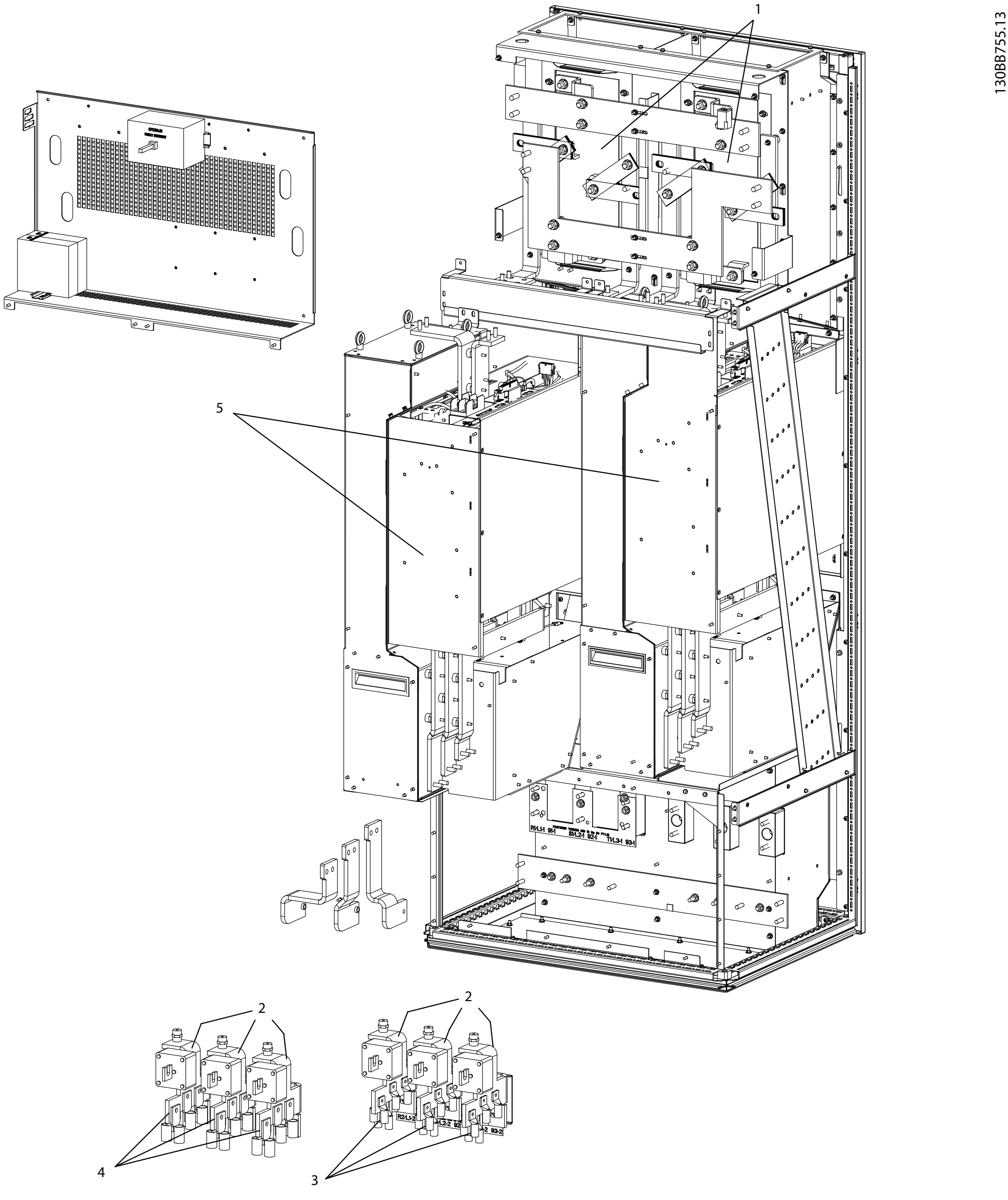
3.5.1 Options Cabinet



1	Safety relay coil fuse with Pilz relay – option	5	Mains input L11, L21, L31
2	Pilz relay terminal – option	6	2x3-phase manual disconnect
3	Mains fuses – option	7	Mains fuses – option
4	Mains input L12, L22, L32	8	RCD or IRM terminal – option

Illustration 3.13 Options Cabinet, F11 or F13 Enclosure

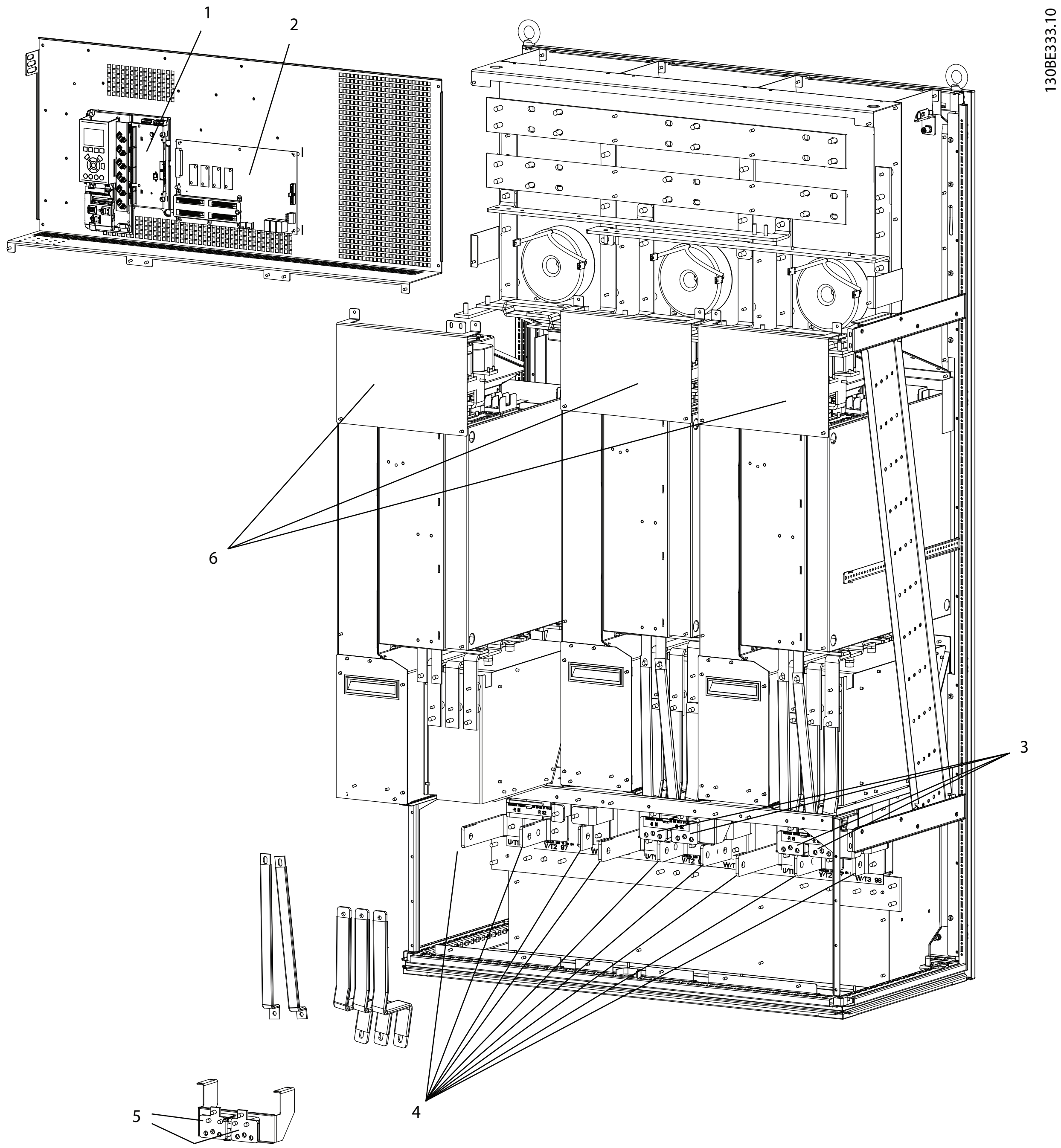
3.5.2 Rectifier Cabinet



1	DC link inductors	4	Mains input L11, L21, L31
2	Mains fuses – option	5	Rectifier module
3	Mains input L12, L22, L32		

Illustration 3.14 Rectifier Cabinet, F10–F13 Enclosure

3.5.3 Inverter Cabinet



1	Control card and control card options	4	Motor terminals
2	MDCIC	5	Brake terminals – option
3	Brake terminals – option	6	Safety covers

Illustration 3.15 Inverter Cabinet, F12–F13 Enclosure (F10–F11 Enclosures Are Similar, But Contain Only 2 Inverter Modules)

3.6 Location of Optional Components

Units are manufactured in different configurations due to the optional components available. Depending on the unit configuration, optional equipment can be mounted in the inverter, rectifier, or options cabinet.

Mains and motor options

Options	Cabinet location
AC fuse	Rectifier or options
Disconnect	Options
Circuit breaker	Options
Contactor	Options
A1 RFI filter	Options
Load share	Rectifier
Regen connection	Inverter
Common motor terminals	Inverter

Table 3.5 Location of Mains and Motor Options

Enclosure options

Options	Cabinet location
Cabinet lights and power outlet	Mounted between rectifier and inverter cabinets
Space heater and thermostat	Mounted between rectifier and inverter cabinets

Table 3.6 Location of Enclosure Options

Control options

Options	Cabinet location
NAMUR terminals	Inverter
Manual motor starter	Rectifier
30 A fuse-protected terminals	Rectifier
24 V DC supply	Rectifier

Table 3.7 Location of Control Options

Monitoring options

Options	Cabinet location
Residual current monitor	Options
Insulation resistance monitor	Options
External temperature monitoring	Inverter
Pilz safety relay	Inverter

Table 3.8 Location of Monitoring Options

4 Operator Interface and Frequency Converter Control

4.1 Introduction

Frequency converters are designed with self-diagnostic circuitry to isolate fault conditions and show messages that simplify troubleshooting and service. The operating status of the frequency converter is shown in real time. Virtually every command given to the frequency converter results in some indication on the local control panel (LCP) display. Fault logs are maintained within the frequency converter for fault history.

The frequency converter monitors supply and output voltages along with the operational condition of the motor and load. When the frequency converter issues a warning or alarm, the fault is not always within the frequency converter itself. In fact, for most service calls, the fault condition exists outside of the frequency converter. Most of the warnings and alarms that the frequency converter shows are in response to faults outside of the frequency converter. This service guide provides techniques and test procedures to help isolate a fault condition whether in the frequency converter or elsewhere.

Familiarity with the information provided on the LCP display is important. More diagnostic data can be accessed easily through the LCP.

4.2 User Interface

The local control panel (LCP) is the combined display and keypad on the front of the unit.

The LCP has several user functions:

- Starts, stops, and controls speed when in local control.
- Shows operational data, status, warnings, and alarms.
- Programs frequency converter functions.
- Manually resets the frequency converter after a fault when auto reset is inactive.

4.2.1 Layout

The LCP is activated when the frequency converter receives power from 1 of the following:

- Mains voltage
- DC bus terminal
- 24 V DC external supply

The LCP is divided into the following 4 functional groups. Refer to *Illustration 4.1*.

A. Display area
Each display readout has a parameter associated with it. Refer to *Illustration 4.1*. The information shown on the LCP can be customized for user application by selecting options in the Quick Menus *Q1 My Personal Menu*.

Callout	Parameter number	Default setting
A1.1	0-20	Refer to *Table 4.6 – Table 4.8*
A1.2	0-21	
A1.3	0-22	
A2	0-23	
A3	0-24	

Table 4.1 LCP Display Area

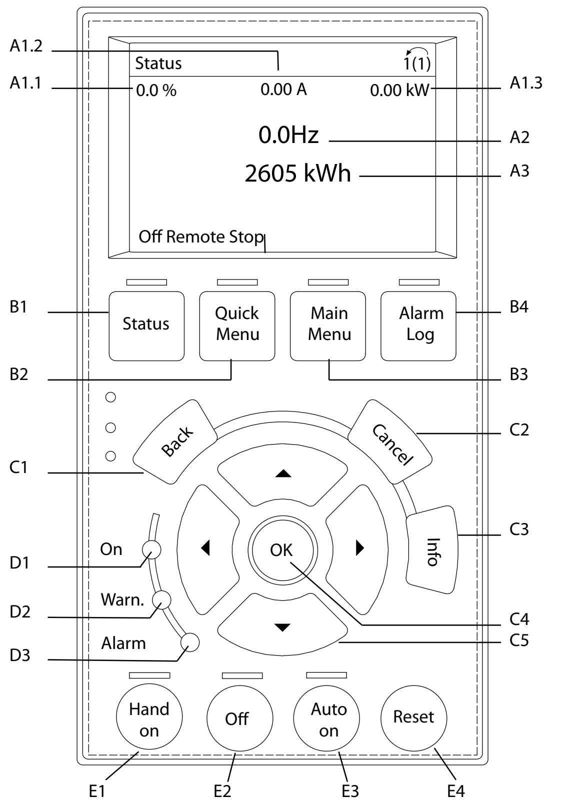


Illustration 4.1 Local Control Panel (LCP)

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.

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 *chapter 4.2.2.1 Quick Menu Mode*.
B3	Main Menu	Allows access to all parameters. Refer to *chapter 4.2.2.6 Main Menu Mode*.
B4	Alarm Log	Shows a list of current warnings and the last 10 alarms.

Table 4.2 LCP Menu Keys

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.

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.

Table 4.3 LCP Navigation Keys

D. Indicator lights

Indicator lights are used to identify the frequency converter status and to provide a visual notification of warning or fault conditions.

Callout	Indicator	Indicator light	Function
D1	On	Green	Activates when the frequency converter 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.

Table 4.4 LCP Indicator Lights

E. Operation keys and reset

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

Callout	Key	Function
E1	[Hand On]	Starts the frequency converter 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 frequency converter.
E3	Auto On	Puts the system in remote operational mode so it can respond to an external start command by control terminals or serial communication.
E4	Reset	Resets the frequency converter manually after a fault has been cleared.

Table 4.5 LCP Operation Keys and Reset

4.2.2 Menus

4.2.2.1 Quick Menu Mode

The LCP provides access to all parameters listed under the Quick Menus. To show the list of options in the quick menu, press [Quick Menu].

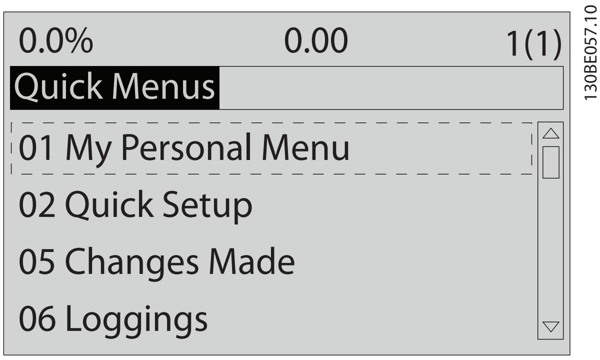


Illustration 4.2 Quick Menu View

4

4.2.2.2 Q1 My Personal Menu

The Personal Menu is used to define the LCP readout display (refer to *chapter 4.2.1 Overview*) and store pre-selected parameters. Store important set-up values by using up to 20 pre-programmed parameters. These parameters are selected in *parameter 0-25 My Personal Menu*.

Parameter	Default setting
Parameter 0-01 Language	English
Parameter 0-20 Display Line 1.1 Small	Reference %
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	kWh counter
Parameter 15-51 Frequency Converter Serial Number	

Table 4.6 Q1 My Personal Menu Settings for VLT® HVAC Basic Drive FC 102

Parameter	Default setting
Parameter 0-01 Language	English
Parameter 0-20 Display Line 1.1 Small	Reference [Unit]
Parameter 0-21 Display Line 1.2 Small	Analog input 53
Parameter 0-22 Display Line 1.3 Small	Motor current
Parameter 0-23 Display Line 2 Large	Frequency
Parameter 0-24 Display Line 3 Large	Feedback [Unit]
Parameter 15-51 Frequency Converter Serial Number	

Table 4.7 Q1 My Personal Menu Settings for VLT® AQUA Drive FC 202

Parameter	Default setting
Parameter 0-01 Language	English
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 %
Parameter 15-51 Frequency Converter Serial Number	

Table 4.8 Q1 My Personal Menu Settings for VLT® AutomationDrive FC 302

4.2.2.3 Q2 Quick Set-up

The parameters in *Q2 Quick Set-up* are the basic parameters that are always necessary for set-up. This menu provides the most efficient set-up for most applications. Perform the unit set-up in the order listed. Refer to the programming guide for the set-up steps.

4.2.2.4 Q5 Changes Made

Select *Q5 Changes Made* to get information about:

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

4.2.2.5 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 show parameters selected in *parameter 0-20 Display Line 1.1 Small* to *parameter 0-24 Display Line 3 Large* can be viewed. It is possible to store up to 120 samples in the memory for later reference.

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 %

Table 4.9 Loggings Parameter Examples

4.2.2.6 Main Menu Mode

The LCP provides access to the *Main Menu* mode. Select the *Main Menu* mode by pressing the [Main Menu] key. The resulting readout appears on the LCP display.

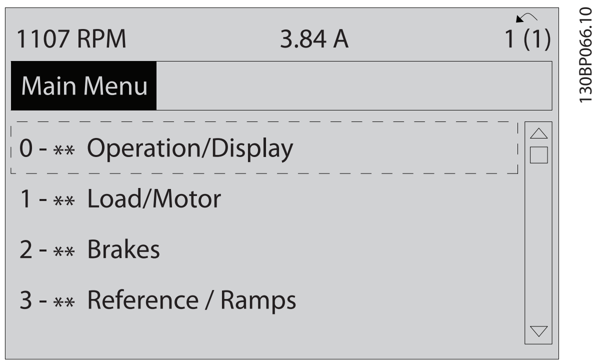


Illustration 4.3 Main Menu View

Lines 2 through 5 on the display show a list of parameter groups that can be selected via the ▲ and ▼ keys.

All parameters can be changed in the main menu. Option cards added to the unit enable extra parameters associated with the option device.

Establishing the correct programming for applications requires setting several parameter functions. Details for parameters are provided in the programming guide.

Parameter settings are stored internally in the frequency converter, allowing the following advantages:

- Parameter settings can be uploaded into the LCP memory and stored as a back-up.
- Multiple units can be programmed quickly by connecting the LCP to the unit and downloading the stored parameter settings.
- Settings that are stored in the LCP are not changed when restoring factory default settings.

4.2.3 Uploading and Downloading Parameter Settings

The frequency converter operates using parameters stored on the control card, which is located within the frequency converter. The upload and download functions move the parameters between the control card and the LCP.

1. Press [Off].
2. Go to *parameter 0-50 LCP Copy* and press [OK].
3. Select 1 of the following:
   - 3a To upload data from the control card to the LCP, select *[1] All to LCP*.
   - 3b To download data from the LCP to the control card, select *[2] All from LCP*.
4. Press [OK]. A progress bar shows the uploading or downloading process.
5. Press [Hand On] or [Auto On].

4.2.4 Restoring Factory Default Settings

NOTICE

LOSS OF DATA

Loss of programming, motor data, localization, and monitoring records occurs when restoring default settings. To create a back-up, upload data to the LCP before initialization. Refer to *chapter 4.2.3 Uploading and Downloading Parameter Settings*.

Restore the default parameter settings by initializing the unit. Initialization is carried out through *parameter 14-22 Operation Mode* or manually.

Parameter 14-22 Operation Mode does not reset settings such as the following:

- Running hours
- Serial communication options
- Personal menu settings
- Fault log, alarm log, and other monitoring functions

Recommended initialization

1. Press [Main Menu] twice to access parameters.
2. Go to *parameter 14-22 Operation Mode* and press [OK].
3. Scroll to *Initialization* and press [OK].
4. Remove power to the unit and wait for the display to turn off.
5. Apply power to the unit. Default parameter settings are restored during start-up. Start-up takes slightly longer than normal.
6. After alarm 80 shows, press [Reset].

Manual initialization

Manual initialization resets all factory settings except for the following:

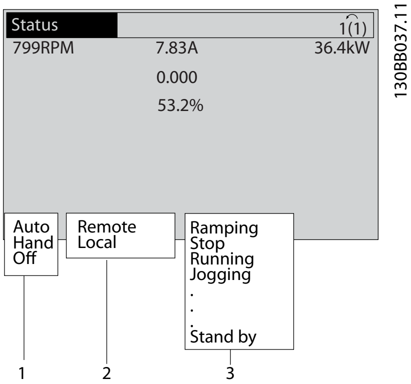
- *Parameter 15-00 Operating hours*
- *Parameter 15-03 Power Up's*
- *Parameter 15-04 Over Temp's*
- *Parameter 15-05 Over Volt's*

To perform manual initialization:

1. Remove power to the unit and wait for the display to turn off.
2. Press and hold [Status], [Main Menu], and [OK] simultaneously while applying power to the unit (approximately 5 s or until an audible click sounds and the fan starts). Start-up takes slightly longer than normal.

4.3 Status Messages

When the frequency converter is in status mode, status messages are generated automatically and appear in the bottom line of the LCP display (refer to *Illustration 4.4*.) Status messages are defined in *Table 4.10* – *Table 4.12*.



1	The first part of the status line indicates where the stop/start command originates. Refer to *Table 4.10*.
2	The second part of the status line indicates where the speed control originates. Refer to *Table 4.11*.
3	The last part of the status line gives the present frequency converter status. The status shows the operational mode that the frequency converter is in. Refer to *Table 4.12*.

Illustration 4.4 Status Display

NOTICE

In auto/remote mode, the frequency converter requires external commands to execute functions.

4.4 Status Message Definitions

Table 4.10 – *Table 4.12* define the meaning of the shown status messages.

Off	The frequency converter does not react to any control signal until [Auto On] or [Hand On] is pressed.
Auto	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 frequency converter. Stop commands, reset, reversing, DC brake, and other signals applied to the control terminals can override local control.

Table 4.10 Operating Mode

Remote	The speed reference is given from • External signals. • Serial communication. • Internal preset references.
Local	The frequency converter uses reference values from the LCP.

Table 4.11 Reference Site

AC braking	AC braking was selected in *parameter 2-10 Brake Function*. The AC braking 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. 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.
Bus jog 1	PROFIdrive profile was selected in *parameter 8-10 Control Word Profile*. The Jog 1 function is activated via serial communication. The motor is running with *parameter 8-90 Bus Jog 1 Speed*.
Bus jog 2	PROFIdrive profile was selected in *parameter 8-10 Control Word Profile*. The Jog 2 function is activated via serial communication. The motor is running with *parameter 8-91 Bus Jog 2 Speed*.
Catch up	The value set in *parameter 3-12 Catch up/slow Down Value* corrects the output frequency. 1. Catch up is selected as a function for a digital input (parameter group *5-1* Digital Inputs*). The corresponding terminal is active. 2. Catch up was activated via serial communication.
Coast	• 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.
Control ready	PROFIdrive profile was selected in *parameter 8-10 Control Word Profile*. The frequency converter needs the first part (for example, 0x047E) of the 2-part start command via serial communication to allow starting. Using a terminal is not possible.

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* at mains fault. • The frequency converter ramps down the motor using a controlled ramp down.
Current high	The frequency converter output current is above the limit set in *parameter 4-51 Warning Current High*.
Current low	The frequency converter output current is below the limit set in *parameter 4-50 Warning Current Low*.
DC hold	*[1] 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.
DC voltage U0	In *parameter 1-01 Motor Control Principle* and in *parameter 1-80 Function at Stop*, DC Voltage U0 is selected. When a stop command (for example, Stop (inverse)) is activated, the voltage selected according to the *parameter 1-55 U/f Characteristic - U* is applied to the motor.
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*.
Flying start	The frequency converter is testing if the connected motor is running with a speed that is in the adjusted speed range. The process was started by connecting a digital input (parameter group *5-1* Digital Inputs*) programmed as coast inverse or by connecting to the mains.
Freeze output	The remote reference is active, which holds the present speed. • 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.	Freeze reference was selected as a function for a digital input (parameter group *5-1* Digital Inputs*). The corresponding terminal is active. The frequency converter 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 runs as programmed in *parameter 3-19 Jog Speed [RPM]*. • *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.
Kinetic back-up	In *parameter 14-10 Mains Failure*, a function was set as kinetic back-up. The mains voltage is below the value set in *parameter 14-11 Mains Voltage at Mains Fault*. The frequency converter is running the motor momentarily with kinetic energy from the inertia of the load.
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 frequency converter, a permanent test current is applied to the motor. Only available in VLT® HVAC Drive FC 102 and VLT® AQUA Drive FC 202.
Off1	PROFIdrive profile was selected in *parameter 8-10 Control Word Profile*. The Off1 function is activated via serial communication. The motor is stopped via the ramp.

Off2	PROFIdrive profile was selected in *parameter 8-10 Control Word Profile*. The Off2 function is activated via serial communication. The output of the frequency converter is disabled immediately and the motor is coasted.
Off3	PROFIdrive profile was selected in *parameter 8-10 Control Word Profile*. The Off3 function is activated via serial communication. The motor is stopped via the ramp.
OVC control	*[2] Enabled* was activated in *parameter 2-17 Over-voltage Control*. The connected motor supplies the frequency converter with generative energy. The overvoltage control adjusts the V/Hz ratio to run the motor in controlled mode, and to prevent the frequency converter from tripping.
Power unit off	(For frequency converters with a 24 V external supply installed only.) Mains supply to the frequency converter is removed, but the control card is supplied by the external 24 V.
Pre-magnetize	Premagnetization is selected in *parameter 1-80 Function at Stop*. A stop command (for example, stop inverse) is activated. A suitable constant magnetizing current is applied to the motor.
Protection md	Protection mode is active. The unit has detected a critical status (an overcurrent or overvoltage). • To avoid tripping, switching frequency is reduced to 1500 kHz if *parameter 14-55 Output Filter* is set to *[2] Sine-Wave Filter Fixed*. Otherwise, the switching frequency is reduced to 1000 Hz. • 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 decelerates using *parameter 3-81 Quick Stop Ramp Time*. • *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 accelerates/decelerates 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 frequency converter 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. Only available in VLT® HVAC Drive FC 102 and VLT® AQUA Drive FC 202.
Running	The frequency converter drives the motor, the ramping phase is done, and the motor revolutions are outside the on-reference range. Occurs when 1 of the motor speed limits (4-11/4-12/4-13/4-14) is set, but the maximum reference is outside this range.
Sleep boost	The boost function in *parameter 22-45 Setpoint Boost* is enabled. This function is only possible in closed-loop operation. Only available in FC 102 and FC 202.
Sleep mode	The energy saving function is enabled, which means the motor has now stopped, but restarts automatically when required. Only available in VLT® HVAC Drive FC 102 and VLT® AQUA Drive FC 202.
Speed down	The value set in *parameter 3-12 Catch up/slow Down Value* is used to correct the output frequency. • Speed down was selected as a function for a digital input (parameter group *5-1* Digital Inputs*). The corresponding terminal is active. • Speed down was activated via serial communication.
Speed high	Motor speed is above the value set in *parameter 4-53 Warning Speed High*.
Speed low	Motor speed is below the value set in *parameter 4-52 Warning Speed Low*.
Standby	In Auto On mode, the frequency converter 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	Start forward and 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.
Start inhibit	PROFIdrive profile was selected in *parameter 8-10 Control Word Profile*. The start inhibition is active. The frequency converter needs the first part (for example, 0x047E) of the 2-part start command via serial communication to allow starting. Refer to the Control ready function under Operation Status.

Stop	The frequency converter receives a stop command from 1 on the following: • LCP • Digital input • Serial communication
Trip	An alarm occurrs and the motor stops. Once the cause of the alarm is cleared, reset the frequency converter manually by • Pressing [Reset]. • Remotely by control terminals. • Via serial communication.
Trip lock	An alarm occurs and the motor stops. Once the cause of the alarm is cleared, cycle power to the frequency converter. Reset the frequency converter manually by • Pressing [Reset]. • Remotely by control terminals. • Via serial communication.
Unit/drive not ready	PROFIdrive profile was selected in *parameter 8-10 Control Word Profile*. A control word is sent to the frequency converter via serial communication with Off 1, Off 2, and Off 3 active. Start inhibit is active. To enable start, refer to Start inhibit function under Operation Status.

Table 4.12 Operation Status

NOTICE

In auto/remote mode, the frequency converter requires external commands to execute functions.

4.5 Service Functions

Service information for the frequency converter is on display lines 3 and 4. Service information includes

- Operating hours.
- Power ups.
- Trips.
- Fault logs of status values during the 20 most recent events that stopped the frequency converter.
- Frequency converter nameplate data.

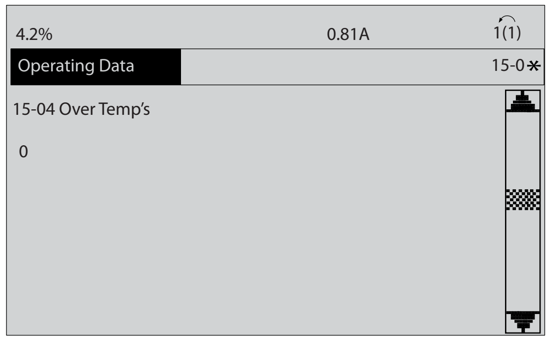


Illustration 4.5 Parameter Group 15 Menu

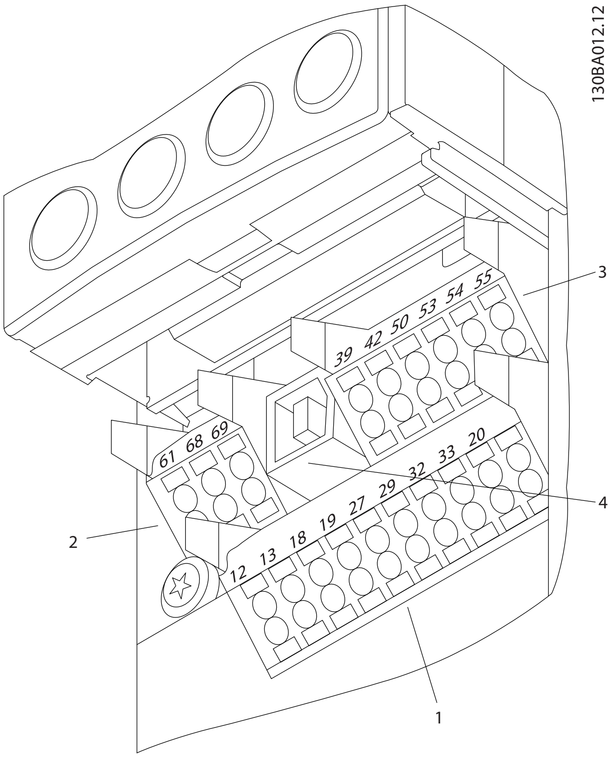
Refer to the programming guide for detailed information on accessing and showing parameters, and for descriptions and procedures for service information available in parameter group *15-** Drive Information*.

4.6 Frequency Converter Inputs and Outputs

The frequency converter operates by receiving control input signals. The frequency converter can also output status data or control auxiliary devices. Control input is connected to the frequency converter in 3 possible ways. One way to control the frequency converter is through the LCP on the front of the frequency converter when operating in local (hand) mode. These inputs include start, stop, reset, and speed reference.

Another control source is through serial communication from a fieldbus. A serial communication protocol supplies commands and references to the frequency converter, can program the frequency converter, and reads status data from the frequency converter. The fieldbus connects to the frequency converter through the RS485 serial port or through a communication option card.

The third way is through signal wiring connected to the frequency converter control terminals. Refer to *Illustration 4.6*. The frequency converter control terminals are located below the frequency converter LCP. Improperly connected control wiring can be the cause of a motor not operating or the frequency converter not responding to a remote input.



1	Digital I/O terminals
2	RS485 (EIA-485) terminal
3	Analog I/O terminals
4	USB connector

Illustration 4.6 Control Terminals

4.6.1 Input Signals

The frequency converter can receive 2 types of remote input signals: digital or analog. Digital inputs are wired to terminals 18, 19, 20 (common), 27, 29, 32, and 33. Analog inputs are wired to terminals 53 or 54 and 55 (common). Underneath the LCP is a switch used for setting the analog terminal functions. Some options include more terminals for input signals.

Analog signals can be either voltage (0–10 V DC) or current (0–20 mA or 4–20 mA). Analog signals can be varied like dialing a rheostat up and down. The frequency converter can be programmed to increase or decrease output in relation to the amount of current or voltage. For example, a sensor or external controller can supply a variable current or voltage. The frequency converter output, in turn, regulates the speed of the motor connected to the frequency converter in response to the analog signal.

Digital signals are a simple binary 0 or 1 that act as a switch. A 0–24 V DC signal controls the digital signals. A voltage signal lower than 5 V DC is a logic 0 (open). A voltage higher than 10 V DC is a logic 1 (closed). Digital inputs to the frequency converter are switched commands such as start, stop, reverse, coast, reset.

NOTICE

SERIAL COMMUNICATION FORMAT

Do not confuse these digital inputs with serial communication formats where digital bytes are grouped into communication words and protocols.

The RS485 serial communication connector is wired to terminals (+) 68 and (-) 69. Terminal 61 is common and is sometimes used for terminating screens when the control cable is run between multiple frequency converters, not other devices. Refer to *chapter 4.9 Grounded Screened Cables* for correct methods for terminating a screened control cable.

4.6.2 Output Signals

The frequency converter also produces output signals that are carried through either the RS485 fieldbus or terminal 42. Output terminal 42 operates in the same manner as the inputs. The terminal can be programmed for either a variable analog signal in mA or a digital signal (0 or 1) in 24 V DC. In addition, a pulse reference can be provided on terminals 27 and 29. Output analog signals generally indicate the frequency converter frequency, current, torque, and so on, to an external controller or system. Digital outputs can be control signals used to open or close a damper, for example, or to send a start or stop command to auxiliary equipment. Some options include more terminals for output signals.

More terminals are Form C relay outputs on terminals 01, 02, and 03, and terminals 04, 05, and 06.

4.6.3 Control Supply

Terminals 12 and 13 provide 24 V DC low voltage power to the digital input terminals (18–33). Those terminals must be supplied with power from either terminal 12 or 13, or from a customer-supplied external 24 V DC power source. Improperly connected control wiring is a common service issue for a motor not operating or a frequency converter not responding to a remote input.

4.7 Control Terminals

Control terminals must be programmed. Each terminal has specific functions it performs and a numbered parameter associated with it. Refer to *Table 4.13*. The setting selected in the parameter enables the function of the terminal. It is important to confirm that the control terminal is programmed for the correct function.

In addition, the input terminal must be receiving a signal. Confirm that the control and power sources are wired to the terminal. Then check the signal.

Signals can be checked in 2 ways. To select digital input for display, press the [Status] key as discussed previously, or use a voltmeter to check for voltage at the control terminal. Refer to *chapter 8.7.13 Input Terminal Signal Tests*.

For proper operation of the frequency converter, the frequency converter input control terminals must be:

- Wired properly.
- Powered.
- Programmed correctly for the intended function.
- Receiving a signal.

4.8 Control Terminal Functions

Table 4.13 describes the functions of the control terminals. Many of these terminals have multiple functions determined by parameter settings. Some options provide more terminals.

Terminal	Function
01, 02, 03 and 04, 05, 06	Two Form C output relays. Maximum 240 V AC, 2 A. Minimum 24 V DC, 10 mA, or 24 V AC, 100 mA. Can be used for indicating status and warnings. Found on the power card.
12, 13	24 V DC supply to digital inputs and external transducers. The maximum output current is 200 mA.
18, 19, 27, 29, 32, 33	Digital inputs for controlling the frequency converter. R = 2 kΩ. Less than 5 V = logic 0 (open). Greater than 10 V = logic 1 (closed). Terminals 27 and 29 are programmable as digital/pulse outputs.
20	Common for digital inputs.
37	0–24 V DC input for Safe Torque Off (some units).
39	Common for analog and digital outputs.
42	Analog and digital outputs for indicating values such as frequency, reference, current, and torque. The analog signal is 0/4 to 20 mA at a maximum of 500 Ω. The digital signal is 24 V DC at a minimum of 500 Ω.
50	10 V DC, 15 mA maximum analog supply voltage for potentiometer or thermistor.
53, 54	Selectable for 0–10 V DC voltage input, R = 10 kΩ, or analog signals 0/4 to 20 mA at a maximum of 200 Ω. Used for reference or feedback signals. A thermistor can be connected here.
55	Common for terminals 53 and 54.
61	RS485 common.
68, 69	RS485 interface and serial communication.

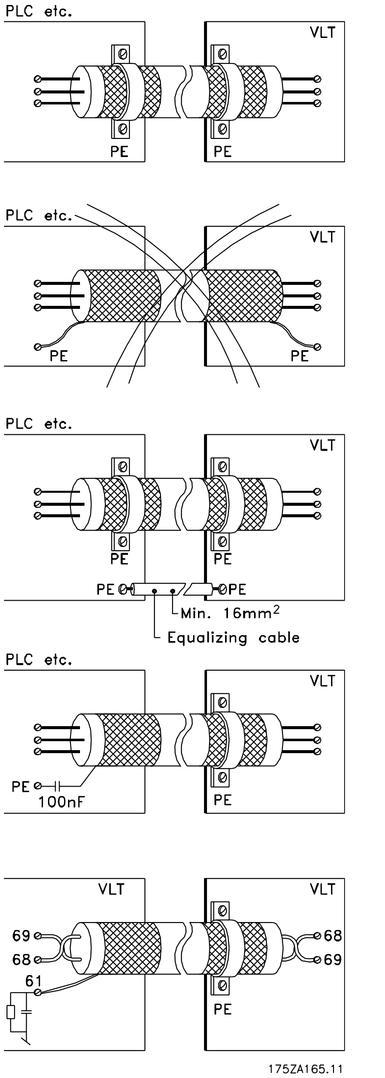
Table 4.13 Control Terminals and Functions

Terminal	18	19	27	29	32	33	37	53	54	42	1–3	4–6
Parameter	5-10	5-11	5-12	5-13	5-14	5-15	5-19	6-1*	6-2*	6-5*	5-4*	5-4*

Table 4.14 Control Terminals and Associated Parameters

4.9 Grounded Screened Cables

Connect the screened control cables with cable clamps at both ends to the metal cabinet of the frequency converter. *Table 4.15* shows ground cabling for optimal results.



Correct grounding Fit control cables and cables for serial communication with cable clamps at both ends to ensure the best possible electrical connection.	
Incorrect grounding Do not use twisted cable ends (pigtails) since it increases screen impedance at high frequencies.	
Ground potential protection When the ground potential between the frequency converter and the PLC or other interface device is different, electrical noise occurs that can disturb the entire system. Fitting an equalizing cable next to the control cable resolves this issue. Minimum cable cross-section is 8 AWG.	
50/60Hz ground loops When using long control cables, 50/60 Hz ground loops can occur that can disturb the entire system. Connecting 1 end of the screen with a 100 nF capacitor and keeping the lead short resolves this issue.	
Serial communication control cables Low-frequency noise currents between frequency converters can be eliminated by connecting 1 end of the screened cable to frequency converter terminal 61. This terminal connects to ground through an internal RC link. Reduce the differential mode interference between conductors by using twisted-pair cables.	

Table 4.15 Grounding Screened Cables

5 Internal Frequency Converter Operation

5.1 General

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

5.2 Description of Operation

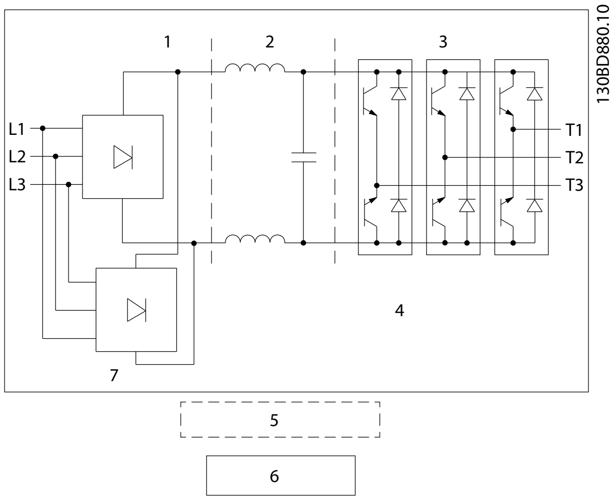
A frequency converter is an electronic controller that supplies a regulated amount of AC power to a 3-phase asynchronous motor. By supplying variable frequency and voltage to the motor, the frequency converter varies the motor speed or maintains a constant speed as the load on the motor changes. Also, the frequency converter can stop and start a motor without the mechanical stress associated with a line start.

In its basic form, the frequency converter can be divided into the following 4 main areas:

- Rectifier
- DC link (DC bus)
- Inverter
- Control

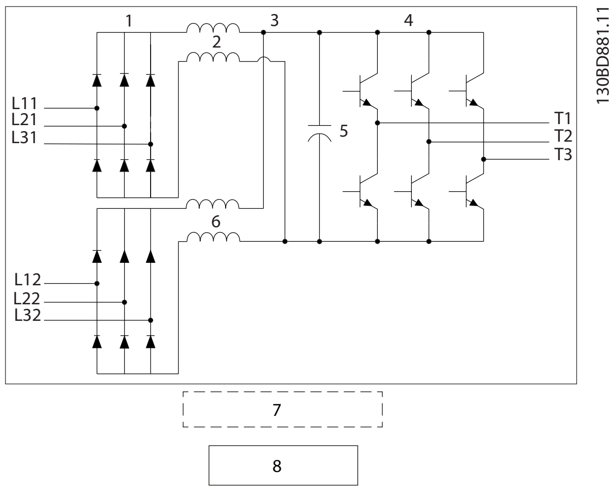
Within those areas, components are grouped into the following sections:

- Control logic
- Logic-to-power interface
- Power



1	Rectifier (SCR/diodes)	5	Logic-to-power interface
2	DC link (DC bus)	6	Control logic
3	Inverter (IGBTs)	7	Soft charge circuitry
4	Power section		

Illustration 5.1 6-pulse Internal Processing



1	Rectifier (SCR/diodes)	4	Inverter (IGBTs)
2	DC inductor (rectifier 1)	5	DC link capacitor
3	DC link (DC bus)	6	DC inductor (rectifier 2)

Illustration 5.2 12-pulse Internal Processing

These areas and components are covered in greater detail in *chapter 5.3 Sequence of Operation*.

5

5.2.1 Logic Section

Microprocessor
The control card contains most of the logic section. Refer to *Illustration 5.3*. The primary logic element of the control card is a microprocessor, which supervises and controls the operation of the frequency converter. In addition, separate PROMs contain the parameters to provide the user with programmable options. These parameters are programmed to enable the frequency converter to meet specific application requirements. This data is then stored in an EEPROM. The EEPROM provides security during power-down and also allows changes to the operational characteristics of the frequency converter.

PWM waveforms
A custom-integrated circuit generates a pulse width modulation (PWM) waveform that is then sent to the interface circuitry on the power card. The PWM waveform is created using an improved control scheme called VVC+. VVC+ provides a variable frequency and voltage to the motor that matches the requirements of the motor. Continuous pulsing SFAVM PWM waveform is available through parameter group *14-** Special Functions*. The SFAVM PWM waveform dynamically responds to system changes to meet the variable requirements of the load.

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 frequency converter. The LCP provides the interface between the operator and the internal logic of the frequency converter. All the programmable parameter settings of the frequency converter can be uploaded into the EEPROM of the LCP. This upload function is useful for maintaining a back-up frequency converter profile and parameter set. When downloaded, it is used to program other frequency converters or to restore a program to a repaired unit. The LCP is removable during operation to prevent program changes. With the addition of a remote mounting kit, the LCP can be mounted in a remote location up to 3 metres away.

Control terminals
Control terminals, with programmable functions, are provided for input commands such as run, stop, forward, reverse, and speed reference. More output terminals are provided to supply signals that run peripheral devices or monitor and report status. The analog and digital output signals are powered through an internal frequency converter supply.

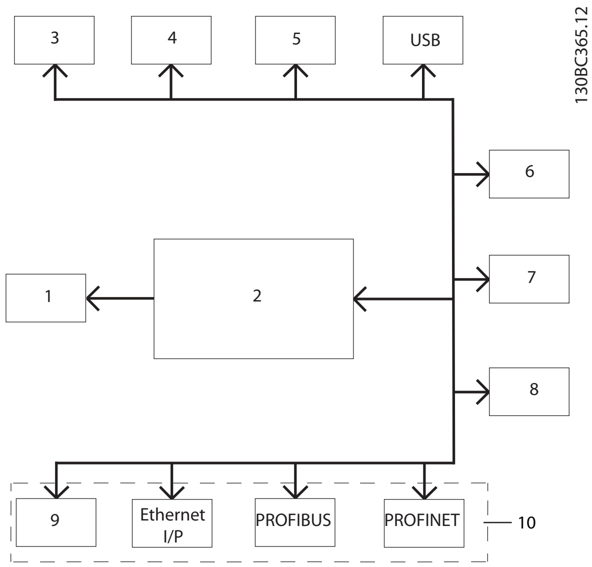
The control card logic can communicate via serial link or USB with outside devices such as personal computers or programmable logic controllers (PLC). The control card also provides 2 voltage supplies for use from the control terminals.

- 24 V DC is used for switching functions such as start, stop, forward, and reverse. The 24 V DC supply can provide 200 mA of power, part of which can be used to power external encoders or other devices.
- 10 V DC supply on terminal 50 is rated at 17 mA and is available for use with speed reference circuitry.

External interfaces
Two relays for monitoring frequency converter status are on the power card. These relays are programmable through parameter group *5-4* Relays*. The relays are Form C, meaning it has 1 normally open contact and 1 normally closed contact on a single throw. The contacts of the relay are rated for a maximum load of 240 V AC at 2 A resistance.

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

- Control
- Serial communication
- More relays
- Cascade pump controller



1	Power card	6	Relay 1 and relay 2
2	Micro controller system	7	Analog in, analog out
3	LCP	8	Digital in, digital out
4	B-option slot	9	24 V back-up supply
5	Standard bus	10	Optional at control card

Illustration 5.3 Control Card External Interfaces

5.2.2 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 consists of the power card and the gatedrive 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 then handles the scaling of current feedback and voltage feedback.

Power card
The power card contains a switch mode power supply (SMPS) that provides the unit with 24 V DC, +18 V DC, -18 V DC, and 5 V DC operating voltages. The SMPS is supplied by DC bus voltage and powers the logic and interface circuitry.

A customer-supplied 24 V DC supply powers an optional secondary SMPS (MCB 107). The MCB 107 supplies the logic circuitry when the main input is disconnected. This option keeps units with communication options live on a network when the frequency converter is not powered from the mains.

Circuitry for controlling the speed of the cooling fans is also provided on the power card.

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

For some 12-pulse frequency converters, an MPIC card is connected to the power card to control extra SCRs in the 12-pulse units. All other functions are identical.

5.2.3 Power Section

The power section consists of the following components:

- AC input and output terminals
- AC and DC bus bars
- Fusing
- Harnessing
- Circuitry
    - Soft charge and SCR/diode modules in the rectifier
    - DC bus filter circuitry containing the DC coils (intermediate or DC bus circuit)
    - Output IGBT modules that make up the inverter section
- Optional components

Soft charge circuit
With the SCR/diode modules, the soft charge circuit limits the inrush current when power is first applied and the DC bus capacitors are charging. The soft charge circuit switches off the SCRs so the charging current bypasses the modules and passes through the soft charge resistors. This bypass results in a slower charge to the capacitors. Once the capacitors are charged, the SCRs are switched on and the charging current flows directly to the modules. The DC bus circuitry smooths the pulsating DC voltage created while converting the AC supply.

DC coils
DC coils reduce mains harmonics. The DC coil has 2 coils wound on a common core. One coil resides in the positive side of the DC bus and the other coil in the negative side. 12-pulse frequency converters use 2 DC coils. 6-pulse frequency converters use 1 DC coil per inverter module.

DC bus capacitors
The DC bus capacitors are arranged into a capacitor bank along with bleeder and balancing circuitry. Each inverter module contains 2 DC capacitor banks.

Inverter
The inverter section is made up of 6 IGBTs, commonly referred to as switches. Two IGBTs are necessary for each phase of the 3-phase supply, for a total of 6 IGBTs. These 6 IGBTs are housed in an IGBT module. Due to the high current handling requirements, each inverter module contains 3 IGBT modules, which are run in parallel. Each inverter module can be paralleled with 1 or 2 extra inverter modules to provide the required current for the power size.

Current level measurement
A Hall-effect current sensor is on each output phase of the inverter module to measure motor current. This type of device is used instead of more common current transformer (CT) devices to reduce the frequency and phase distortion that CTs introduce into the signal. The Hall-effect sensors monitor the average, peak, and ground leakage currents. The current sensors from each inverter module are summed with the same phase of the other inverter modules by the MDCIC to provide 1 current level to the control card.

5.3 Sequence of Operation

5.3.1 Rectifier and Option Cabinet

Input power
When input power is first applied to the frequency converter, it enters through the input terminals.

- 6-pulse (L1, L2, and L3)
- 12-pulse (L11, L21, L31 and L12, L22, and L32)

Depending on the configuration, the unit contains several optional components through which the power flows before reaching the SCRs. For example, fuses are an option that limits damage caused by a short circuit in the power section. For a diagram of the 6-pulse configuration, refer to *Illustration 5.4*. For 12-pulse configuration, refer to *Illustration 5.5*.

If optional components are provided, power flows through them in the following sequence:

- Disconnect
- Fuses
    - FU1, FU2, and FU3 (6-pulse)
    - FU1, FU2, FU3, FU4, FU5, and FU6 (12-pulse)
- Contactor
- RFI

The SCRs are not gated, allowing current to travel to the rectifier on the soft charge card. The SCR and diode modules are separate. Extra fuses on the soft charge card provide protection in the event of a short in the soft charge or fan circuits. Three-phase power is branched off and sent to the power card. The soft charge card provides the power card with a reference of the main supply voltage and provides a supply voltage for the cooling fans.

Charging process
During the charging process, the top diodes of the soft charge rectifier conduct and rectify during the positive half cycle. The diodes in the main rectifier conduct during the negative half cycle. The DC voltage is applied to the bus capacitors through the soft charge resistor. Charging the DC bus through this resistor limits the high inrush current that would otherwise be present.

Frequent cycling
Positive temperature coefficient (PTC) resistors on the soft charge card are in series with the soft charge resistor. Frequent cycling of the input power or the DC bus charging over an extended time can cause the PTC resistors to heat up due to the current flow. Resistance of the PTC device increases with temperature, eventually adding enough resistance to the circuit to prevent significant current flow. These PTC resistors protect the soft charge resistor and other components from damage during continuous attempts to charge the DC bus.

DC bus voltage
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 SCR gating circuit on the power card. The SCRs are gated automatically when forward biased, acting similar to an uncontrolled rectifier.

When the DC bus capacitors are fully charged, the voltage on the DC bus is equal to the peak voltage of the input mains. Theoretically, this value can be calculated by multiplying the mains 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 and can drop to V AC x 1.32 while running under load.

For example, a frequency converter 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 frequency converter, this voltage is present in the DC link and the inverter circuit. It is also fed to the switch mode power supply (SMPS) on the power card and is used for generating all other low-voltage supplies.

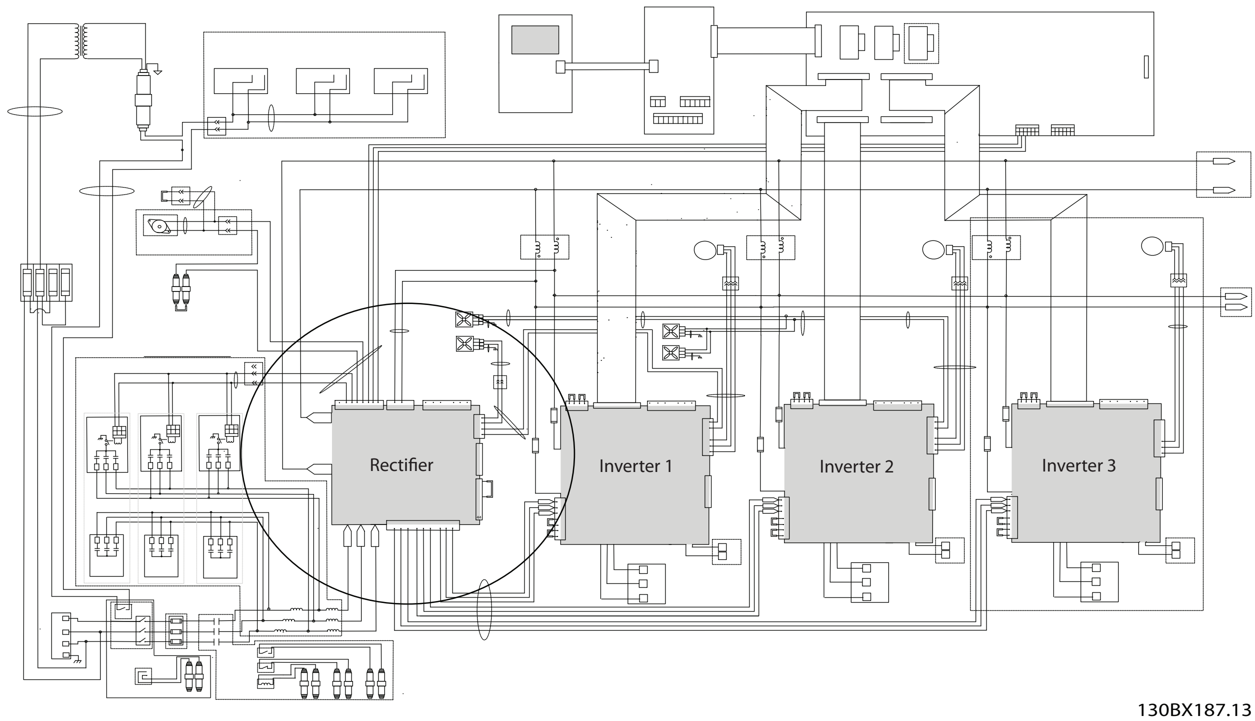


Illustration 5.4 6-pulse Rectifier Circuit

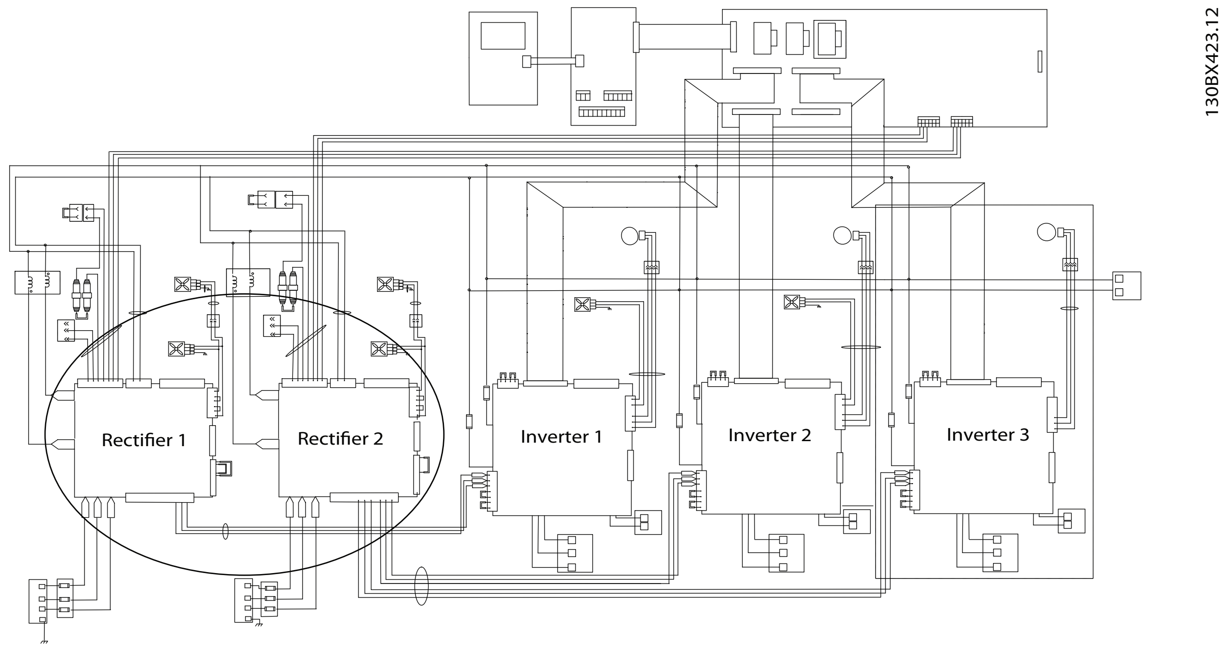


Illustration 5.5 12-pulse Rectifier Circuit

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5.3.2 Intermediate Section

Following the rectifier section, voltage passes to the intermediate section. (Refer to *Illustration 5.6*). An LC filter circuit consisting of the DC bus inductor and the DC bus capacitor banks in each inverter module smooths the rectified voltage.

The DC bus inductor provides series impedance to changing current, which aids the filtering process while reducing harmonic distortion to the input AC current waveform.

Each inverter module contains 1 or 2 DC capacitor bank assemblies consisting of up to 8 capacitors arranged in a series/parallel configuration. Also contained within the assembly is the bleeder/balance circuitry. This circuitry maintains equal voltage drops across each capacitor and provides a current path for discharging the capacitors once power has been removed from the frequency converter.

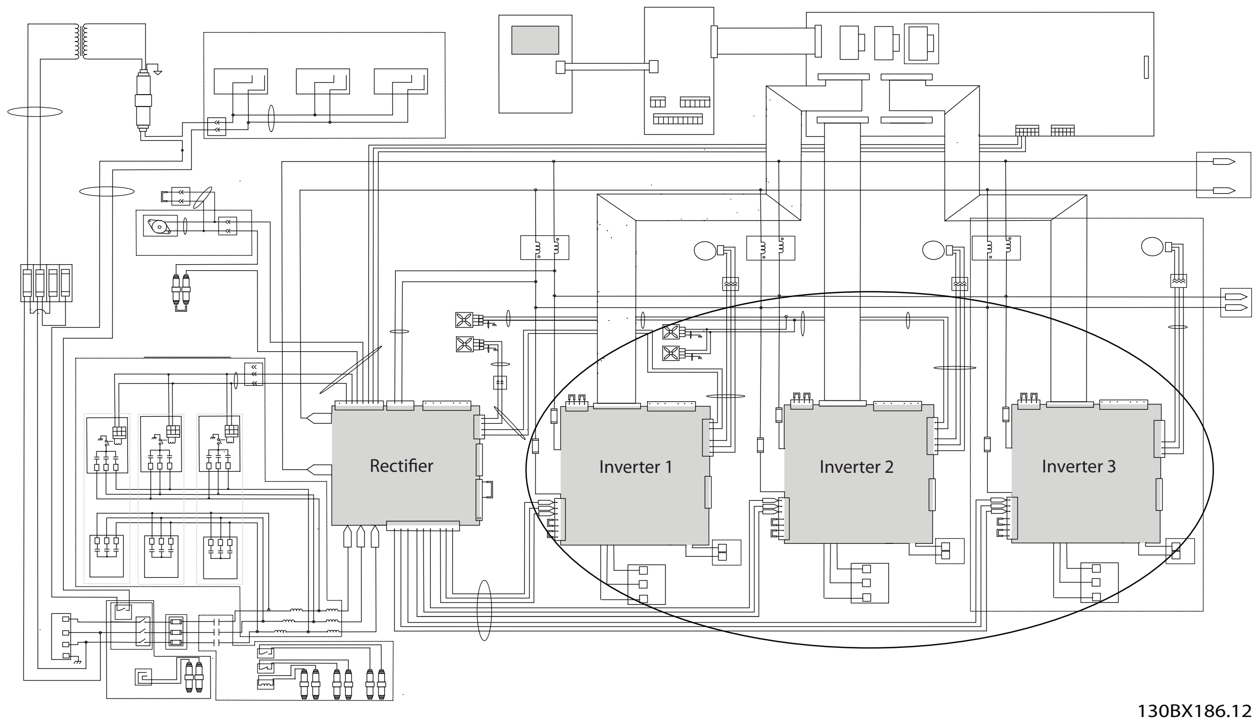

Illustration 5.6 Inverter Sections

High-frequency filter card

Also located in the intermediate section is the high-frequency (HF) filter card for each inverter module. Each card contains a high-frequency filter circuit to reduce naturally occurring currents in the HF range to prevent interference with other sensitive equipment in the area. The circuit, as with other RFI filter circuitry, is sensitive to unbalanced phase-to-ground voltages in the 3-phase AC input line. Occasionally, this sensitivity 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 into the RFI/HF switch, which can be switched on or off in *parameter 14-50 RFI Filter*. The RFI/HF switch disconnects the ground references to all filters to eliminate nuisance overvoltage conditions created by unbalanced phase-to-ground voltages.

5.3.3 Inverter Section

In the inverter section, gate signals are received from the control card through the MDCIC. Then the gate signals are sent to each inverter module power card and the gatedrive card to the IGBT gates. Refer to *Illustration 5.6*. The output of each IGBT, connected in series, then passes through the current sensors.

Output waveform

Once a run command and speed reference are provided, the IGBTs begin switching to create the output waveform, as shown in *Illustration 5.7*. Looking at the phase-to-phase voltage waveform with an oscilloscope, the pulse width modulation (PWM) principle creates a series of pulses that vary in width. The pulses are narrower as 0 crossing is approached and wider the farther from 0 crossing. The width is controlled by the pulse duration of applied DC voltage. Although the voltage waveform is a consistent amplitude, the inductances within the motor windings serve to average the voltage delivered. As the pulse width of the waveform varies, the average voltage seen by the motor varies as well. The PWM principle results in a current waveform that takes on the sine-wave shape expected in an AC system. The pulse rate determines the frequency of the waveform. By employing a sophisticated control scheme, the frequency converter delivers a current waveform that nearly replicates a true AC sine-wave.

Monitoring the waveform

Hall-effect current sensors monitor the output current of each inverter module and deliver proportional signals via the power cards to the MDCIC. The signals are summed, 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.

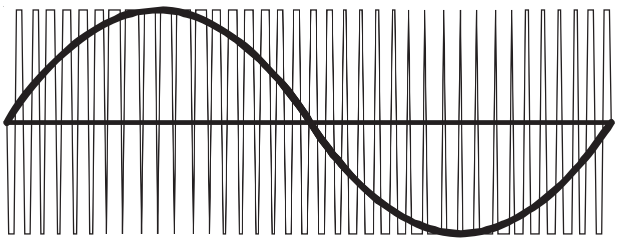

Illustration 5.7 Output Voltage and Current Waveforms

System monitoring

During normal operation, the power card and control card monitor various functions within the frequency converter:

- Current feedback
- DC bus voltage and mains voltage
- Voltage delivered to the motor
- Heat sink temperature for each rectifier

5.3.4 Brake Option

For frequency converters equipped with the dynamic brake option, 2 brake IGBTs along with terminals 81(R-) and 82(R+) are included in each inverter module for connecting an external brake resistor.

The function of the brake IGBT is to limit the voltage in the DC link whenever the maximum voltage limit is exceeded. (Refer to *Illustration 5.8*). By switching the externally mounted resistor across the DC bus to remove excess DC voltage present on the bus capacitors, the DC-link voltage is limited. Typically, excess DC bus voltage results from an overhauling load causing regenerative energy to be returned to the DC bus. For example, when the load drives the motor, it causes the voltage to return to the DC bus circuit.

Placing the brake resistor externally has the following advantages:

- Selecting the resistor based on application need
- Dissipating the energy outside of the control panel
- Protecting the frequency converter from overheating if the brake resistor is overloaded

The brake IGBT gate signal originates on the control card and is delivered to the brake IGBTs via the MDCIC to each inverter module power card and gatedrive card. Also, the power and control cards monitor the brake IGBT and brake resistor connection for short circuits and overloads.

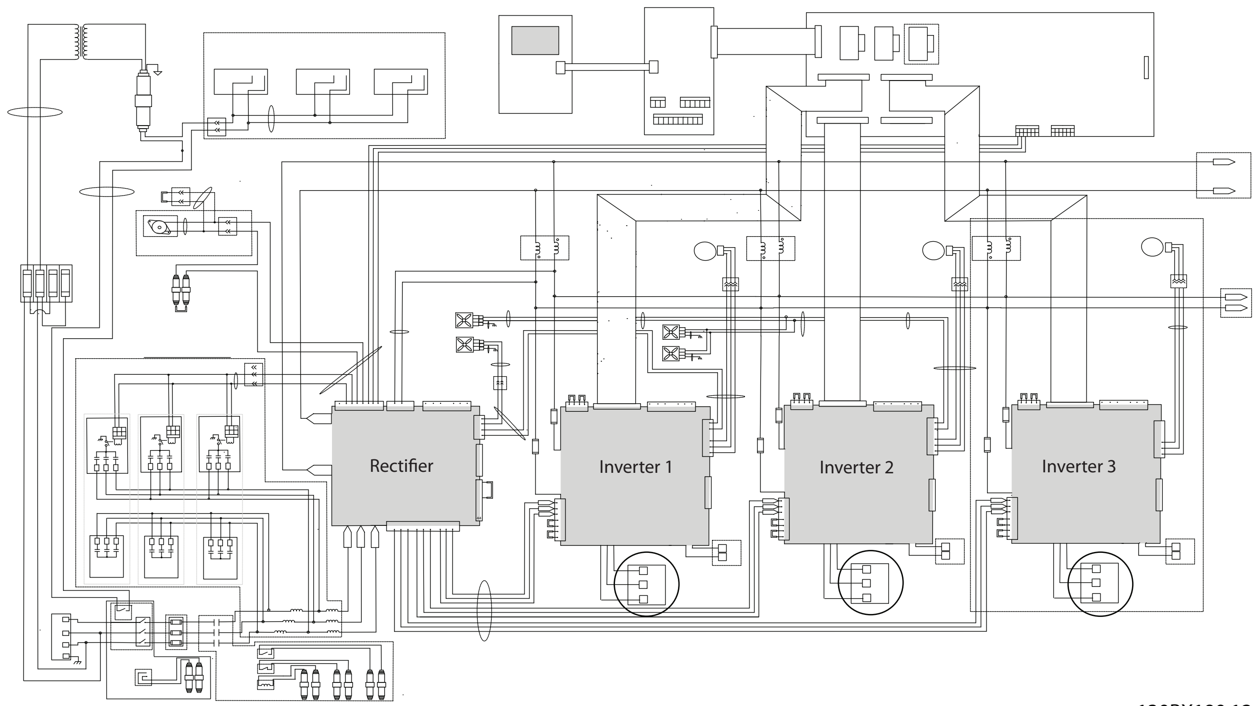

Illustration 5.8 Brake Option

5.3.5 Cooling Fans

All F-size enclosures are equipped with cooling fans to provide airflow along the heat sinks and within the enclosures. Mains voltage is used to power all fans. Circuitry on the power card regulates the voltage to 200 V AC or 230 V AC, before the autotransformers steps the voltage down for the fans. On/off and high/low speed control of the fans is provided to reduce overall acoustical noise and extend the life of the fans.

The following conditions activate the fans:

- 60% of nominal current exceeded.
- Specific heat sink temperature exceeded (power size dependent).
- Specific power card ambient temperature exceeded.
- Specific control card ambient temperature exceeded.
- DC hold active.
- DC brake active.
- Premagnetization of the motor.
- Automatic motor adaptation in progress.
- Regardless of the heat sink temperature, the fans are started shortly after mains input power is applied to the frequency converter.

Once fans are started, they run for a minimum of 10 minutes.

5.3.6 Fan Control

5.3.6.1 Fan Speed

The cooling fans are controlled with sensor feedback that regulates fan operation and speed control as described in *Table 5.1 – Table 5.3*.

IGBT thermal sensor measured temperature

IGBT thermal sensor	Temperature
Fan turn ON low speed	55 °C
Fan low speed to high speed	65 °C
Fan high speed to low speed	65 °C
Fan turn OFF from low speed	50 °C

Table 5.1 IGBT Thermal Sensor

Power card ambient temperature sensor measured temperature

Power card ambient	Temperature
Fan turn ON to low speed	50 °C
Fan low speed to high speed	65 °C
Fan high speed to low speed	65 °C
Fan turns off	<50 °C

Table 5.2 Power Card Ambient Temperature Sensor

Control card thermal sensor measured temperature

Control card ambient	Temperature
Fan turn ON to low speed	55 °C
Fan turn OFF from low speed	50 °C
Fan turns low speed to high speed	>62 °C
Fan turns high speed to low speed	<62 °C

Table 5.3 Control Card Thermal Sensor

Output current value
If the output current is greater than 60% of rated current or if the power card ambient temperature is >50 °C, the fan turns on low speed. After operating for 10 minutes, the fans turn off automatically.

5

5.3.6.2 Fan Location

Fan location	Control source		
	F1–F4	F8–F9	F10–F13
Door fan 1, options cabinet	Inverter module 1	Rectifier module 1	Rectifier module 1
Door fan 2, options cabinet	–	–	Rectifier module 2
Door fan 1, rectifier cabinet	Inverter module 2	Rectifier module 1	Rectifier module 1
Door fan 2, rectifier cabinet	–	–	Rectifier module 2
Door fan 1, inverter cabinet	Inverter module 2	Inverter module 1	Inverter module 1
Door fan 2, inverter cabinet	Inverter module 2	–	Inverter module 2
Heat sink fan 1, rectifier module 1	Inverter module 1	Rectifier module 1	Rectifier module 1
Heat sink fan 2, rectifier module 2	–	–	Rectifier module 2
Heat sink fan 1, inverter module 1	Inverter module 1	Inverter module 1	Inverter module 1
Heat sink fan 2, inverter module 2	Inverter module 2	–	Inverter module 2
Heat sink fan 3, inverter module 3	Inverter module 3	–	Inverter module 3

Table 5.4 Fan Location and Control Source

5.3.7 Module Layout

Module	F1	F2	F3	F4	F8	F9	F10–F11	F12–F13
Rectifier 1	Only 1 module	Only 1 module	Only 1 module	Only 1 module	Only 1 module	Only 1 module	Left module	Left module
Rectifier 2	–	–	–	–	–	–	Right module	Right module
Inverter 1	Left module	Left module	Left module	Left module	Center module	Only 1 module	Left module	Left module
Inverter 2	Right module	Center module	Right module	Center module	–	–	Right module	Center module
Inverter 3	–	Right module	–	Right module	–	–	–	Right module

Table 5.5 Location and Module Numbering

5.3.8 Soft Charge Layout

	F1	F2	F3	F4	F8	F9	F10	F11	F12
Rectifier module 1	2	3	2	3	2	2	1	1	1
Rectifier module 2	–	–	–	–	–	–	1	1	2

Table 5.6 Location of and Number of Soft Charge Cards

5.3.9 Load Sharing and Regeneration

Units with the built-in load sharing option contain terminals 89 (+) DC and 88 (-) DC. Within the frequency converter, these terminals connect to the DC bus on the input side of the DC link reactor. The use of the load sharing terminals has 2 configurations.

In the first configuration, the terminals are used to tie the DC bus circuits of multiple frequency converters together, allowing 1 frequency converter in a regenerative mode to share its excess bus voltage with another frequency converter in motoring mode. This configuration reduces the need for external dynamic brake resistors while also saving energy. Any number of frequency converters can be connected in this way, as long as they are of the same voltage rating. Also, it may be necessary to install DC reactors and DC fuses and mains AC reactors on the mains. Attempting such a configuration requires detailed considerations. Do not attempt without first consulting Danfoss Application Engineering.

In the second configuration, the frequency converter is powered exclusively from a DC source. An external DC source is required. Do not attempt without first consulting Danfoss Application Engineering

Units with a built-in regeneration option contain terminals 82 (+) DC and 83 (-) DC. Within the frequency converter, the regeneration terminals connect to the DC bus on the output side of the DC-link reactor.

Use regeneration terminals to connect 1 frequency converter to 1 external regeneration module. Do not use the regeneration terminals to connect together the DC bus circuits of multiple frequency converters.

5.3.10 Specific Card Connections

FK102 connector
FK102 connector (terminals 104, 105, and 106) is on the power cards and provides a connection for an external temperature switch. The input could be used, for example, to monitor the temperature of an external brake resistor. A normally closed switch can be connected between terminals 104 and 106. Terminals 104 and 106 are on TB3 inside the rectifier cabinet towards the top. If the input changes states, the frequency converter trips on *alarm 27, Brake Chopper Fault*. Also, the input SCRs would be disabled to prevent further energy from being supplied to the DC bus. If no such input is used, or the normally open configuration is selected, install a jumper between terminals 104 and 106.

FK103 connector
FK103 (terminals 100, 101, 102, and 103) is on the power cards and provides a connection for an external supply to power AC cooling fans using the mains voltage. The terminals on the power card are wired to plugs on the top of the modules. For 6-pulse units, the connection is only on the inverter module. For the 12-pulse units, the connection is on both the inverter and the rectifier modules. This connection is required when the frequency converter is used in a load sharing application where no AC power is provided to the mains input terminals. To use this connection, remove the jumpers from terminals 100 and 102, and 101 and 103. Then connect the auxiliary mains voltage supply to terminals 100 and 101.

MK112 power card
The power card MK112 (terminals 1–3 and 4–6 provide access to 2 auxiliary relays. The relays are wired to a terminal mounted in the inverter cabinet above the MDCIC. These relays are Form C sets of contacts, meaning 1 normally open and 1 normally closed contact on a single throw. The contacts are rated for a maximum of 240 V AC, 2 A and a minimum of 24 V AC, 10 mA or 24 V AC, 100 mA. The relay can be programmed via *parameter 5-40 Function Relay* to indicate frequency converter status.

6 Troubleshooting

6

6.1 Troubleshooting Tips

- Some points in the frequency converter are referenced to the negative DC bus and are at bus potential even though it may appear on diagrams to be a neutral reference.
- If any of the DC bus fuses are blown, always ensure that no DC bus voltage is present on either side of the DC fuses. When any DC bus fuse is blown, capacitor banks in the other inverter modules are no longer electrically connected. As a result, 1 inverter module may have stored voltage even when the rest of the unit has none.
- Do not assume that the frequency converter contains no voltage when the LCP indicator lights are off.
- Never apply power to a unit that is suspected of being faulty. Many faulty components within the frequency converter can damage other components when power is applied. Always complete the steps described in *chapter 8.9.1 System Test*.
- With an external supply and cable assembly, the logic section of the frequency converter can be powered without applying power to the rest of the unit. This method of power isolation is recommended for troubleshooting logic problems.
- Never attempt to defeat any fault protection circuitry within the frequency converter. Doing so results in unnecessary component damage and can cause personal injury.
- Always use factory approved replacement parts. The frequency converter has been designed to operate within certain specifications. Incorrect parts can affect tolerances and damage the unit.
- Read the instruction and service guides. A thorough understanding of the unit is the best approach. If ever in doubt, consult the factory or authorized repair center for assistance.

6.2 Exterior Fault Troubleshooting

Servicing a frequency converter that has been operational for an extended period is slightly different from a new installation. When using proper troubleshooting procedures on a long-term installation, do not assume that a motor is wired properly. Look for issues such as loose connections, improper programming, or added equipment. It is best to develop a detailed approach, beginning with a physical inspection of the system. Refer to *Table 6.1*.

6.3 Fault Symptom Troubleshooting

This troubleshooting section is organized based on the symptom being experienced. Refer to *chapter 6.5 Fault Symptoms*.

Typical symptoms may be:

- Unrecognizable display on the LCP.
- Problems with motor operation.
- Warning or alarm shown by the frequency converter.

The frequency converter processor monitors inputs and outputs as well as internal frequency converter functions. Thus, an alarm or warning does not necessarily indicate a problem within the frequency converter itself. For a list of warnings and alarms, refer to *Table 6.2*.

Chapter 6.7 Warning and Alarm Definitions describes how to troubleshoot that particular symptom. When necessary, detailed discussions of frequency converters and system troubleshooting are provided in this chapter for the experienced repair technician to effectively analyze the problem.

Always perform a system test when the following conditions apply:

- Starting a frequency converter for the first time
- Approaching a frequency converter that is suspected of being faulty
- After a repair to the frequency converter

Refer to *chapter 8.9.1 System Test*.

6.4 Visual Inspection

Table 6.1 lists conditions that require visual inspection as part of any initial troubleshooting procedure.

Inspect for	Description
Auxiliary equipment	Look for auxiliary equipment, switches, disconnects, or input fuses/circuit breakers that reside on either the input power side of frequency converter or the output side to the motor. Examine the operation and condition of these items for possible causes of operational faults. Check the function and installation of pressure sensors or encoders or other devices that provide feedback to the frequency converter.
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 150–200 mm (6–8 in) between the cables, or separate them with a grounded conductive partition. Avoid routing cables through free air.
Control wiring	Check for broken or damaged wires and connections. Check the voltage source of the signals. Though not always necessary depending on the installation conditions, the use of screened cable or a twisted pair is recommended. Ensure that the screen is terminated correctly. Refer to *chapter 4.9 Grounded Screened Cables*.
Cooling	Check the operational status of all cooling fans. Check the door filters on NEMA 1 (IP21)/NEMA 12 (IP54) units. Check for blockage or constrained air passages. Make sure that the bottom gland plate is installed.
Display	The local control panel display shows the following: • Warnings • Alarms • Status • Fault history
Interior	The frequency converter interior must be free of dirt, metal chips, moisture, and corrosion. Check for burnt or damaged power components or carbon deposits resulting from catastrophic component failure. Check for cracks or breaks in the housings of power semiconductors, or pieces of broken component housings loose inside the unit.
EMC considerations	Check for proper installation regarding electromagnetic capability. Refer to the frequency converter operating instructions and *chapter 7 Frequency Converter and Motor Applications* for further details.
Environmental conditions	Under specific conditions, these units can be operated within a maximum ambient temperature of 50 °C (122 °F). Humidity levels must be less than 95% noncondensing. Check for harmful airborne contaminates such as sulphur-based compounds.
Grounding	The frequency converter requires a dedicated ground wire from its frame to the building ground. It is also recommended that the motor be grounded to the frequency converter frame. The use of a conduit or mounting the frequency converter onto a metal surface is not considered a suitable ground. Check for good ground connections that are tight and free of oxidation.
Input power wiring	Check for loose connections, proper fusing, and blown fuses.
Motor	Check the nameplate ratings of the motor. Ensure that the motor ratings correspond with the frequency converters. Make sure that the motor parameters (*parameter 1-20 Motor Power [kW]* to *parameter 1-25 Motor Nominal Speed*) are set according to the motor ratings.
Output to motor wiring	Check for loose connections. Check for switching components in the output circuit. Check for faulty contacts in the switch gear.
Programming	Make sure that the frequency converter parameter settings are correct according to motor, application, and I/O configuration.
Proper clearance	Frequency converters require adequate top and bottom clearance to ensure proper airflow for cooling in accordance with the frequency converter size. Frequency converters with exposed heat sinks out the back must be mounted on a flat solid surface.
Vibration	Look for any unusual amount of vibration around the frequency converter. Mount the unit solidly or use shock mounts.

Table 6.1 Visual Inspection

6.5 Fault Symptoms

6.5.1 No Display

- Check that power is supplied.
- Cycle power to the unit.
- Reinitialize the frequency converter (refer to *chapter 4.2.4 Restoring Factory Default Settings*).

6.5.2 Intermittent Display

Cutting out or flashing of the entire display and power LED indicates that the supply (SMPS) is shutting down due to an overload. This situation can be caused by the following:

- Improper control wiring
- Overload of the 24 V output
- Fault within the frequency converter

Check for a problem in the control wiring by disconnecting all control wiring from the control terminal blocks on the installation card.

If the display stays lit, then the problem is in the control wiring (external to the frequency converter). Check all control wiring for shorts or incorrect connections.

If the display continues to cut out, refer to *chapter 6.5.1 No Display*.

6.5.3 Motor Does Not Run

If this symptom is detected, first verify that the unit is properly powered up (display is lit) and that no warning or alarm messages are shown. The most common cause is either incorrect control logic or an incorrectly programmed frequency converter. Such occurrences result in one or more of the following status messages being shown.

Cause: LCP Stop
Action: The [Off] key has been pressed.

Press the [Auto On] or [Hand On] key.

Cause: Standby
This indicates that there is no start signal at terminal 18.

Action: Ensure that a start command is present at terminal 18. Refer to *chapter 8.7.13 Input Terminal Signal Tests*.

Cause: Unit ready
Terminal 27 is low (no signal).

Action: Ensure that terminal 27 is logic 1. Refer to *chapter 8.7.13 Input Terminal Signal Tests*.

Run OK, 0 Hz
This message indicates that a run command has been given to the frequency converter, but the reference (speed command) is 0 or missing.

Check the control wiring to ensure that the proper reference signal is present at the frequency converter input terminals. Also check that the unit is programmed properly to accept the signal. Refer to *chapter 8.7.13 Input Terminal Signal Tests*.

Off 1 (2 or 3)
This message indicates that bit #1 (or #2, or #3) in the control word is logic 0. This situation only occurs when the frequency converter is being controlled via the fieldbus.

A correct control word must be transmitted to the frequency converter over the communication bus to correct this error.

STOP
One of the digital input terminals 18, 19, 27, 29, 32, or 33 (parameter *5-1* Digital Inputs*) is programmed for *Stop Inverse* and the corresponding terminal is low (logic 0).

Ensure that the parameters are programmed correctly and that any digital input programmed for *Stop Inverse* is high (logic 1).

DC undervolt [8]
If the unit is equipped with an external 24 V DC option, check that mains power is supplied to the frequency converter.

6.5.4 Incorrect Motor Operation

Occasionally, a fault can occur where the motor continues to run, but not in the correct manner. The symptoms and causes can vary considerably. Many of the possible problems are listed by symptom.

Wrong speed/unit does not respond to command
Possible incorrect reference (speed command).

Ensure that the unit is programmed correctly according to the reference signal being used, and that all reference limits are set correctly.

Motor speed unstable
Possible incorrect parameter settings, faulty current feedback circuit, or loss of motor (output) phase.

Check the settings of all motor parameters, including all motor compensation settings such as slip compensation and load compensation. For closed loop-operation, check PID settings.

Motor runs rough

- Possible overmagnetization
- IGBT misfiring
- Motor under heavy load
- Alarm 13 trips intermittently

Check settings of all motor parameters.

Motor draws high current, but cannot start
Possible open winding in motor or open phase in connection to motor.

Run an AMA to check the motor for open windings and unbalanced resistance. Inspect all motor wiring connections.

Motor does not brake
Possible fault in the brake circuit. Possible incorrect setting in the brake parameters. The ramp down time is too short. The LCP may show an alarm or warning message.

Check all brake parameters and ramp-down time (parameter groups *2-0* DC-Brake* and *3-4* Ramp 1*).

6.6 Alarms and Warnings

The frequency converter indicates a warning or an alarm by the relevant indicator light on the LCP and a code on the display.

A warning remains active until its cause is no longer present. Under certain circumstances, operation of the motor can still be continued. Warning messages can be critical, but are not necessarily so.

An alarm indicates that the frequency converter tripped. The alarm must be reset to restart operation once its problem is fixed. Resetting can be done one of 4 ways:

- By using the [Reset] control key on the LCP
- Via a digital input with the Reset function
- Via serial communication/optional fieldbus
- By resetting automatically using the [Auto Reset] function

NOTICE

After a manual reset using the [RESET] key on the LCP, the [Auto on] key must be pressed to restart the motor.

If an alarm cannot be reset, it is possible that the problem is not fixed or that the alarm is trip locked. Refer to *Table 6.2*.

Alarms that are trip locked offer extra protection, since the mains supply must be switched off before the alarm can be reset. After being switched back on, the frequency converter is no longer blocked and can be reset once the problem is fixed.

Alarms that are not trip locked can also be reset using the automatic reset function in *parameter 14-20 Reset Mode*.

⚠WARNING

AUTOMATIC RESET

Automatic reset should not be used in industrial applications where it can unexpectedly cause the frequency converter and motor to restart. Always use the manual restart setting in *parameter 14-20 Reset Mode*. Failure to use manual reset in industrial applications can cause death or serious injury.

If a warning and alarm is marked against a code in *Table 6.2*, it means that either a warning occurs before an alarm, or it can be specified whether it is a warning or an alarm that is shown for a given fault.

This situation is possible, for instance, in *parameter 1-90 Motor Thermal Protection*. After an alarm or trip, the motor coasts, and the alarm and warning flash on the frequency converter. Once the problem has been rectified, only the alarm continues flashing.

No.	Description	Warning	Alarm/trip	Alarm/trip lock	Parameter reference
1	10 V low	X	–	–	–
2	Live zero error	(X)	(X)	–	6-01
3	No motor	(X)	–	–	1-80
4	Mains phase loss	(X)	(X)	(X)	14-12
5	DC-link voltage high	X	–	–	–
6	DC-link voltage low	X	–	–	–
7	DC overvoltage	X	X	–	–
8	DC undervoltage	X	X	–	–
9	Inverter overloaded	X	X	–	–
10	Motor ETR overtemperature	(X)	(X)	–	1-90
11	Motor thermistor overtemperature	(X)	(X)	–	1-90
12	Torque limit	X	X	–	–
13	Overcurrent	X	X	X	–
14	Ground fault	X	X	X	–
15	Hardware mismatch	–	X	X	–
16	Short circuit	–	X	X	–
17	Control word timeout	(X)	(X)	–	8-04
18	Start failed	–	X	–	–
19	Discharge temperature high	X	X	–	–
22	Hoist mechanical braking	–	X	–	–
23	Internal fans	–	–	–	–
24	External fans	–	–	–	–
25	Brake resistor short-circuited	X	–	–	–
26	Brake resistor power limit	(X)	(X)	–	2-13
27	Brake chopper short-circuited	X	X	–	–
28	Brake check	(X)	(X)	–	2-15
29	Heat sink temp	X	X	X	–
30	Motor phase U missing	(X)	(X)	(X)	4-58
31	Motor phase V missing	(X)	(X)	(X)	4-58
32	Motor phase W missing	(X)	(X)	(X)	4-58
33	Inrush fault	–	X	X	–
34	Fieldbus communication fault	X	X	–	–
36	Mains failure	–	–	–	–
37	Imbalance of supply voltage	–	X	–	–
38	Internal fault	–	X	X	–
39	Heat sink sensor	–	X	X	–
40	Overload of digital output terminal 27	(X)	–	–	–
41	Overload of digital output terminal 29	(X)	–	–	–
42	Overload of digital output on X30/6 or overload of digital output on X30/7	(X)	–	–	–
45	Ground fault 2	X	X	X	–
46	Power card supply	–	X	X	–
47	24 V supply low	X	X	X	–
48	1.8 V supply low	–	X	X	–
49	Speed limit	X	X	–	–
50	AMA calibration failed	–	X	–	–
51	AMA check U_{nom} and I_{nom}	–	X	–	–
52	AMA low I_{nom}	–	X	–	–
53	AMA motor too large	–	X	–	–
54	AMA motor too small	–	X	–	–
55	AMA parameter out of range	–	X	–	–
56	AMA interrupted by user	–	X	–	–
57	AMA timeout	–	X	–	–

No.	Description	Warning	Alarm/trip	Alarm/trip lock	Parameter reference
58	AMA internal fault	X	X	–	–
59	Current limit	X	–	–	–
60	External interlock	–	–	–	–
61	Encoder loss	(X)	(X)	–	–
62	Output frequency at maximum limit	X	–	–	–
63	Mechanical braking low	–	(X)	–	–
64	Voltage limit	X	–	–	–
65	Control board overtemperature	X	X	X	–
66	Heat sink temperature low	X	–	–	–
67	Option configuration has changed	–	X	–	–
68	Safe torque off activated	–	X	–	–
69	Power card temperature	–	X	X	–
70	Illegal FC configuration	–	–	–	–
71	PTC 1 safe torque off	X	X	X	–
72	Dangerous failure	X	X	X	–
73	Safe torque off auto restart	X	X	–	–
76	Power unit setup	X	–	–	–
77	Reduced power mode	X	–	–	–
78	Tracking error	X	X	–	–
79	Illegal PS config	–	X	X	–
80	Frequency converter initialized to default value	–	X	–	–
81	CSIV corrupt	–	X	–	–
82	CSIV parameter error	–	X	–	–
90	Encoder loss	(X)	(X)	–	–
91	Analog input 54 wrong settings	–	–	X	–
92	No-flow	X	X	–	22-2*
93	Dry pump	X	X	–	22-2*
94	End of curve	X	X	–	22-5*
95	Broken belt	X	X	–	22-6*
96	Start delayed	X	–	–	22-7*
97	Stop delayed	X	–	–	22-7*
98	Clock fault	X	–	–	0-7*
100–199	Refer to operating instructions for MCO 305	–	–	–	–
200	Fire mode	(X)	–	–	–
201	Fire mode was active	(X)	–	–	–
202	Fire mode limits exceeded	(X)	–	–	–
243	Brake IGBT	X	X	–	–
244	Heat sink temperature	X	X	X	–
245	Heat sink sensor	–	X	X	–
246	Power card supply	–	X	X	–
247	Power card temperature	–	X	X	–
248	Illegal PS config	–	X	X	–
250	New spare part	–	–	X	–
251	New type code	–	X	X	–

Table 6.2 Alarm/Warning Code List

(X) Dependent on parameter

LED indication	
Warning	Yellow
Alarm	Red (flashing)
Trip lock	Yellow and red

Table 6.3 Description of LED Indicator Lights

Alarm Word and Extended Status Word					
Bit	**Hex**	**Dec**	**Alarm word**	**Warning word**	**Extended status word**
0	00000001	1	Brake check	Brake check	Ramping
1	00000002	2	Pwr. card temp	Pwr. card temp	AMA running
2	00000004	4	Ground fault	Ground fault	Start CW/CCW
3	00000008	8	Ctrl. card temp	Ctrl. card temp	Slow down
4	00000010	16	Ctrl. word TO	Ctrl. word TO	Catch up
5	00000020	32	Overcurrent	Overcurrent	Feedback high
6	00000040	64	Torque limit	Torque limit	Feedback low
7	00000080	128	Motor Th over	Motor Th over	Output current high
8	00000100	256	Motor ETR over	Motor ETR over	Output current low
9	00000200	512	Inverter overld.	Inverter overld.	Output freq high
10	00000400	1024	DC under volt	DC under volt	Output freq low
11	00000800	2048	DC over volt	DC over volt	Brake check ok
12	00001000	4096	Short circuit	DC voltage low	Braking max
13	00002000	8192	Inrush fault	DC voltage high	Braking
14	00004000	16384	Mains ph. loss	Mains ph. loss	Out of speed range
15	00008000	32768	AMA not OK	No motor	OVC active
16	00010000	65536	Live zero error	Live zero error	–
17	00020000	131072	Internal fault	10 V low	–
18	00040000	262144	Brake overload	Brake overload	–
19	00080000	524288	U phase loss	Brake resistor	–
20	00100000	1048576	V phase loss	Brake IGBT	–
21	00200000	2097152	W phase loss	Speed limit	–
22	00400000	4194304	Fieldbus fault	Fieldbus fault	–
23	00800000	8388608	24 V supply low	24 V supply low	–
24	01000000	16777216	Mains failure	Mains failure	–
25	02000000	33554432	1.8 V Supply low	Current limit	–
26	04000000	67108864	Brake resistor	Low temp	–
27	08000000	134217728	Brake IGBT	Voltage limit	–
28	10000000	268435456	Option change	Unused	–
29	20000000	536870912	Frequency converter initialized	Unused	–
30	40000000	1073741824	Safe torque off	Unused	–

Table 6.4 Description of Alarm Word, Warning Word, and Extended Status Word

The alarm words, warning words and extended status words can be read out via fieldbus or optional fieldbus for diagnosis. Also, refer to *parameter 16-90 Alarm Word*, *parameter 16-92 Warning Word*, and *parameter 16-94 Ext. Status Word*.

Bit	Hex	Dec	Alarm Word 2	Warning Word 2
0	00000001	1	–	Start Delayed
1	00000002	2	–	Stop Delayed
9	00000200	512	Discharge Temperature High	Discharge Temperature High
10	00000400	1024	Start Limit	–
11	00000800	2048	Speed Limit	–

Table 6.5 Description of Alarm Word 2 and Warning Word 2

6.7 Warning and Alarm Definitions

WARNING 1, 10 Volts low
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.

WARNING/ALARM 2, Live zero error
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 frequency converter programming and switch settings match the analog signal type.
- Perform an input terminal signal test.

WARNING/ALARM 3, No motor
No motor has been connected to the output of the frequency converter. This warning or alarm only appears if programmed in *parameter 1-80 Function at Stop*.

Troubleshooting:
Check the connection between the frequency converter and the motor.

WARNING/ALARM 4, Mains phase loss
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 frequency converter.

WARNING 5, DC link voltage high
The DC-link voltage (DC) is higher than the high-voltage warning limit. The limit depends on the frequency converter voltage rating. The unit is still active.

WARNING 6, DC link voltage low
The DC-link voltage (DC) is lower than the low-voltage warning limit. The limit depends on the frequency converter voltage rating. The unit is still active.

WARNING/ALARM 7, DC overvoltage
If the DC-link voltage exceeds the limit, the frequency converter 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*).

WARNING/ALARM 8, DC under voltage
If the DC-link voltage drops below the undervoltage limit, the frequency converter checks for 24 V DC back-up supply. If no 24 V DC back-up supply is connected, the frequency converter trips after a fixed time delay. The time delay varies with unit size.

Troubleshooting

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

WARNING/ALARM 9, Inverter overload
The frequency converter 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 frequency converter cannot be reset until the counter is below 90%.

Troubleshooting

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

WARNING/ALARM 10, Motor ETR overtemperature:
According to the electronic thermal protection (ETR), the motor is too hot. It can be selected if the frequency converter is programmed to give an alarm when the counter reaches 100% in *parameter 1-90 Motor Thermal Protection*. If the motor is overloaded by more than 100%

for too long, this fault is shown. Check that *parameter 1-24 Motor Current* is set correctly.

Troubleshooting

- Check if motor is overheated.
- Verify that the motor is not mechanically overloaded.
- Verify that the *parameter 1-24 Motor Current* is set correctly.
- Check motor data in *parameter 1-20 Motor Power [kW]* through *parameter 1-25 Motor Nominal Speed* is set correctly.
- Check *parameter 1-91 Motor External Fan*setting.
- Run AMA in *parameter 1-29 Automatic Motor Adaptation (AMA)*.

WARNING/ALARM 11, Motor thermistor overtemp
Check whether the thermistor is disconnected. Select whether the frequency converter issues a warning or an alarm in *parameter 1-90 Motor Thermal Protection*.

Troubleshooting

- Check for motor overheating.
- 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 or 54 is set for voltage. Check that *parameter 1-93 Thermistor Source* selects terminal 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 Source*.

WARNING/ALARM 12, Torque limit
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, 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.

WARNING/ALARM 13, Over current
The inverter peak current limit (approximately 200% of the rated current) is exceeded. The warning lasts approximately 1.5 s, then the frequency converter 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.

Troubleshooting

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

ALARM 14, Ground fault
There is a discharge from the output phases to ground, either in the motor or in the cable between the frequency converter and the motor. Turn off the frequency converter and remove the ground fault.

Troubleshooting

- Turn off the frequency converter and remove the ground fault.
- Measure the resistance to ground of the motor cables and the motor with a megohmmeter to check for ground faults in the motor.

ALARM 15, In-complete hardware
A fitted option is not operational with the present control board hardware or software. Record the value of the following parameters and contact a Danfoss supplier.

Troubleshooting

- *Parameter*
- *Parameter*
- *Parameter*
- *Parameter*
- *Parameter*
- *Parameter*
- *Parameter*
- *Parameter*
- *Parameter*

ALARM 16, Short circuit
There is short-circuiting in the motor or motor wiring.

Troubleshooting

- Remove the power to the frequency converter and repair the short circuit.

WARNING/ALARM 17, Control word timeout
There is no communication to the frequency converter. 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 frequency converter 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.

ALARM 18, Start failed
The speed has not been able to exceed *parameter 1-77 Compressor Start Max Speed [RPM]* during start within the allowed time that was set in *parameter 1-79 Compressor Start Max Time to Trip*. A blocked motor can cause this alarm.

Warning/Alarm 19, Discharge temperature high
The warning indicates that the discharge temperature exceeds the level programmed in *parameter 28-24 Warning Level*. If so programmed in *parameter 28-25 Warning Action*, the frequency converter lowers the speed of the compressor in an attempt to lower the discharge temperature.

The alarm indicates that the discharge temperature exceeds the level programmed in *parameter 28-26 Emergency Level*.

WARNING 22, Hoist mechanical brake
0 = The torque reference was not reached before timeout.
1 = There was no brake feedback before the timeout.

WARNING 23, Internal fan fault
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 frequency converters with DC fans, there is a feedback sensor mounted in the fan. If the fan is commanded to run and there is no feedback from the sensor, this alarm appears. For frequency converters with AC fans, the voltage to the fan is monitored.

Troubleshooting

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

WARNING 24, External fan fault
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 frequency converters with DC fans, there is a feedback sensor mounted in the fan. If the fan is commanded to run and there is no feedback from the sensor, this alarm appears. For frequency converters with AC fans, the voltage to the fan is monitored.

Troubleshooting

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

WARNING 25, Brake resistor short circuit
The brake resistor is monitored during operation. If a short circuit occurs, the brake function is disabled and the warning appears. The frequency converter is still operational, but without the brake function.

Troubleshooting

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

WARNING/ALARM 26, Brake resistor power limit
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 frequency converter trips when the dissipated braking power reaches 100%.

WARNING/ALARM 27, Brake chopper fault
The brake transistor is monitored during operation, and if a short circuit occurs, the brake function is disabled, and a warning is issued. The frequency converter 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 power to the frequency converter and remove the brake resistor.
- Troubleshoot the short circuit.

⚠WARNING

OVERHEATING RISK

The surge in power can cause the brake resistor to overheat and possibly catch fire. Failure to remove power to the frequency converter and remove the brake resistor can cause equipment damage.

WARNING/ALARM 28, Brake check failed
The brake resistor is not connected or not working.

Troubleshooting

- Check *parameter 2-15 Brake Check*.

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ALARM 29, Heat Sink temp
The maximum temperature of the heat sink has been exceeded. The temperature fault does not reset until the temperature drops below a defined heat sink temperature. The trip and reset points are different based on the frequency converter power size.

Troubleshooting
Check for the following conditions:

- Ambient temperature too high
- Motor cable too long
- Incorrect airflow clearance above and below the frequency converter
- Blocked airflow around the frequency converter
- Damaged heat sink fan
- Dirty heat sink

For the D, E, and F-size enclosures, this alarm is based on the temperature measured by the heat sink sensor mounted inside the IGBT modules. For F-size enclosures, the thermal sensor in the rectifier module can also trigger this alarm.

Troubleshooting

- Check fan resistance.
- Check soft charge fuses.
- Check IGBT thermal.

ALARM 30, Motor phase U missing
Motor phase U between the frequency converter and the motor is missing.

Troubleshooting

- Remove the power from the frequency converter and check motor phase U.

ALARM 31, Motor phase V missing
Motor phase V between the frequency converter and the motor is missing.

Troubleshooting

- Remove the power from the frequency converter and check motor phase V.

ALARM 32, Motor phase W missing
Motor phase W between the frequency converter and the motor is missing.

Troubleshooting

- Remove the power from the frequency converter and check motor phase W.

ALARM 33, Inrush fault
Too many power-ups have occurred within a short time period.

Troubleshooting

- Let the unit cool to operating temperature.

WARNING/ALARM 34, Fieldbus communication fault
The fieldbus on the communication option card is not working.

WARNING 35, Out of frequency range
This warning is active if the output frequency has reached *parameter 4-52 Warning Speed Low* or *parameter 4-53 Warning Speed High*. If the frequency converter is set to *[3] Closed Loop* in *parameter 1-00 Configuration Mode*, the warning is active in the display. If the frequency converter is not in this mode, bit 008000 Out of frequency range in the extended status word is active but there is no warning in the display.

WARNING/ALARM 36, Mains failure
This warning/alarm is only active if the supply voltage to the frequency converter is lost and *parameter 14-10 Mains Failure* is not set to *[0] No Function*.

Troubleshooting

- Check the fuses to the frequency converter and mains supply to the unit.

ALARM 37, Phase imbalance
There is a current imbalance between the power units.

ALARM 38, Internal fault
When an internal fault occurs, a code number defined in *Table 6.6* 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.

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.
1024–1284	Internal fault. Contact the Danfoss supplier or the 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.

Number	Text
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 frequency converter 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.

Table 6.6 Internal Fault Codes

ALARM 39, Heat sink sensor
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 the ribbon cable between the power card and gatedrive card.

WARNING 40, Overload of digital output terminal 27
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*.

WARNING 41, Overload of digital output terminal 29
Check the load connected to terminal 29 or remove the short-circuit connection. Also check *parameter 5-00 Digital I/O Mode* and *parameter 5-02 Terminal 29 Mode*.

WARNING 42, Overload of digital output on X30/6 or overload of digital output on X30/7
For terminal X30/6, check the load connected to terminal X30/6 or remove the short circuit connection. Also 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 terminal X30/7 or remove the short-circuit connection. Check *parameter 5-33 Term X30/7 Digi Out (MCB 101)* (VLT® General Purpose I/O MCB 101).

ALARM 46, Power card supply
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

When powered with VLT® 24 V DC with 24 V DC Supply MCB 107, only the 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.

WARNING 47, 24 V supply low
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.

WARNING 48, 1.8 V supply low
The 1.8 V DC supply used on the control card is outside of the allowable 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.

WARNING 49, Speed limit
The warning is shown when the speed is 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 frequency converter trips.

ALARM 50, AMA calibration failed
Contact the Danfoss supplier or Danfoss service department.

ALARM 51, AMA check U_{nom} and I_{nom}
The settings for motor voltage, motor current, and motor power are wrong.

Troubleshooting

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

ALARM 52, AMA low I_{nom}
The motor current is too low.

Troubleshooting

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

ALARM 53, AMA motor too big
The motor is too large for the AMA to operate.

ALARM 54, AMA motor too small
The motor is too small for the AMA to operate.

ALARM 55, AMA parameter out of range
AMA cannot run because the parameter values of the motor are outside of the acceptable range.

ALARM 56, AMA interrupted by user
The AMA is manually interrupted.

ALARM 57, AMA internal fault
Try to restart AMA. Repeated restarts can overheat the motor.

ALARM 58, AMA Internal fault
Contact the Danfoss supplier.

WARNING 59, Current limit
The current is higher than the value in *parameter 4-18 Current Limit*. Ensure that 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.

WARNING 60, External interlock
A digital input signal indicates a fault condition external to the frequency converter. An external interlock has commanded the frequency converter to trip. Clear the external fault condition. To resume normal operation, apply 24 V DC to the terminal programmed for external interlock, and reset the frequency converter.

WARNING 61, Tracking error
An error has been detected between the calculated motor speed and the speed measurement from the feedback device. The function for Warning/Alarm/Disable is set in *parameter 4-30 Motor Feedback Loss Function*. Error setting is found in *parameter 4-31 Motor Feedback Speed Error*. Allowed error time is found in *parameter 4-32 Motor Feedback Loss Timeout*. During the commissioning process, this function can be useful.

WARNING 62, Output frequency at maximum limit
The output frequency has reached the value set in *parameter 4-19 Max Output Frequency*. Check the application for possible causes. Possibly 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.

ALARM 63, Mechanical brake low
The actual motor current has not exceeded the release brake current within the start delay time window.

WARNING 64, Voltage limit
The combination of load and speed requires a motor voltage higher than what can be provided due to the actual DC-link voltage.

WARNING/ALARM 65, Control card over temperature
The cut-out temperature of the control card is 85 °C.

Troubleshooting

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

WARNING 66, Heat sink temperature low
The frequency converter is too cold to operate. This warning is based on the temperature sensor in the IGBT module. Increase the ambient temperature of the unit. Also, a trickle amount of current can be supplied to the frequency converter whenever the motor is stopped by setting *parameter 2-00 DC Hold/Preheat Current* to 5% and *parameter 1-80 Function at Stop*.

ALARM 67, Option module configuration has changed
One or more options have either been added or removed since the last power-down. Check that the configuration change is intentional and reset the unit.

ALARM 68, Safe Stop activated
Safe Torque Off (STO) has been activated. To resume normal operation, apply 24 V DC to terminal 37, then send a reset signal (via bus, digital I/O, or by pressing [Reset]).

ALARM 69, Power card temperature
The temperature sensor on the power card is either too hot or too cold.

Troubleshooting

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

ALARM 70, Illegal FC configuration
The control card and power card are incompatible. To check compatibility, contact the Danfoss supplier with the type code from the unit nameplate and the part numbers of the cards.

WARNING/ALARM 71, PTC 1 safe stop
Safe Torque Off (STO) has been activated from the VLT® PTC Thermistor Card MCB 112 because the motor is too warm. Once the motor cools and the digital input from the MCB 112 is deactivated, normal operation can resume when the MCB 112 applies 24 V DC to terminal 37 again. When the motor is ready for normal operation, a reset signal is sent (via serial communication, digital I/O, or by pressing [Reset] on the LCP). Note that if automatic restart is enabled, the motor can start when the fault is cleared.

ALARM 72, Dangerous failure
Safe Torque Off (STO) with trip lock. Unexpected signal levels on Safe Torque Off and digital input from the VLT® PTC Thermistor Card MCB 112.

WARNING 73, Safe Stop auto restart
STO activated. With automatic restart enabled, the motor can start when the fault is cleared.

WARNING 76, Power unit setup
The required number of power units does not match the detected number of active power units.

This warning occurs when replacing a module for an F-size enclosure if the power-specific data in the module power card does not match the rest of the frequency converter.

Troubleshooting

- Confirm that the spare part and its power card are the correct part number.

WARNING 77, Reduced power mode
The frequency converter is operating in reduced power mode (less than the allowed number of inverter sections). This warning is generated on power cycle when the frequency converter is set to run with fewer inverters and remains on.

ALARM 78, Tracking error
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 frequency converter.
- Select motor feedback function in *parameter 4-30 Motor Feedback Loss Function*.
- Adjust tracking error band in *parameter 4-35 Tracking Error* and *parameter 4-37 Tracking Error Ramping*.

ALARM 79, Illegal power section configuration
The scaling card has an incorrect part number or is not installed. The MK102 connector on the power card could not be installed.

ALARM 80, Initialization to default value
Parameter settings are initialized to default setting after a manual (3-finger) reset.

ALARM 81, CSIV corrupt
CSIV file has syntax errors.

ALARM 82, CSIV parameter error
CSIV has failed to record a parameter.

ALARM 91, Analog input 54 wrong settings
Set switch S202 in position OFF (voltage input) when a KTY sensor is connected to analog input terminal 54.

ALARM 92, No flow
A no-flow condition is detected in the system. *Parameter 22-23 No-Flow Function* is set for alarm.

Troubleshooting

- Troubleshoot the system and reset the frequency converter after clearing the fault.

ALARM 93, Dry pump
A no-flow condition in the system with the frequency converter operating at high speed may indicate a dry pump. *Parameter 22-26 Dry Pump Function* is set for alarm.

Troubleshooting

- Troubleshoot the system and reset the frequency converter after clearing the fault.

ALARM 94, End of curve
The feedback is lower than the setpoint. This may indicate leakage in the system. *Parameter 22-50 End of Curve Function* is set for alarm.

Troubleshooting

- Troubleshoot the system and reset the frequency converter after clearing the fault.

ALARM 95, Broken belt
Torque is below the torque level set for no load, indicating a broken belt. *Parameter 22-60 Broken Belt Function* is set for alarm.

Troubleshooting

- Troubleshoot the system and reset the frequency converter after clearing the fault.

ALARM 96, Start delayed
Motor start has been delayed due to short-cycle protection. *Parameter 22-76 Interval between Starts* is enabled.

Troubleshooting

- Troubleshoot the system and reset the frequency converter after clearing the fault.

WARNING 97, Stop delayed
Stopping the motor has been delayed because the motor has been running for less than the minimum time specified in *parameter 22-77 Minimum Run Time*.

WARNING 98, Clock fault
Time is not set, or the RTC clock has failed. Reset the clock in *parameter 0-70 Date and Time*.

WARNING 200, Fire mode
The frequency converter is operating in fire mode. The warning clears when fire mode is removed. Refer to the fire mode data in the alarm log.

WARNING 201, Fire mode was active
The frequency converter has entered fire mode. Cycle power to the unit to remove the warning. Refer to the fire mode data in the alarm log.

WARNING 202, Fire mode limits exceeded
While operating in fire mode, 1 or more alarm conditions that would normally trip the unit have been ignored. Operating in this condition voids unit warranty. Cycle power to the unit to remove the warning. Refer to the fire mode data in the alarm log.

Warning 219, Compressor Interlock:
At least 1 compressor is inversely interlocked via a digital input. The interlocked compressors can be viewed in *parameter 25-87 Inverse Interlock*.

ALARM 243, Brake IGBT
This alarm is only for F-size enclosures and is equivalent to *alarm 27, Brake Chopper Fault*.

The report value in the alarm log indicates which power module generated the alarm:

1 = Left most inverter module.

2 = Either the middle inverter module in a unit with 3 inverter modules or the right inverter module in a unit with 2 inverter modules.

3 = Right inverter module in a unit with 3 inverter modules.

5 = Either the rectifier module in a 6-pulse unit or the left rectifier module in a 12-pulse unit. The single jumper on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

6 = Right rectifier module in a 12-pulse unit. Two jumpers on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

ALARM 244, Heat sink temperature
This alarm is only for F-size enclosures and is equivalent to *alarm 29, Heat Sink Temp*.

The report value in the alarm log indicates which power module generated the alarm:

1 = Left most inverter module.

2 = Either the middle inverter module in a unit with 3 inverter modules or the right inverter module in a unit with 2 inverter modules.

3 = Right inverter module in a unit with 3 inverter modules.

5 = Either the rectifier module in a 6-pulse unit or the left rectifier module in a 12-pulse unit. The single jumper on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

6 = Right rectifier module in a 12-pulse unit. Two jumpers on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

ALARM 245, Heat sink sensor
This alarm is only for F-size enclosures and is equivalent to *alarm 39, Heat Sink Sensor*.

The report value in the alarm log indicates which power module generated the alarm:

1 = Left most inverter module.

2 = Either the middle inverter module in a unit with 3 inverter modules or the right inverter module in a unit with 2 inverter modules.

3 = Right inverter module in a unit with 3 inverter modules.

5 = Either the rectifier module in a 6-pulse unit or the left rectifier module in a 12-pulse unit. The single jumper on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

6 = Right rectifier module in a 12-pulse unit. Two jumpers on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

ALARM 246, Power card supply
This alarm is only for F-size enclosures and is equivalent to *alarm 46, Power Card Supply*.

The report value in the alarm log indicates which power module generated the alarm:

1 = Left most inverter module.

2 = Either the middle inverter module in a unit with 3 inverter modules or the right inverter module in a unit with 2 inverter modules.

3 = Right inverter module in a unit with 3 inverter modules.

5 = Either the rectifier module in a 6-pulse unit or the left rectifier module in a 12-pulse unit. The single jumper on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

6 = Right rectifier module in a 12-pulse unit. Two jumpers on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

ALARM 247, Power card temperature
This alarm is only for F-size enclosures and is equivalent to *alarm 29, Power Card Temperature*.

The report value in the alarm log indicates which power module generated the alarm:

1 = Left most inverter module.

2 = Either the middle inverter module in a unit with 3 inverter modules or the right inverter module in a unit with 2 inverter modules.

3 = Right inverter module in a unit with 3 inverter modules.

5 = Either the rectifier module in a 6-pulse unit or the left rectifier module in a 12-pulse unit. The single jumper on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

6 = Right rectifier module in a 12-pulse unit. Two jumpers on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

ALARM 248, Illegal power section configuration
This alarm is only for F-size enclosures and is equivalent to *alarm 79, Illegal Power Section Configuration*.

The report value in the alarm log indicates which power module generated the alarm:

1 = Left most inverter module.

2 = Either the middle inverter module in a unit with 3 inverter modules or the right inverter module in a unit with 2 inverter modules.

3 = Right inverter module in a unit with 3 inverter modules.

5 = Either the rectifier module in a 6-pulse unit or the left rectifier module in a 12-pulse unit. The single jumper on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

6 = Right rectifier module in a 12-pulse unit. Two jumpers on the 44-pin jumper P1 on the top of the module identifies it as 12-pulse.

WARNING 250, New spare part
The power or switch mode supply has been exchanged. Restore the frequency converter type code in the EEPROM. Select the correct type code in *parameter* according to the label on the frequency converter. Remember to select Save to EEPROM at the end.

WARNING 251, New typecode
The power card or other components are replaced and the type code has changed.

7 Frequency Converter and Motor Applications

7.1 Torque Limit, Current Limit, and Unstable Motor Operation

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

- *Parameter 1-00 Configuration Mode* sets the frequency converter for open or closed loop operation or torque mode operation.
- *Parameter 1-03 Torque Characteristics* sets the mode in which the frequency converter operates.
- *Parameters 1-20* to *1-29* match the frequency converter to the motor and adapt to the motor characteristics.
- *Parameter 4-16 Torque Limit Motor Mode*, *parameter 4-17 Torque Limit Generator Mode*, and *parameter 14-25 Trip Delay at Torque Limit* set the torque control features of the frequency converter for the application.

Parameter 1-00 Configuration Mode
This parameter sets the frequency converter for open loop, closed loop, or torque mode operation. In a closed-loop configuration, a feedback signal controls the frequency converter speed. The settings for the PID controller play a key role for stable operation in closed loop, as described in the operating instructions. In open loop, the frequency converter calculates the torque requirement based on current measurements of the motor.

Parameter 1-03 Torque Characteristics
This parameter sets the frequency converter for constant or variable torque operation. It is imperative that the correct torque characteristic is selected. If, for example, the load type is constant torque, such as a conveyor, and variable torque is selected, the frequency converter can have great difficulty starting the load. Consult Danfoss if uncertain about the torque characteristics of an application.

Parameter 1-20 Motor Power [kW] and parameter 1-25 Motor Nominal Speed
These parameters configure the frequency converter for the connected motor. These parameters are motor power, voltage, frequency, current, and nominal motor speed. Accurate setting of these parameters is important. Enter the required motor data as listed on the motor nameplate. For effective and efficient load control, the frequency converter relies on this information for calculating the output waveform in response to the changing demands of the application.

Parameter 1-29 Automatic Motor Adaptation (AMA)
This parameter activates the automatic motor adaptation (AMA) function. When AMA is performed, the frequency converter measures the electrical resistance of the motor stator windings (R1). *Parameter 1-31 Rotor Resistance (Rr) – parameter 1-35 Main Reactance (Xh)* must be requested from the motor manufacturer the optimal performance of the frequency converter data. To set *parameter 1-31 Rotor Resistance (Rr) – parameter 1-35 Main Reactance (Xh)*, use the values supplied by the motor manufacturer or leave at the factory default values.

Never adjust these parameters to random values even though it seems to improve operation. Such adjustments can result in unpredictable operation under changing conditions.

Parameter 4-17 Torque Limit Generator Mode and parameter 4-16 Torque Limit Motor Mode
These parameters set the limit for the frequency converter 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 frequency converter programmed to operate a smaller rated motor yields a higher torque limit value than the same frequency converter programmed to operate a larger size 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 frequency converter 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
This parameter works with torque limit. This parameter selects the period in which the frequency converter operates in torque limit before a trip. The factory default value is Off. This setting means that the frequency converter does not trip on torque limit, although the unit can still trip from an overload condition. Built into the frequency converter 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 frequency converter, a timer is activated. If the load remains excessive long enough, the frequency converter trips on inverter time. Adjustments cannot be made to alter this circuit. Improper parameter settings effecting load current can result in premature trips of this type. The timer can be shown on the LCP.

7.1.1 Overvoltage Trips

This trip occurs when the DC bus voltage reaches its DC bus alarm voltage high. Before tripping, the frequency converter shows a high-voltage warning. Most times, an overvoltage condition is caused by 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 frequency converter. 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 frequency converter trips.

Ways to avoid overvoltage trips

There are a few ways to avoid this situation:

- Reduce the deceleration rate so it takes longer for the frequency converter to decelerate. The frequency converter 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 due to the inertia, 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 frequency converter to trip. This trip is done deliberately to avoid confusion about the operation of the frequency converter.
- Control regenerated energy with a dynamic brake. If the DC bus level becomes too high, the frequency converter switches the resistor across the DC bus. The unwanted energy is dissipated into the external resistor bank mounted outside of the frequency converter. This process increases deceleration rate.

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 speed of the load. The same restriction on the amount of influence applies.

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

7.1.2 Mains Phase Loss Trips

The frequency converter 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, and can cause overheating in the DC bus capacitors and the DC coil. If the ripple voltage on the DC bus is unchecked, the lifetime of the capacitors is reduced drastically.

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

Possible sources of disturbance

- Line notching
- Defective transformers
- Other loads that affect the form factor of the AC waveform

Mains imbalances that exceed 3% cause sufficient DC bus ripple to initiate a trip. 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 frequency converter.
Severe 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.

Refer to *chapter 8.7.7 Input Imbalance of Supply Voltage Test*.

7.1.3 Control Logic Problems

Problems with control logic can often be difficult to diagnose since there is usually no associated fault indication. Typically, the frequency converter does not respond to a given command.

To obtain an output, provide these basic commands to the frequency converter:

- Start command: To execute.
- Reference or speed command: To identify the speed of execution.

The frequency converters are designed to accept various signals. First determine which of these signals the frequency converter 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 frequency converter has detected the desired signal. Refer to *chapter 4.6 Frequency Converter Inputs and Outputs* and *chapter 8.7.13 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 frequency converter. Refer to *chapter 8.7.13 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 frequency converter. Check the circuitry providing the signal along with its associated wiring.

7.1.4 Programming Problems

Difficulty with operation of the frequency converter can be a result of improper programming of the frequency converter parameters.

The 3 areas where programming errors can affect frequency converter and motor operation are:

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

Refer to *chapter 4.6 Frequency Converter Inputs and Outputs*.

Set up the frequency converter 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 frequency converter. This data enables the frequency converter processor to match the frequency converter 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 frequency converter 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 frequency converter 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 frequency converter 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

The motor or motor wiring can develop a phase-to-phase or phase-to-ground short circuit resulting in an alarm indication. Check whether the problem is in the motor wiring or the motor itself.

A motor with unbalanced or asymmetrical impedances on all 3 phases can result in rough operation or unbalanced output currents. For measurements, use a clamp-on style ammeter to determine whether the current is balanced on the 3 output phases. Refer to *chapter 8.7.14 Output Imbalance of Motor Supply Voltage Test*.

Usually, a current limit warning indicates an incorrect mechanical load. If possible, disconnect the motor from the load to determine if the load is incorrect.

Often, the indications of motor problems are similar to the problems of a defective frequency converter. To determine whether the problem is with the frequency converter, disconnect the motor from the frequency converter motor terminals. Perform the test in *chapter 8.7.14 Output Imbalance of Motor Supply Voltage Test*. If the 3 voltage measurements are balanced, the frequency converter functions correctly.

If the voltage measurements are not balanced, the frequency converter malfunctions. Typically, 1 or more output IGBTs do not function correctly. This problem can be a result of a defective IGBT or gate signal.

7.2 Internal Frequency Converter Problems

To identify most problems related to failed power components, perform a visual inspection and the static tests as described in *chapter 8 Test Procedures*. However, the following problems must be diagnosed in a different manner.

7.2.1 Overtemperature Faults

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

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 frequency converter 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, resulting in the sum of the 3 output currents being a value other than 0. If the deviation from 0 (current amplitude) approaches a specific level, the frequency converter assumes a ground fault and issues an alarm.

To determine whether a current sensor is defective, disconnect the motor from the frequency converter and observe the current in the frequency converter display. With the motor disconnected, the current must be 0. A frequency converter with a defective current sensor indicates some current flow. Because the current sensors for the higher horsepower frequency converters have less resolution, an indication of a fraction of 1 A is tolerable. However, that value must be considerably lower than 1 A. If the display shows more than 1 A of current, the current sensor is defective.

To determine which current sensor is defective, measure the voltage offset at zero current for each current sensor. Refer to *chapter 8.7.11 Current Sensor Test*.

7.3 Electromagnetic Interference

The following is an overview of general signal and power wiring considerations when addressing the electromagnetic compatibility (EMC) concerns for typical commercial and industrial equipment. High-frequency RF emissions and immunity are discussed. Compliance to national and European CE EMC directives are required.

7.3.1 Effect of EMI

While electromagnetic interference (EMI) disturbances to the operation of the unit are uncommon, the following detrimental EMI effects can be seen:

- Motor speed fluctuations
- Serial communication transmission errors
- Frequency converter CPU exception faults
- Unexplained frequency converter trips

A disturbance resulting from other nearby equipment is more common. Generally, other 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.

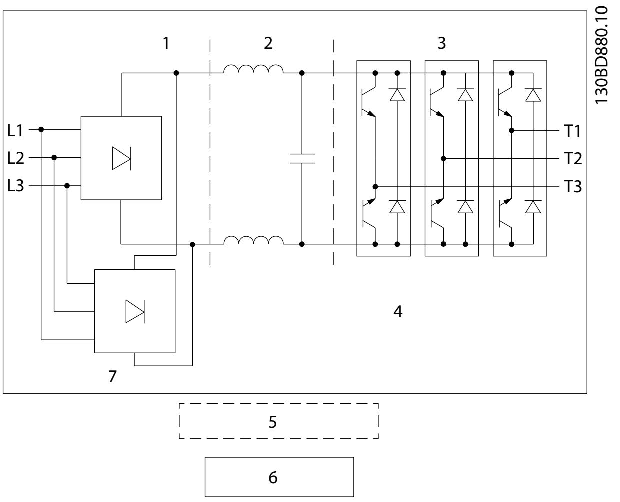
Detrimental effects to these systems can include the following:

- 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

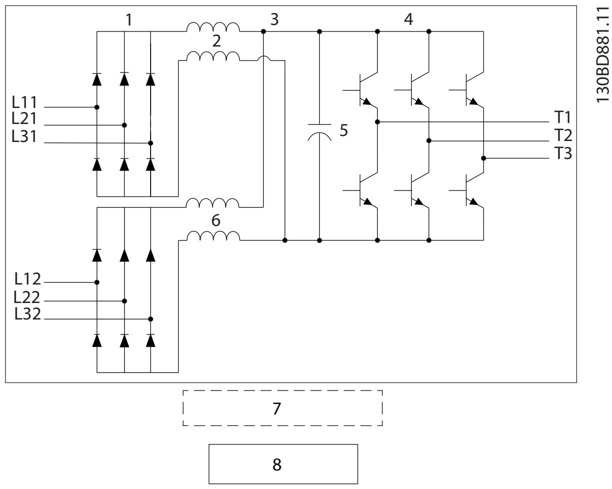
Modern frequency converters (*Illustration 7.1* and *Illustration 7.2*) utilize IGBTs to provide an efficient and cost effective means to create the pulse width modulated (PWM) output waveform necessary for accurate motor control. These IGBTs rapidly switch the fixed DC bus voltage creating a variable frequency and a variable voltage PWM waveform. This high rate of voltage change [dU/dt] is the primary source of the frequency converters generated EMI.

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



1	Rectifier (SCR/diodes)
2	DC link (DC bus)
3	Inverter (IGBTs)
4	Power section
5	Logic-to-power interface
6	Control logic
7	Soft charge circuitry

Illustration 7.1 6-pulse Functionality Diagram



1	Rectifier (SCR/diodes)
2	DC inductor - rectifier #1
3	DC link (DC bus)
4	Inverter (IGBTs)
5	DC link capacitor
6	DC inductor - rectifier #2

Illustration 7.2 12-pulse Functionality Diagram

7.3.3 EMI Propagation

Frequency converter-generated EMI is both conducted to the mains and radiated to nearby conductors. Refer to *Illustration 7.3*. 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 frequency converter itself. However, imperfections in the frequency converter 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 frequency converter or the interconnected control device. Refer to *Illustration 7.5*.

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

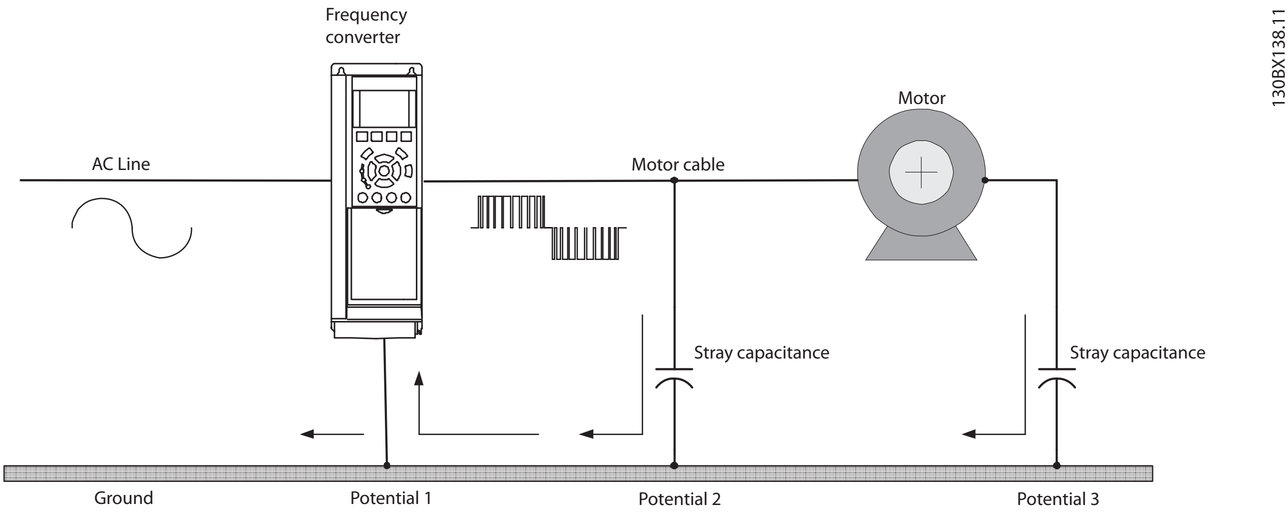


Illustration 7.3 Ground Currents

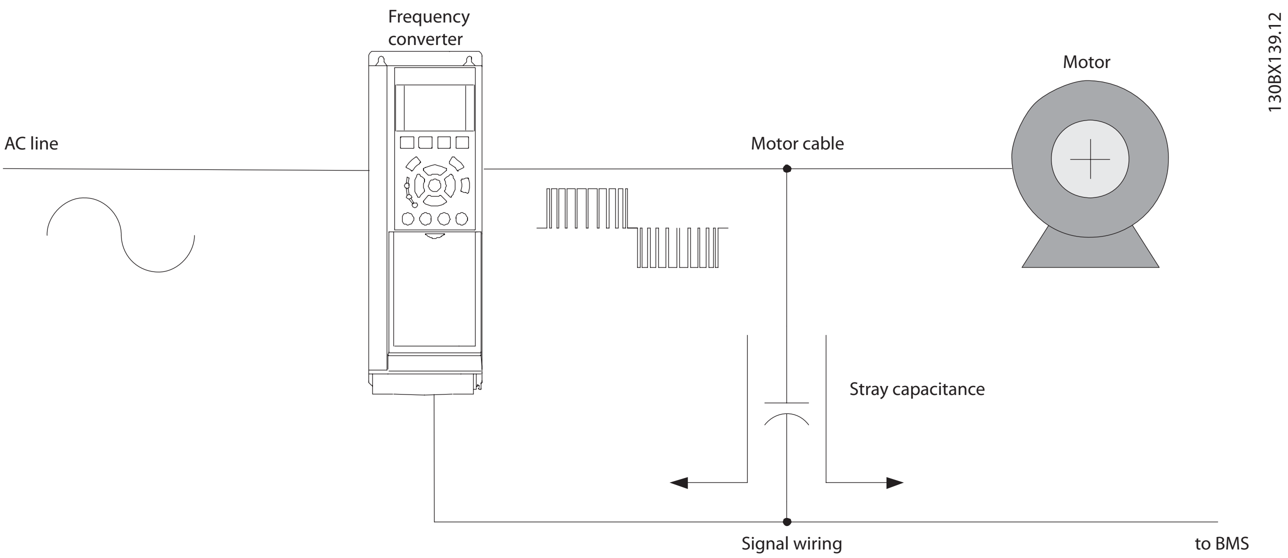


Illustration 7.4 Signal Conductor Currents

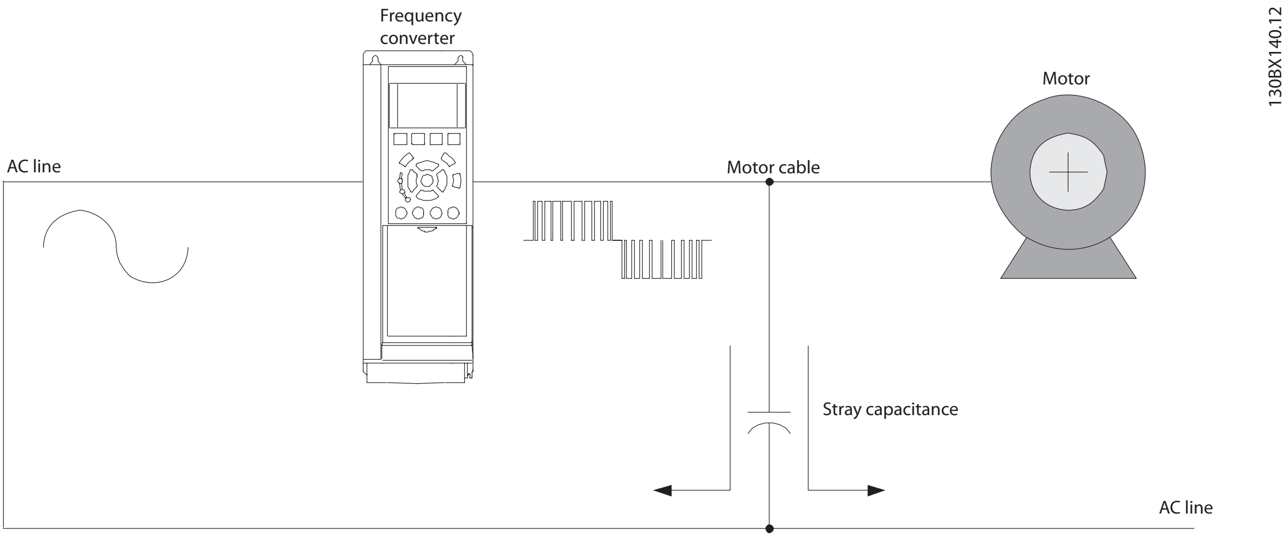


Illustration 7.5 Alternate Signal Conductor Currents

7.3.4 Preventive Measures

EMI-related problems are more effectively alleviated during the design and installation phases rather than during service. Many of the steps listed here can be implemented at a relatively low cost when compared to the cost of identifying and fixing the problem later in the field.

Grounding
The frequency converter and motor must be solidly grounded to the equipment frame. A good high-frequency connection is necessary to allow the high-frequency currents to return back to the frequency converter 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 frequency converter or motor onto a painted surface does not create an effective ground connection. In addition, running a separate ground conductor directly between the frequency converter 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 screened twisted pair cables are available that are designed to minimize the effects of EMI. While unscreened twisted pair cables are often adequate, screened twisted pair cables provide another degree of protection. Terminate the signal cable screen in a manner that is appropriate for the connected equipment. Avoid terminating the screen through a pigtail connection as this method increases the high-frequency impedance and reduces the effectiveness of the screen. Refer to *chapter 4.9 Grounded Screened 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 materials on hand.

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.

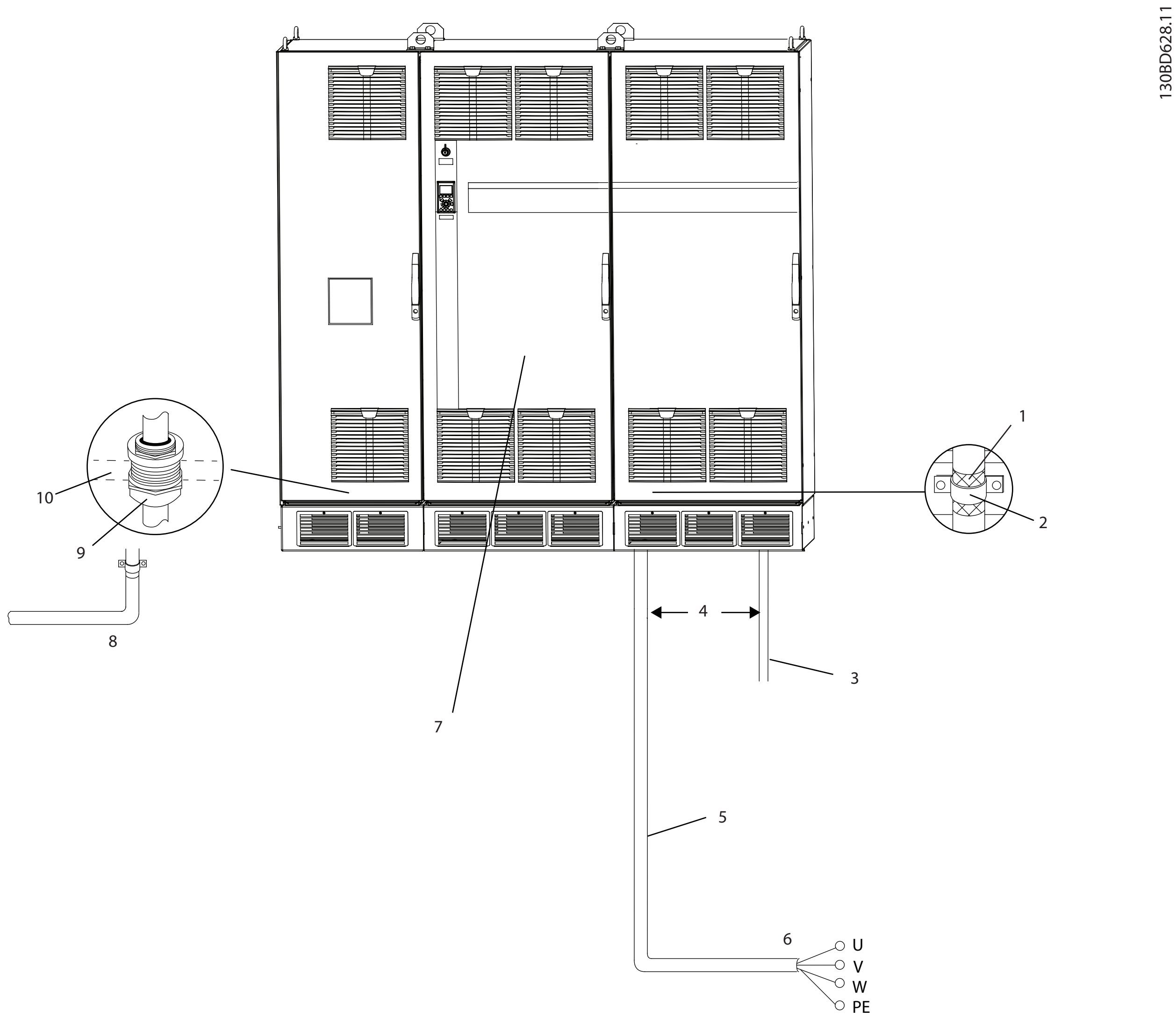
Installing screened power cable is the most effective methods to alleviate EMI problems. The screen forces the noise current to flow directly back to the frequency converter before it gets back into the power network or takes other undesirable and unpredictable high-frequency paths. Unlike most signal wiring, the screening on the motor cable must be terminated at both ends.

If a screened motor cable is not available, then 3-phase conductors plus ground in a conduit provides some degree of protection. This technique is not as effective as screened 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 screened cable provides extra EMI protection, the screen capacitance can reduce the maximum allowable cable length at high data rates.

7.3.5 Proper EMC Installation

Illustration 7.6 shows a correct installation with EMC considerations in mind. Although most installations do not follow all the recommended practices, the closer an installation resembles this example, the better immunity the network has against EMI. If EMI problems occur in an installation, refer to this example. Attempt to replicate this installation recommendation as closely as possible to alleviate such problems.



1	Stripped cable insulation	6	Motor cable, 3-phase cables, and ground
2	Clamped screen-to-ground point inside cabinet	7	To prevent ground loops due to variations in ground potential, fit an equalizing cable next to the control cable. Minimum cable cross-section is 16 mm^2 (4 AWG)
3	Control cables	8	Mains cable, 3-phase cables, and reinforced ground
4	Minimum 200 mm (7.9 in) between control cables, motor cable, and mains cable	9	EMC cable gland
5	Screened cable	10	Gland plate

Illustration 7.6 Proper EMC Installation

8 Test Procedures

8.1 Introduction

⚠WARNING

PERSONAL INJURY RISK

Touching electrical parts of the frequency converter may be fatal even after equipment has been disconnected from AC power.

- **Before touching any potentially live parts of the frequency converter, refer to *chapter 2.3 Safety Precautions*.**
- **Wait for the frequency converter components to discharge fully. Refer to *Table 2.1* or the label on the frequency converter for specific discharge time.**

This section contains detailed procedures for testing frequency converters. Previous sections of this guide provide symptoms, alarms, and other conditions which require more test procedures to diagnose the frequency converter further. The results of these tests indicate the appropriate repair actions.

Frequency converter testing is divided into static tests and dynamic tests.

Static tests

Static tests are performed on the rectifier and inverter modules. These tests are conducted without power applied to the frequency converter. Most frequency converter problems can be diagnosed simply 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 frequency converter. Dynamic testing traces signal circuitry to isolate faulty components.

8.2 Tools Required for Testing

Item	Description
ESD protection kit	Wrist strap and mat
Metric socket set	7–19 mm
Socket extensions	100–150 mm (4 inch and 6 inch)
Magnetic sockets	–
Ratchet wrench	–
Torque wrench	Torque range 0.5–19 Nm (6–170 in-lb)
Torx driver set	T10–T50
Needle nose pliers	–
Screwdrivers	Standard and Phillips

Table 8.1 Tools Required for Service of Frequency Converter

Item	Description
Digital volt-ohm meter (PWM compatible)	• Rated for true RMS • Supports diode mode • Rated for the mains voltage of the frequency converter
Analog voltmeter	–
Oscilloscope	–
Clamp-on ammeter	Clamp-on ammeter rated for true RMS
Split bus supply	p/n 130B3146
Signal test board	p/n 176F8437
Signal test board extension	p/n 130B3147
Test cable	p/n 176F8766

Table 8.2 Instruments Recommended for Testing of Frequency Converter

8.2.1 Signal Test Board

The signal test board plugs into the top of the modules and tests the circuitry within the frequency converter. Its use is described in the procedures where called out. Refer to *chapter 11.1.3 Signal Test Board Pin Outs: Description and Voltage Levels* for detailed pin descriptions.

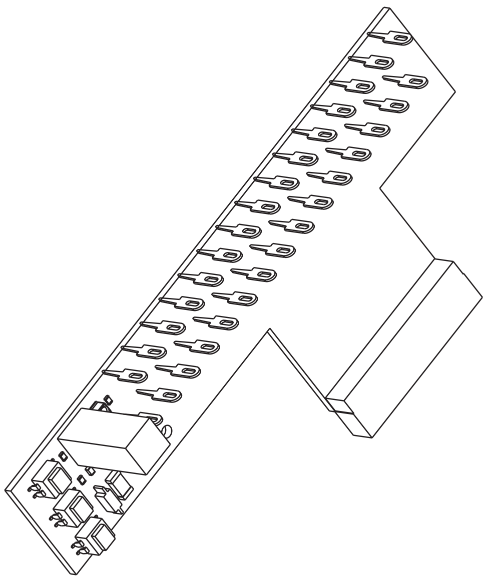


Illustration 8.1 Signal Test Board

8.2.2 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 Pre-test Precautions

Consider the following safety precautions before performing 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 frequency converter is always present while performing service.
- Handle disassembled electronic parts with care.
- Perform the static test before powering up the faulty unit.
- Perform static test after completing the repair and assembly of the frequency converter.
- Connect the frequency converter to the mains only after completion of static tests.
- Complete all necessary precautions for system start-up, before applying power to frequency converter.

8.4 Static Tests for Rectifier Module

8.4.1 Access to Rectifier Module Test Points

⚠WARNING

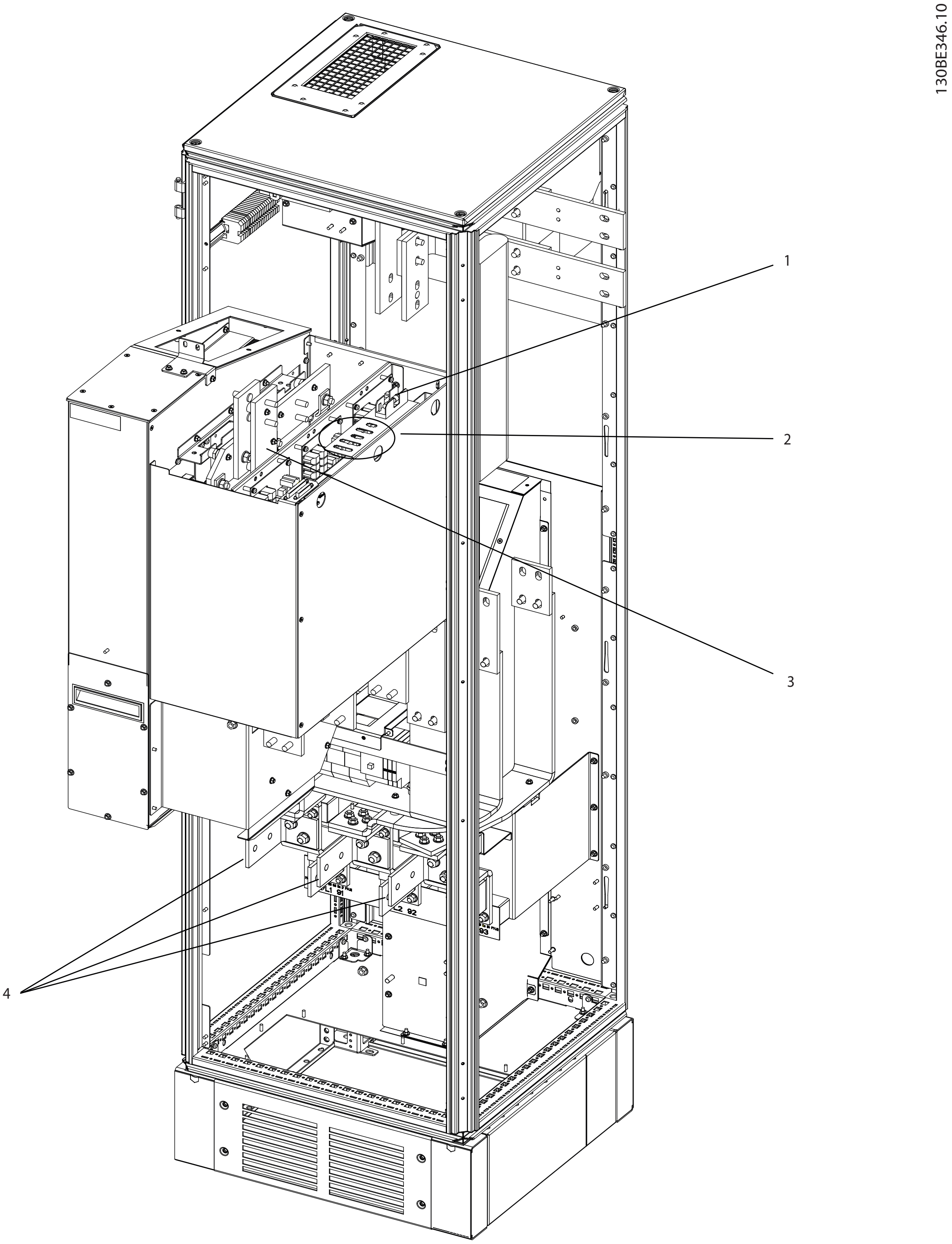
SHOCK AND INJURY HAZARD

Touching electrical parts of the frequency converter can be fatal even after the equipment has been disconnected from AC power.

Perform the following steps before touching any internal components:

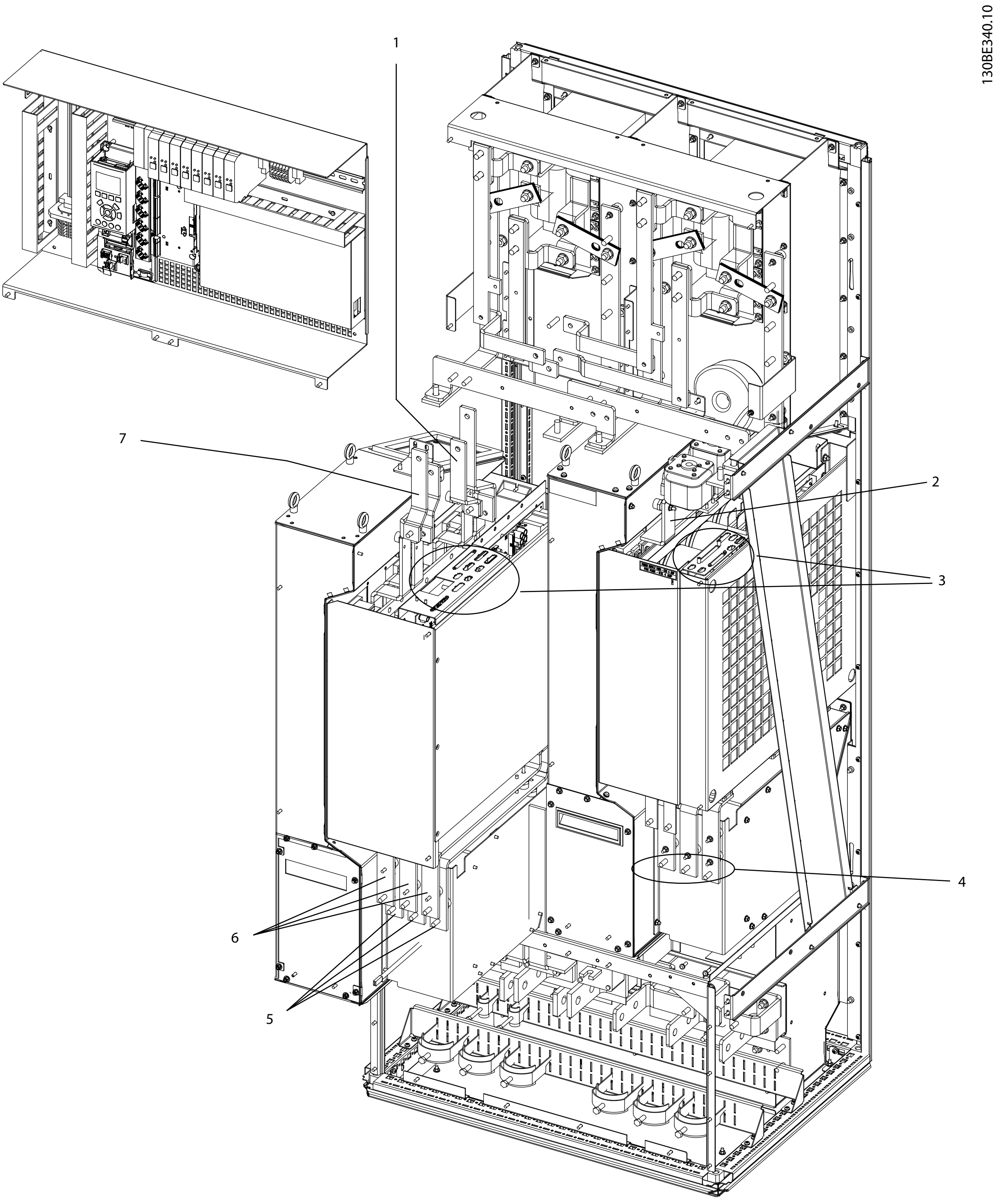
1. **Disconnect the mains power.**
2. **Disconnect the motor.**
3. **If there is a brake option, disconnect the brake.**
4. **If there is a load share/regeneration option, disconnect it.**
5. **Wait for the capacitors to discharge fully. Refer to the label on the front of the frequency converter door for the exact discharge time.**
6. **Ensure that the DC-bus capacitors have discharged fully by measuring the DC bus using a voltage meter.**

Many of the following test procedures require access to the DC bus. Refer to *Illustration 8.2 – Illustration 8.4* for rectifier module test points.



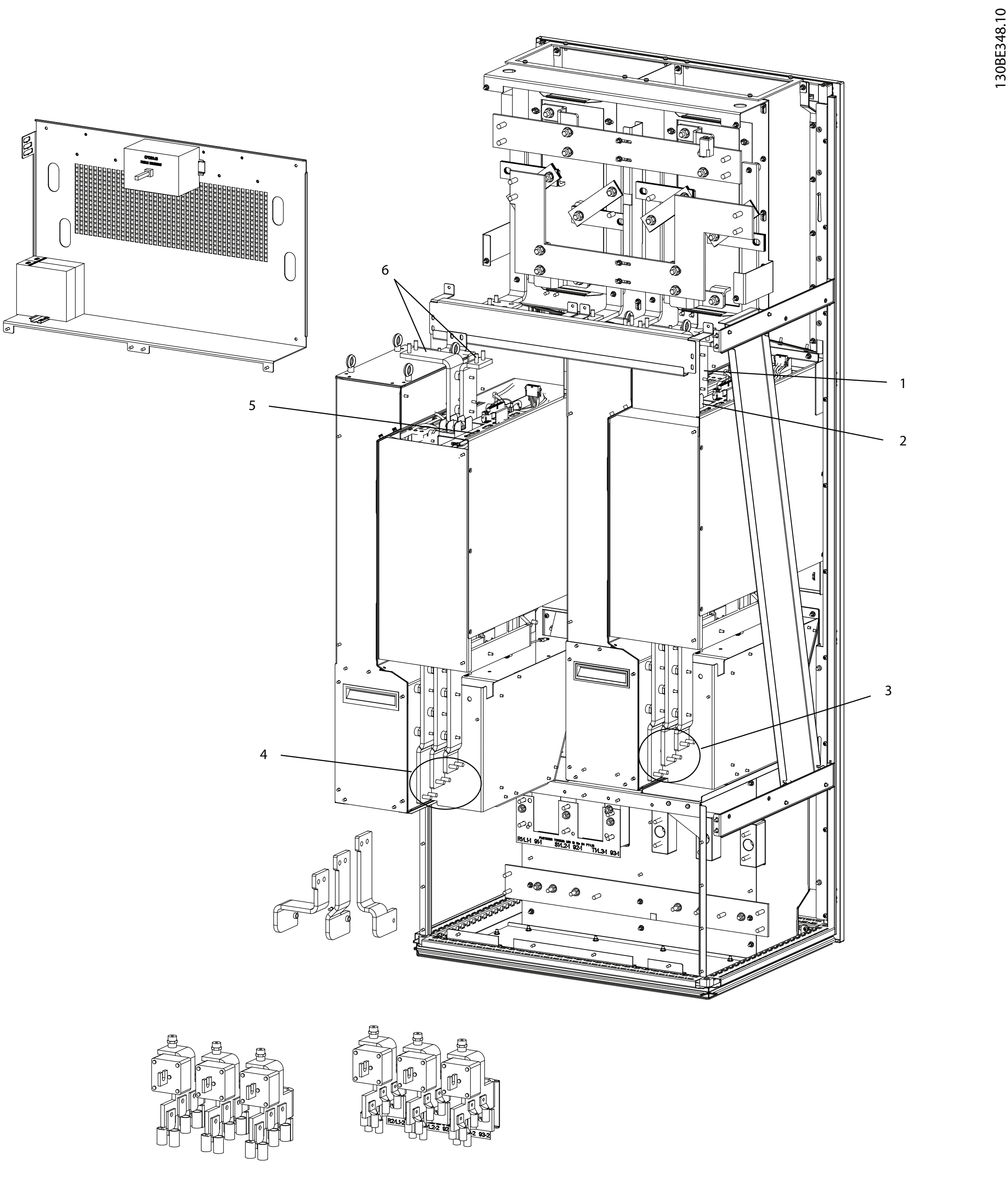
1	Power card fuse	3	DC bus bars
2	Signal plug connectors	4	Mains input

Illustration 8.2 Rectifier Module Test Points, F1–4 Enclosure Size



1	DC bus bar (rectifier 2)	5	Mains input
2	DC bus bar	6	Mains input
3	Signal plug connectors	7	DC bus bar (rectifier 1)
4	Motor output		

Illustration 8.3 Rectifier and Inverter Module Test Points, F8–F9 Enclosure Size



1	DC bus bar (module 2)	4	Mains input (module 1)
2	Signal plug connectors (module 2)	5	Signal plug connectors (module 1)
3	Mains input (module 2)	6	DC bus bar (module 1)

Illustration 8.4 Rectifier Module Test Points, F10–F13 Enclosure Size

8

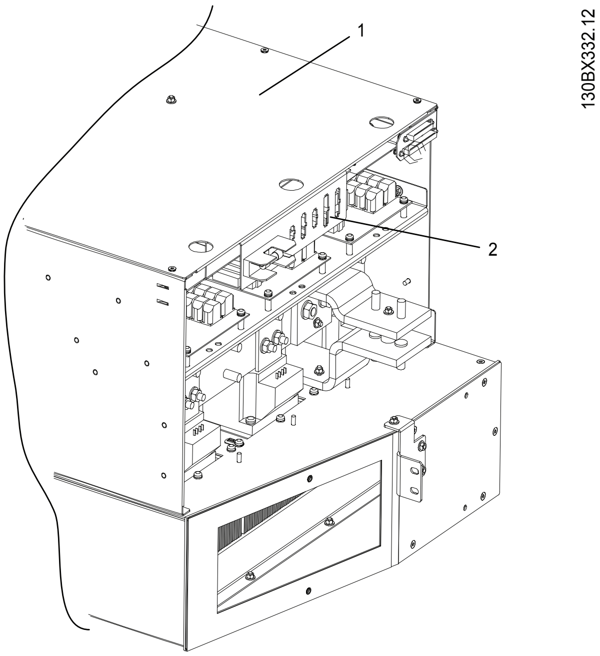
8.4.2 Soft Charge Fuse Test

This test determines if any of the soft charge fuses are open.

Use the 12-pin connector on the top of the rectifier module for testing.

1. L1 to pins 6, 11, and 12 (red wires).
2. L2 to pins 4, 9, and 10 (white wires).
3. L3 to pins 2, 7, and 8 (black wires).

A measurement of 0 Ω indicates good continuity. To replace the fuses on the soft charge card, remove the rectifier module.



1	Rectifier module
2	12-pin connector

Illustration 8.5 Rectifier Detail

8.4.3 Soft Charge and Rectifier Circuit Tests

Different enclosures contain multiple circuits, and it is important to perform these tests on each soft charge and rectifier circuit.

- F1–F4 enclosures contain 1 rectifier module, with 1 soft charge and 1 rectifier circuit.
- F8–F9 enclosures contain 1 rectifier module, with 2 soft charge circuits and 2 rectifier circuits.
- F10–F13 enclosures contain 2 rectifier modules, with 1 soft charge and 1 rectifier circuit per module.

Both the rectifier and soft charge circuits are tested simultaneously. The soft charge circuit is made up of a soft charge rectifier, fuses, and a soft charge resistor. The rectifier circuit is made up of the SCR/diode modules. The soft charge resistor limits the inrush current when power is applied to the frequency converter. The soft charge circuit card also provides snubbing for the SCRs.

NOTICE

It is important to pay close attention to the polarity of the meter leads to ensure identification of a faulty component if an incorrect reading appears.

8.4.3.1 Soft Charge/Rectifier Circuit Test 1

1. Verify that power is disconnected from the frequency converter and ensure that the capacitors are fully discharged.
2. Remove the safety covers to access the unit.
3. Connect the positive (+) meter lead to the positive (+) DC bus.
4. Connect the negative (-) meter lead to terminals L1, L2, and L3 in turn.
5. Check the reading for each connection. Each reading must show infinity. The meter can start out at a low value and climb toward infinity as capacitance is charged within the unit.

Incorrect reading
With the part 1 test connection, the SCRs in the SCR/diode modules are reverse biased so they are blocking current flow. If a short circuit exists, it is possible that either the SCRs or the diodes in the soft charge rectifier are shorted. To isolate between SCRs or the soft charge rectifier, perform internal module testing.

8.4.3.2 Soft Charge/Rectifier Circuit Test 2

1. Reverse meter leads by connecting the negative (-) meter lead to the positive (+) DC bus.
2. Connect the positive (+) meter lead to L1, L2, and L3 in turn.
3. Check the reading for each connection. Each reading must show a diode drop.

Incorrect reading
With the part 2 test connection, even though the SCRs in the SCR/diode modules are forward biased by the meter, current does not flow through the SCRs without providing a signal to their gates. The upper diodes in the soft charge rectifier are forward biased so the meter reads the voltage drop across those diodes.

- If an open reading is present, it indicates that the upper diodes in the soft charge rectifier are open.

It also can indicate that 1 or more of the soft charge fuses are open. Furthermore, it can indicate that the soft charge resistor is open. To isolate between the 3 possibilities, perform internal module testing.

- A short circuit reading indicates either 1 or more of the upper soft charge rectifier diodes are shorted, or the SCRs are shorted in the SCR/diode module. To isolate between SCRs or the soft charge rectifier, perform internal module testing.

8.4.3.3 Soft Charge/Rectifier Circuit Test 3

1. Connect the positive (+) meter lead to the negative (-) DC bus.
2. Connect the negative (-) meter lead to terminals L1, L2, and L3 in turn.
3. Check the reading for each connection. Each reading must show a diode drop.

Incorrect reading
With the part 3 test connection, the diodes in the SCR/diode modules and the lower diodes in the soft charge rectifier are forward biased. The meter reads the diode drops. If a short circuit exists, it is possible that either the diodes in the SCR/diode modules or the lower diodes in the soft charge rectifier are shorted. To isolate between SCRs or the soft charge rectifier, perform internal module testing.

Although an open reading is possible, it is unlikely since it indicates that both the diodes in the SCR/diode modules and the lower diodes in the soft charge rectifier are open. If that occurs, replace both diodes.

8.4.3.4 Soft Charge/Rectifier Circuit Test 4

1. Reverse meter leads by connecting the negative (-) meter lead to the negative (-) DC bus.
2. Connect the positive (+) meter lead to L1, L2, and L3 in turn. Each reading must show infinity.
3. Check the reading for each connection. Each reading must show infinity. The meter can start out at a low value and climb toward infinity as capacitance is charged within the unit.

Incorrect reading
With the part 4 test connection, the diodes in the SCR/diode modules and the lower diodes in the soft charge rectifier are reversed biased. If a short circuit exists, it is possible that either the diodes in the SCR/diode modules or the lower diodes in the soft charge rectifier are shorted. To isolate between SCRs or the soft charge rectifier, perform internal module testing.

8.5 Static Tests for Inverter Module

8.5.1 Access to Inverter Module Test Points

⚠WARNING

SHOCK AND INJURY HAZARD

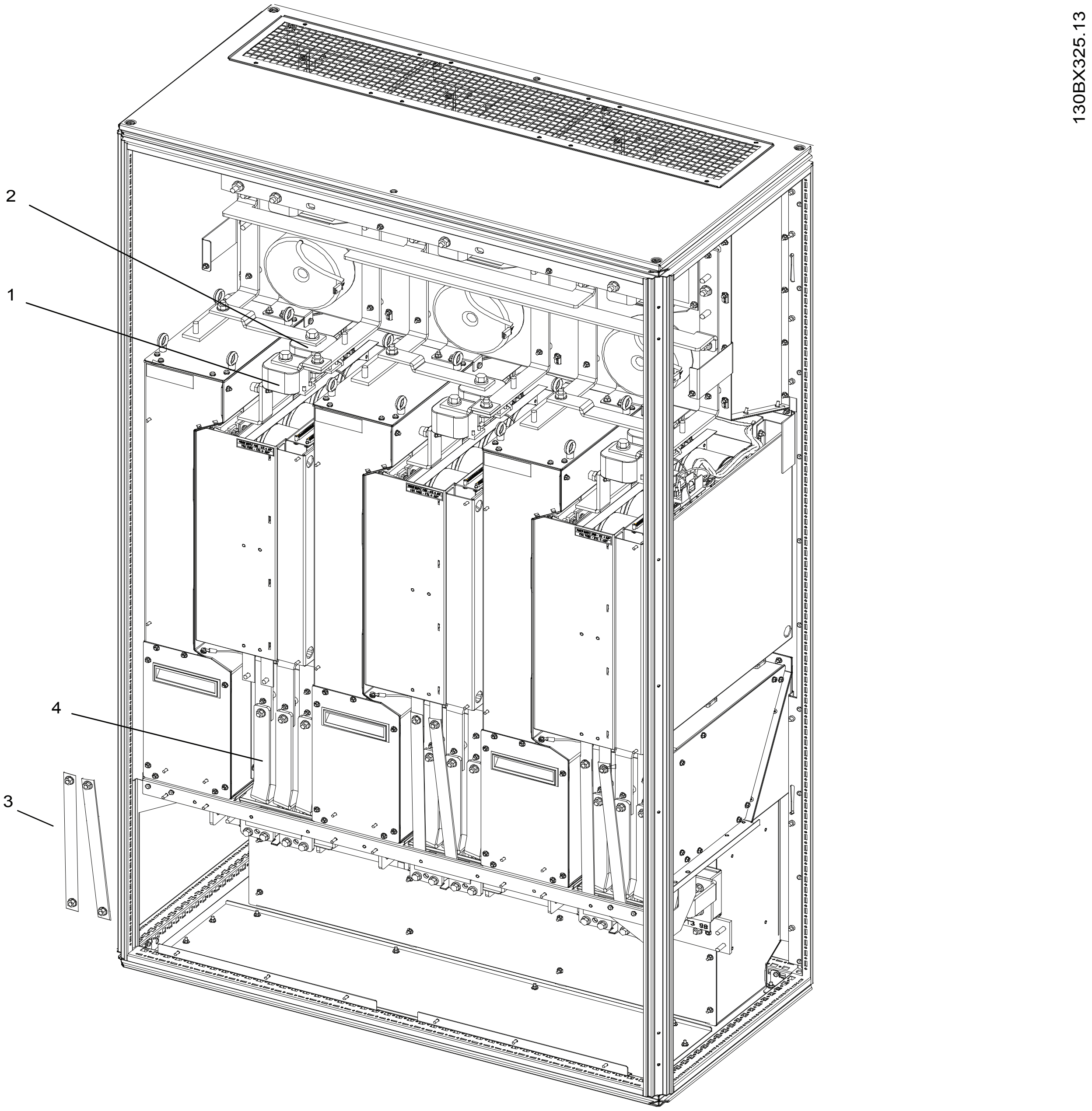
Touching electrical parts of the frequency converter can be fatal even after the equipment has been disconnected from AC power.

Perform the following steps before touching any internal components:

1. **Disconnect the mains power.**
2. **Disconnect the motor.**
3. **If there is a brake option, disconnect the brake.**
4. **If there is a load share/regeneration option, disconnect it.**
5. **Wait for the capacitors to discharge fully. Refer to the label on the front of the frequency converter door for the exact discharge time.**
6. **Ensure that the DC-bus capacitors have discharged fully by measuring the DC bus using a voltage meter.**

To access the inverter module test points, perform the following steps:

1. If a brake option is present, remove 2 brake option jumper bus bars from each module by removing the attaching nut at each end of the bus bar.
2. Remove 3 motor jumper bus bars from each module by removing the attaching nut at each end of the bus bar.
3. Remove the positive DC jumper bus bar from the fuse by removing attaching hardware at each end of the bus bar.
4. Remove the negative DC jumper bus bar from the fuse by removing the attaching hardware at each end of the bus bar.



1	Positive (+) DC link fuse	3	Brake option jumper bus bar
2	Negative (-) DC link fuse	4	Motor jumper bus bar

Illustration 8.6 Inverter Module Test Points, F-size Enclosure

8.5.2 Inverter Circuit Tests

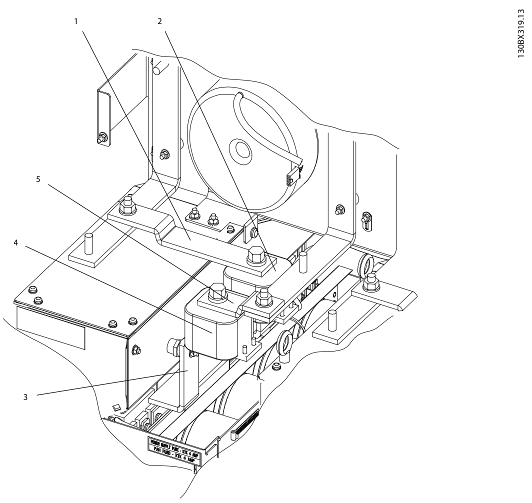
The inverter module is primarily made up of the IGBTs used for switching the DC bus voltage to create the output to the motor. The IGBTs are grouped into 3 per module. The frequency converter also has snubber capacitors on each IGBT module.

8.5.2.1 Inverter Circuit Test 1

Before starting tests, ensure that meter is set to diode scale.

1. Verify that power is disconnected from the frequency converter and ensure that the capacitors are fully discharged.
2. Remove the safety covers to access the unit.
3. Connect the positive (+) meter lead to the (+) positive DC bus bar.
4. Connect the negative (-) meter lead to terminals U, V, and W in sequence.
5. Check the reading for each connection. Each reading must show infinity. The meter can start out at a low value and climb toward infinity as capacitance is charged within the unit.

Incorrect reading
An incorrect reading indicates a failed IGBT in that inverter module. Replace the IGBT module according to *chapter 10.1.7 IGBT Module Replacement*.



1	Top (-) DC link fuse bus bar
2	(-) DC link fuse (none in 12-pulse models F8/F9)
3	Bottom (+) DC link fuse bus bar
4	(+) DC link fuse (none in 12-pulse models F8/F9)
5	Top (+) DC link fuse bus bar

Illustration 8.7 Exploded View of Inverter Test Points

8.5.2.2 Inverter Circuit Test 2

1. Reverse the meter leads by connecting the negative (-) meter lead to the positive (+) DC bus bar.
2. Connect the positive (+) meter lead to U, V, and W in sequence.
3. Check the reading for each connection. Each reading must show a diode drop.

Incorrect reading
An incorrect reading indicates a failed IGBT in that inverter module. Replace the IGBT module according to *chapter 10.1.7 IGBT Module Replacement*.

8.5.2.3 Inverter Circuit Test 3

1. Connect the positive (+) meter lead to the negative (-) DC bus bar.
2. Connect the negative (-) meter lead to terminals U, V, and W in sequence.
3. Check the reading for each connection. Each reading must show a diode drop.

Incorrect reading
An incorrect reading indicates a failed IGBT in that inverter module. Replace the IGBT module according to *chapter 10.1.7 IGBT Module Replacement*.

8.5.2.4 Inverter Circuit Test 4

1. Reverse the meter leads by connecting the negative (-) meter lead to the negative (-) DC bus bar.
2. Connect the positive (+) meter lead to U, V, and W in sequence.
3. Check the reading for each connection. Each reading must show infinity. The meter can start out at a low value and climb toward infinity as capacitance is charged within the unit.

Incorrect reading
An incorrect reading indicates a failed IGBT in that inverter module. Replace the IGBT module according to *chapter 10.1.7 IGBT Module Replacement*.

8.5.3 Brake IGBT Tests

This test can only be carried out on units equipped with a dynamic brake option.

1. Verify that power is disconnected from the frequency converter and ensure that the capacitors are fully discharged.
2. Remove the safety covers to access the unit.

3. Note the position of the brake jumper bus bars before removal.
4. Remove the brake jumper bus bars. Refer to *chapter 8.5.1 Access to Inverter Module Test Points*.

8.5.3.1 Brake IGBT Test 1

1. Verify that power is disconnected from the frequency converter and ensure that the capacitors are fully discharged.
2. Connect the positive (+) meter lead to the brake resistor terminal R+ (82).
3. Connect the negative (-) meter lead to the brake resistor terminal R- (81).

Incorrect reading
An incorrect reading indicates that the brake IGBT is defective. Replace the brake IGBT according to *chapter 10.1.6 Brake IGBT Module Replacement*.

8.5.3.2 Brake IGBT Test 2

1. Connect the positive (+) meter lead to the brake resistor terminal R- (81).
2. Connect the negative (-) meter lead to the brake resistor terminal R+ (82).
3. Check the reading for each connection. Each reading must show a diode drop.

Incorrect reading
An incorrect reading indicates that the brake IGBT is defective. Replace the brake IGBT according to *chapter 10.1.6 Brake IGBT Module Replacement*.

8.5.3.3 Brake IGBT Test 3

1. Connect the positive (+) meter lead to the brake resistor terminal R- (81).
2. Connect the negative (-) meter lead to the negative (-) DC bus.
3. Check the reading for each connection. Each reading must show infinity. The meter can start out at a low value and climb toward infinity as capacitance is charged within the unit.

Incorrect reading
An incorrect reading indicates that the brake IGBT is defective. Replace the brake IGBT according to *chapter 10.1.6 Brake IGBT Module Replacement*.

8.6 Fan Continuity Tests

Make all continuity checks using an ohmmeter set to Rx1 scale. A digital or analog ohmmeter can be used also. Some instability can result when measuring resistance of a transformer with a multimeter. Reduce this instability by turning off the auto-ranging function and setting the measurement manually. For a list of fan locations and source control, refer to *chapter 5.3.6.2 Fan Location*.

8.6.1 Fan Continuity Test 1

This test checks the fan fuses.

Check the 15 A fan fuse on the top of each inverter module.

An open fuse could indicate more faults. Replace the fuse and continue the fan checks.

8.6.2 Fan Continuity Test 2

This test checks the continuity from the AC input terminals to each inverter module.

F1–F4 enclosure sizes

1. Unplug the 10-pin connector from the top of each inverter module.
2. Verify that the 8-pin connector is plugged into the top of the inverter module and that the 12-pin connector is plugged into the top of the rectifier module.
3. Read the terminals on the inverter module side (female connector).
4. For each inverter module, measure from L3 (T) to terminal 1. The reading must be <1 Ω.
5. For each inverter, measure from L2 (S) to terminal 2. The reading must be <1 Ω.

F8–F9 enclosure sizes

1. Unplug the 10-pin connector from the top of each inverter module.
2. Verify that the 8-pin connector is plugged into the top of the inverter module and that the 12-pin connector is plugged into the top of the rectifier module.
3. Read the terminals on the inverter module side (female connector).
4. For each inverter module, measure from L32 (T2) to terminal 1. The reading must be <1 Ω.
5. For each inverter module, measure from L22 (S2) to terminal 2. The reading must be <1 Ω.

F10–F13 enclosure sizes

Some inverter modules are connected to S1 and T1, while other inverter modules are connected to S2 and T2.

1. Unplug the 10-pin connector from the top of each inverter module.
2. Verify that the 8-pin connector is plugged into the top of the inverter module and that the 12-pin connector is plugged into the top of the rectifier module.
3. Read the terminals on the inverter module side (female connector).
4. For each inverter module, measure from T1/T2 to terminal 1. The reading must be <1 Ω.
5. For each inverter module, measure from S1/S2 to terminal 2. The reading must be <1 Ω.

Incorrect reading

An incorrect reading makes it necessary to perform the following steps:

1. Perform the rectifier module soft charge fuse test. Refer to *chapter 8.4.2 Soft Charge Fuse Test*. If any soft charge fuses are open, replace the fuse and retest the fan continuity.
2. Check the wire harness between the rectifier module (12-pin connector) and each inverter module (8-pin connector). If the wire harness is the problem, replace and retest the fan continuity.
3. If the prior checks do not identify the problem, remove the faulty inverter module and check the connections between the connectors on the top of the module and the power card. If these connections are the problem, replace the faulty connectors and retest the fan continuity.

NOTICE

After this check, reconnect all connectors on top of the rectifier module and the inverter modules.

8.6.3 Fan Continuity Test 3

This test checks the fan transformer. There is 1 fan transformer for each inverter module.

For F8–F13 enclosure sizes, there is also a fan transformer inside the rectifier module. This transformer cannot be tested without removing the module from the frequency converter. The fan transformer inside the rectifier module has similar resistance readings.

T4/T5 frequency converters

1. Unplug the 10-pin connector on the top of each inverter module.
2. Read the terminals on the connector end of the wire harness (male connector).
3. For each fan transformer, measure between pins 1 and 2. The reading must be approximately 4 Ω.
4. For each fan transformer, measure between pins 1 and 7. The reading must be approximately 3 Ω.
5. For each fan transformer, measure between pins 2 and 7. The reading must be approximately 1 Ω.

T7 frequency converters

1. Unplug the 10-pin connector on the top of each inverter module.
2. Read the terminals on the connector end of the wire harness (male connector).
3. For each fan transformer, measure between pins 1 and 2. The reading must be approximately 7.4 Ω.
4. For each fan transformer, measure between pins 1 and 7. The reading must be approximately 3.6 Ω.
5. For each fan transformer, measure between pins 2 and 7. The reading must be approximately 3.2 Ω.

Incorrect reading

An incorrect reading indicates a defective fan transformer. Replace the fan transformer.

NOTICE

After this check, reconnect the 10-pin connector to the top of each inverter module.

8.6.4 Fan Continuity Test 4 (F1–F4 only)

This test checks the wiring between the inverter module and the rectifier cabinet door fans (F1–F4 only). All 3 door fans are controlled from inverter module number 2. For inverter module location, refer to *chapter 5.3.7 Module Layout*.

1. Unplug the 10-pin connector from the top of inverter module number 2.
2. Read the terminals on the connector end of the wire harness (male connector).
3. Measure between pins 5 and 10. The reading must be approximately 25 Ω.

Incorrect reading

An incorrect reading can indicate a failed fan or a bad wire harness.

To check for a failed fan (all F-size enclosures)

1. Disconnect the wiring from the fan terminals.
2. Read across the fan terminals on each fan. The reading must be approximately 78 Ω.
3. Replace any defective fans and repeat the test.

NOTICE

After this check, reconnect the 10-pin connector on top of inverter module number 2.

8.6.5 Fan Continuity Test 5 (F1–F4 only)

This test checks the rectifier heat sink fan and the door fan in the options cabinet.

1. Unplug the 10-pin connector from the top of inverter module number 1.
2. Read the terminals on the connector end of the wire harness (male connector).
3. Measure between pins 5 and 10.
    - The reading for an F1 or F2 enclosure size (no option cabinet) must be approximately 21 Ω.
    - The reading for an F3 or F4 enclosure size (with option cabinet) must be approximately 15 Ω.

Incorrect reading

An incorrect reading can indicate a failed fan or a bad wire harness. The following steps are necessary to further identify the problem:

1. Perform the heat sink fan ohm test on the rectifier module.
2. If the frequency converter is an F3 or F4 enclosure size (with option cabinet), perform the option cabinet door fan test.
3. If the previous checks do not identify the problem, remove the faulty rectifier module and check the connections between the connectors on the top of the module and the power card. If these connections are the problem, replace the faulty connectors and retest the fan continuity.
4. If none of the checks identify the problem, replace the wire harness between inverter module number 1 and the rectifier module.

NOTICE

After this check, reconnect the 10-pin connector on top of inverter module number 1.

8.6.6 Fan Continuity Test 6

This test checks the resistance of the heat sink fan on each module.

Rectifier module (F1–F4 only)

1. Unplug the 8-pin connector from the top of the rectifier module.
2. Read the terminals on the inverter module side (female connector).
3. For each rectifier module, measure between pins 1 and 4. The reading must be approximately 21 Ω.

Inverter module (all F-size enclosures)

1. Unplug the 10-pin connector from the top of each inverter module.
2. Read the terminals on the inverter module side (female connector).
3. For each inverter module, measure between pins 5 and 10. The reading must be approximately 21 Ω.

Incorrect reading

An incorrect reading indicates either a defective heat sink fan or defective wiring to the fan.

1. Remove the heat sink fan. Refer to *chapter 9.2.4 Heat Sink Fan Replacement*.
2. Make the following measurements on the connector leading to the fan.
3. Measure between pins 1 and 2. The reading must be approximately 21 Ω.
4. Measure between pins 1 and 3. The reading must be approximately 45 Ω.
5. Measure between pins 2 and 3. The reading must be approximately 68 Ω.
6. Measure between pins 1 and 4. Must read open.
7. Measure between pins 2 and 4. Must read open.
8. Measure between pins 3 and 4. Must read open.

An incorrect reading here indicates a failed fan. Replace the fan. Refer to *chapter 9.2.4 Heat Sink Fan Replacement*.

If the readings are OK, the problem is the wire harness inside the module. Remove the faulty module and replace the fan wire harness.

NOTICE

After this check, reconnect all connectors on top of the rectifier module and the inverter modules.

8.6.7 Fan Continuity Test 7 (F3–F4 only)

This is an additional test for F3–F4 enclosure sizes. This test checks the wiring between the rectifier module and the option cabinet door fan.

1. Unplug the 8-pin connector from the top of the rectifier module.
2. Read the terminals on the connector end of the wire harness (male connector).
3. Measure between pins 5 and 8. The reading must be approximately 78 Ω.

Incorrect reading
Incorrect reading can indicate a failed fan or a bad wire harness. Measure the fan resistance at the option cabinet door fan. If bad, replace the door fan. If good, replace the wire harness.

NOTICE

After this check, reconnect the 8-pin connector on top of the rectifier module.

8.7 Dynamic Test Procedures

The test procedures in this section are numbered for reference only and do not need to be performed order. Perform tests only as necessary.

8.7.1 Split Bus Mode

In the split bus mode, the DC bus in each module is split into 2 parts. One part connects to the DC bus and power card to provide low-voltage power for the SMPS. The other part provides low-voltage power to the DC capacitors and the output IGBTs for test purposes. For more information, refer to *chapter 11.1.1 Split Bus Supply*.

8.7.2 Warnings

⚠WARNING

SHOCK HAZARD AND RISK OF INJURY

Never disconnect the input cabling to the frequency converter with power applied. Contact with powered components can result in death or serious injury.

⚠WARNING

HIGH VOLTAGE

Frequency converters 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.**

⚠WARNING

SHOCK HAZARD AND RISK OF INJURY

For dynamic test procedures, mains input power is required, and all devices and supplies connected to mains are energized at rated voltage. Contact with powered components can result in death or serious injury.

- **Do not touch energized parts of the frequency converter when connected to mains.**

8.7.3 No Display Text

A frequency converter with no display can result from several causes. If the display is dark and the green power-on indicator light is not lit, proceed with the following tests.

8.7.4 Input Voltage Test

1. Apply power to frequency converter.
2. Use a digital volt-meter to measure input mains voltage between the frequency converter input terminals in turn:
   - 2a For F1–F4 enclosure sizes
     L1 to L2
     L1 to L3
     L2 to L3
   - 2b For F8–F13 enclosure sizes
     L11 to L12
     L21 to L22
     L31 to L32

For 380–480 V frequency converters, all measurements must be within the range of 342–528 V AC. Readings of less than 342 V AC indicate problems with the input AC mains voltage. For 525–690 V frequency converters, all measurements must be within the range of 446–759 V AC. Readings of less than 446 V AC indicate problems with the input AC mains voltage.

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

Danfoss calculates line imbalance per an IEC specification.

$$\text{Imbalance} = 0.67 \times (V_{max} - V_{min}) / V_{avg}$$

For example, if 3-phase readings were taken and the results were 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 frequency converter can operate at higher line imbalances, the lifetime of components, such as DC bus capacitors, is shortened.

Incorrect reading

An incorrect reading requires that the main supply is further tested for:

- Open (blown) input fuses or tripped circuit breakers

NOTICE

Open (blown) input fuses or tripped circuit breakers usually indicate a more serious problem. Before replacing fuses or resetting breakers, perform static tests.

- Open disconnects or line side contactors
- Problems with the power distribution system

8.7.5 Basic Control Card Voltage Test

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

Incorrect reading

An incorrect reading can indicate that a fault in the customer connections is loading down the supply. Unplug the terminal strip and repeat the test. Remember to check the customer connections.

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).

Incorrect reading

An incorrect reading can indicate that a fault in the customer connections is loading down the supply. Unplug the terminal strip and repeat the test. Remember to check the customer connections.

Correct reading

A correct reading of both control card voltages indicates that the LCP or the control card is defective. Replace the LCP with a known good one. If the problem persists, replace the control card.

8.7.6 DC Undervoltage Test

The soft charge circuit initially charges the DC bus. If the DC bus voltage is below normal, it indicates that either the mains voltage is out of tolerance or the soft charge circuit is restricting the DC-bus from charging. Ensure that the mains voltage is correct by conducting the input voltage test.

If excessive input power cycling has occurred, the PTC resistors on the soft charge card can be restricting the bus from charging. If so, expect to read a DC-bus voltage in the area of 50 V DC. Refer to *chapter 8.7.4 Input Voltage Test*.

8.7.7 Input Imbalance of Supply Voltage Test

Theoretically, the current drawn on all 3 input phases must be equal. Some imbalance can be seen, however, due to variations in the phase-to-phase input voltage and single-phase loads within the unit.

A current measurement of each phase reveals the balanced condition of the line. To obtain an accurate reading, run the frequency converter at its rated load or at a load of not less than 40%.

1. Perform the input voltage test. Refer to *chapter 8.7.4 Input Voltage Test*. Voltage imbalances result in a corresponding current imbalance.
2. Apply power to the frequency converter and place it in run.
3. Using a clamp-on amp meter, read the current on each of 3 input lines.
   Typically, the current does not vary from phase-to-phase by more than 5%. Greater current variation indicates a problem with the mains supply or a problem within the frequency converter.
4. Remove power to frequency converter and let the capacitors discharge fully.
5. Swap the phase that appears to be incorrect with 1 of the other 2 phases. If all 3 phases are different from one another, swap the phase with the highest current with the phase with the lowest current.
6. Reapply power to the frequency converter and place it in run.
7. Repeat the current measurements.

If the imbalance of supply current moves when swapping the leads, then the mains supply is suspect. Otherwise, it can indicate a problem with the gating of the SCR. This problem can be due to a defective SCR. It can also be caused by problems in the gate signals from the power card to the module, including the power card wire harness to the SCR gates. Further tests on the proper gating of the SCRs require an oscilloscope equipped with current probes.

8.7.8 Input Waveform Test

Testing the current waveform on the input of the frequency converter 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 1 of the SCR/diode modules becomes defective or the gate signal to the SCR is lost, the frequency converter responds the same as losing 1 of the phases.

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

Under normal operating conditions, the waveform of a single phase of input AC voltage to the frequency converter appears as in *Illustration 8.8*.

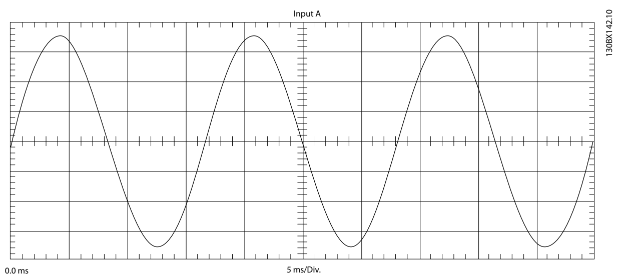


Illustration 8.8 Normal AC Input Voltage Waveform

The waveform shown in *Illustration 8.9* shows the input current waveform for the same phase as in *Illustration 8.8* while the frequency converter is running at 40% load. The 2 positive and 2 negative jumps are typical of any 6 diode bridge. It is the same for frequency converters with SCR/diode modules.

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

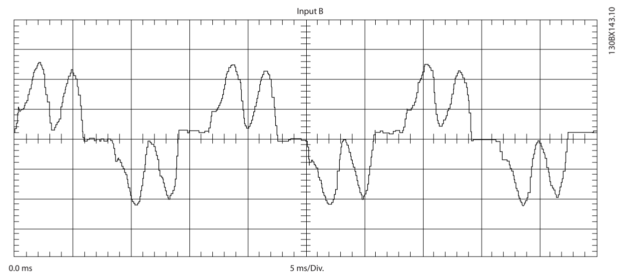


Illustration 8.9 AC Input Current Waveform with Diode Bridge

With a phase loss, the current waveform of the remaining phases resembles *Illustration 8.10*.

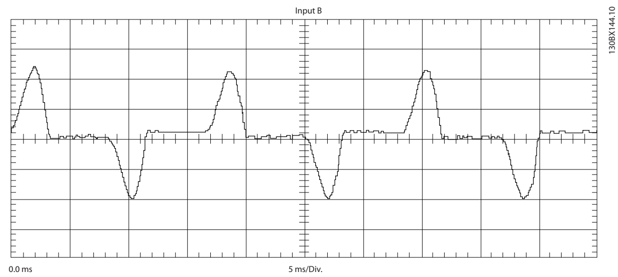


Illustration 8.10 Input Current Waveform with Phase Loss

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 in the frequency converter. Perform the soft charge and rectifier tests. Refer to *chapter 8.4 Static Tests for Rectifier Module*.

8.7.9 Gate Signal Test

1. Remove the output bus bars from all inverter modules.
2. Power the frequency converter in split bus mode. Refer to *chapter 8.7.1 Split Bus Mode*.
3. Connect a 24 V DC supply to the (+) and (-) DC bus bars.
4. Connect the signal test board to the 30-pin connector at the top of the inverter module.
5. Apply a run command and a speed command above 0 RPM. (Local start mode is sufficient).
6. Connect the common lead of an oscilloscope to terminal 4 of the signal test board. Observe the waveform on terminals 25–30 in turn. Each reading must appear similar to *Illustration 8.11*.
7. Repeat this procedure for each inverter module.

8

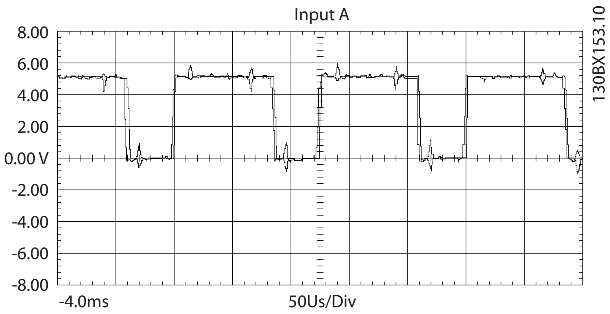


Illustration 8.11 Gate Signal Waveform

Incorrect reading
If 1 or more of the IGBT gate signals are missing, it indicates a faulty connection in the ribbon cable from the control card to the MDCIC, or from the MDCIC to the inverter module. Check the cables and replace if necessary. If all 6 signals are missing, replace the control card.

Conduct the IGBT switching test with the frequency converter powered as in this procedure.

8.7.10 IGBT Switching Test

1. Power the unit in the split bus mode as described in the gate signal test procedure.
2. Observe the phase-to-phase output waveforms on all 3 phases with the oscilloscope.
3. All waveform readings must appear similar to *Illustration 8.12*.
4. Repeat this procedure for all inverter modules.

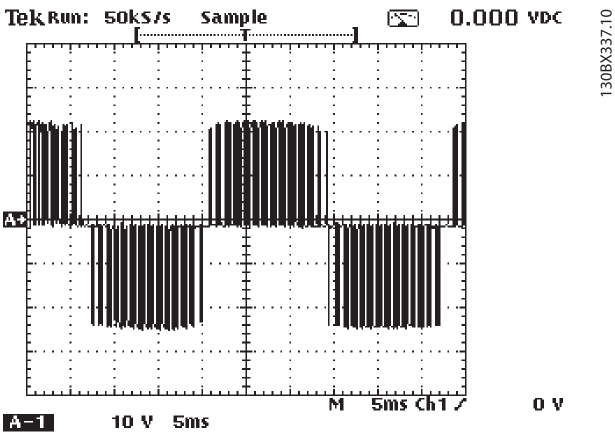


Illustration 8.12 Output Waveform

Incorrect reading
An incorrect reading indicates that an IGBT or gate driver card is defective. Check all IGBT modules for signs of damage. If no damage is found, replace gate driver card.

8.7.11 Current Sensor Test

1. Apply power to the unit.
2. Ensure that the following parameter set-ups that create a holding torque while at 0 speed are disabled:
    - Motor check
    - Premagnetizing
    - DC hold
    - DC brake

    If the parameters are not disabled, the current shown exceeds 1–2 A.
3. Run frequency converter with a 0 speed reference.
4. Read the output current in the display. It must indicate approximately 1–2 A.

Incorrect reading

If the current is greater than 1–2 A and a current producing parameter is not active, perform the following steps:

1. Remove power from frequency converter.
2. Ensure that the DC bus is fully discharged.
3. Remove output motor bus bars from each inverter module.
4. Apply power to frequency converter.
5. Run frequency converter with a 0 speed reference.
6. Read the output current in the display. The display must indicate less than 1 A.

An incorrect reading indicates that further tests of the current feedback signals are required. Refer to *chapter 8.7.12 Testing Current Feedback with the Signal Test Board*.

8.7.12 Testing Current Feedback with the Signal Test Board

1. Remove power to the frequency converter.
2. Ensure that the DC bus is fully discharged.
3. Install the signal test board into the 30-pin test connector socket in inverter 1.
4. Apply power to the frequency converter.
5. Using a DVM, connect the negative (-) meter lead to terminal 4 (common) of the test board.
6. Ensure that the following parameter set-ups that create a holding torque while at 0 speed are disabled:

- Motor check
- Premagnetizing
- DC hold
- DC brake

If the parameters are not disabled, the current shown exceeds 1–2 A.

7. Run the frequency converter with a 0 speed reference.
8. In turn, measure AC voltage at terminals 1, 2, and 3 of the signal test board. These terminals correspond with current sensor outputs U, V, and W, respectively. Expect a reading near 0 V but no greater than 15 mV.
9. Repeat the procedure for each inverter module in the frequency converter.

Incorrect reading
A current sensor feedback signal here must read approximately 400 mV at 100% frequency converter load. Replace the corresponding current sensor if the reading is greater than 15 mV. Refer to *chapter 10.1.5 Current Sensor Replacement*.

8.7.13 Input Terminal Signal Tests

The presence of signals on either the digital or analog input terminals of the frequency converter can be verified on the frequency converter 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.

Digital inputs
Show 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 side of the display. A 1 indicates the presence of a signal, which means the logic is true and the input is on.

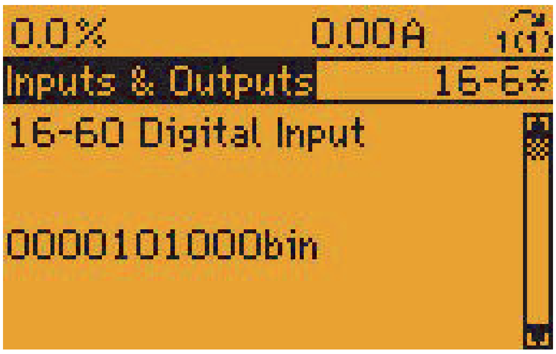


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Illustration 8.13 Digital Inputs Display

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

- External control wiring to the frequency converter
- 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 frequency converter, or from an external supply. If an external supply is used, reference the common of the supply to terminal 20.

Check for an internal power supply

1. 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.

Check the individual inputs if *parameter 5-00 Digital I/O Mode* is PNP

1. Connect the (-) negative meter lead to terminal 20.
2. 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.

Check the individual inputs if *parameter 5-00 Digital I/O Mode* is NPN

1. Connect the (-) negative meter lead to terminal 20.
2. 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.

Analog inputs
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.

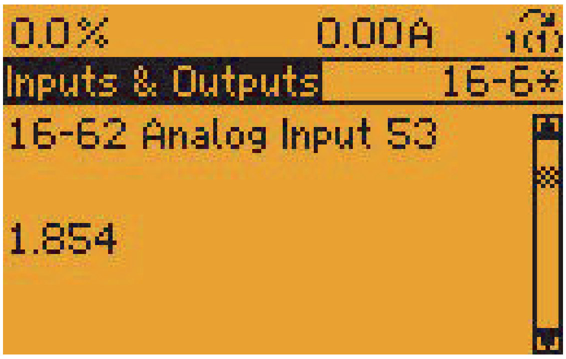

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Illustration 8.14 Analog Inputs Display

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

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

Verify the control voltage supply

1. 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 frequency converter. *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 frequency converter and change switches S201 and S202.

Check the individual inputs if configured for voltage

1. Connect the (-) negative meter lead to terminal 55.
2. 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.

Check the individual inputs if configured for current

1. Connect the (-) negative meter lead to terminal 55.
2. 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.

NOTICE

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

8.7.14 Output Imbalance of Motor Supply Voltage Test

Before checking output imbalance, make sure to test the inverter module. Refer to *chapter 8.5 Static Tests for Inverter Module*. When testing the phase-to-phase output, both voltage and current are monitored. Perform the initial test with the motor connected and running its load.

NOTICE

FALSE OUTPUT READINGS

Use an analog voltmeter for monitoring output voltage. Digital voltmeters are sensitive to waveform and switching frequencies and commonly return erroneous readings.

If the voltage is balanced, but the current is not, the motor is drawing an uneven load. This can be caused by the following:

- Defective motor
- Poor connection in the wiring between the frequency converter and the motor
- Defective motor overload

If both the output current and voltage are unbalanced, the frequency converter does not work properly. This can be caused by the following:

- Defective power card
- Improper connection of the output circuitry

If suspect readings are recorded, perform the following steps:

1. Stop the motor and wait until the motor has stopped rotating.
2. Set the frequency converter to coast.
3. Disconnect the motor cables.

4. Use a voltmeter to measure AC output voltage at the frequency converter motor terminals U, V, and W. Measure phase-to-phase, checking U to V, then U to W, and then V to W.
   All 3 readings must be within 8 V AC of each other. The actual value of the voltage depends on the speed at which the frequency converter runs. The V/Hz ratio is relatively linear (except in VT mode). For example, if the rated motor frequency is 60 Hz, the voltage should be approximately equal to the applied mains voltage. At 30 Hz, it is about half of that. This also applies to any other speed selected. The exact voltage reading is less important than balance between phases.
5. Reconnect the motor to the frequency converter.
6. Use a clamp-on ammeter to monitor current on the 3 output phases at the motor terminals U, V, and W. An analog ammeter is recommended. To achieve an accurate reading, run the frequency converter above 40 Hz.
7. Check that the output current is balanced from phase-to-phase, with no phase varying more than 2–3%.
   - 7a If each phase is within 2–3%, the frequency converter is balanced.
   - 7b If any phase is above 3%, disconnect the motor cables and repeat the voltage balance test.
     If a voltage imbalance is detected with the motor cables disconnected, then either the IGBT or gate driver card is defective. Refer to *chapter 8.7.10 IGBT Switching Test* and *chapter 8.7.9 Gate Signal Test*.

8.8 Module-level Static Test Procedures

8.8.1 Inverter Module

Heat sink temperature sensor test
Remove the inverter module from the frequency converter. Refer to *chapter 9.2.6 Inverter Module Replacement*.

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

On the gatedrive 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/under temperature conditions.

1. Set the ohmmeter to read Ω.
2. Unplug connector MK100 on the gatedrive card and measure the resistance across the cable leads.

The relationship between temperature and resistance is non-linear. At 25 °C (77 °F), the resistance is approximately 5 kΩ. At 0 °C (32 °F), the resistance is approximately 13.7 kΩ. At 60 °C (140 °F), the resistance is approximately 1.5 kΩ. The higher the temperature, the lower the resistance.

Incorrect reading
An incorrect reading indicates a faulty heat sink temperature sensor. Replace the sensor.
Refer to *chapter 10.1.7 IGBT Module Replacement*.

8.8.2 Rectifier Module

Heat sink temperature sensor test
Remove the rectifier module from the frequency converter. Refer to *chapter 9.2.5 Rectifier Module Replacement*.

The temperature sensor is an NTC (negative temperature coefficient) device. As a result, high resistance means low temperature. As temperature decreases, resistance increases. The power card reads the resistance of the NTC sensor to regulate fan speed and to monitor for overtemperature conditions.

1. Set the ohmmeter to read Ω.
2. Based on the frequency converter model, perform the following step:
   - 2a For F1–F4 and F10–F13 units, unplug connector MK103 on power card and measure across cable leads.
   - 2b For F8–F9 units, there are 2 sensors inside the module. Unplug connector MK102 on the MPIC card and measure across pins 1 and 5 for the first sensor and pins 2 and 6 for the second sensor.

The full range of the sensor is 787 Ω to 10 kΩ where 10 kΩ equals 25 °C (77 °F) and 787 Ω equals 95 °C (203 °F). The higher the temperature, the lower the resistance.

Incorrect reading
An incorrect reading indicates a faulty heat sink temperature sensor. Replace the sensor.
Refer to *chapter 10.2.9 Heat Sink Thermal Sensor Replacement*.

Soft charge rectifier test
The frequency converter contains either 1 or 2 rectifier modules depending on the enclosure size. Repeat the following test for each rectifier module and for each soft charge card inside the rectifier module.

8

NOTICE

SOFT CHARGE CARD LOCATIONS

F1/F3 and F8/F9 enclosure sizes contain 2 cards per rectifier. F2/F4 contain 3 cards per rectifier. F10/F11 contain 1 card per rectifier. F12/F13 contain 1 card in 1 rectifier and 2 cards in the other one.

1. Remove the rectifier module from the frequency converter. Refer to *chapter 9.2.5 Rectifier Module Replacement*.
2. Remove the power card mounting plate. Refer to *chapter 10.2.3 Power Card Mounting Plate Disassembly/Reassembly*.
3. Disconnect the connector MK3 from each soft charge card.

Since the rectifier test requires the soft charge resistor to be in the circuit, verify that the resistor is good before proceeding.

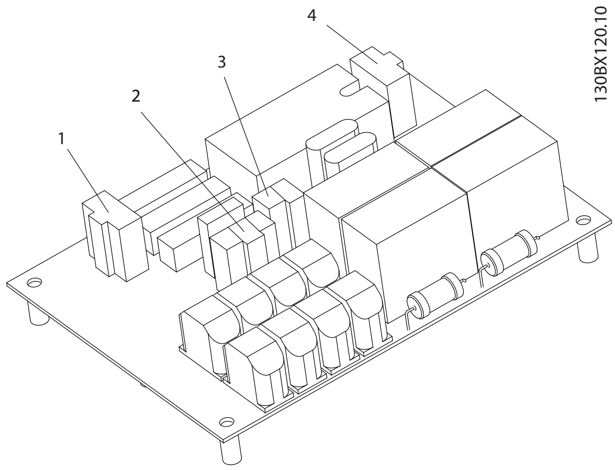
1. Measure the resistance between pins A and B of connector MK4 on the soft charge card. It must read 27 Ω (±10%) for 380–500 V frequency converters or 68 Ω (±10%) for 525–690 V frequency converters. If a reading falls outside this range, replace the soft charge resistor and then continue tests. Refer to *chapter 10.2.6 Soft Charge Resistor Replacement*.

If the resistor is defective and a replacement is not readily available, the remainder of the tests can be carried out by disconnecting the cable at connector MK4 on the soft charge card and placing a temporary jumper across pins A and B. This method provides a path for continuity for the remaining tests. For the following tests, set the meter to diode check or Rx100 scale.

2. Connect the negative (-) meter lead to the positive (+) MK3 (A) (DC output to DC bus), and connect the positive (+) meter lead to MK1 terminals R, S, and T in sequence. Each reading must show a diode drop.
3. Reverse meter leads with the positive (+) meter lead to the positive (+) MK3 (A). Connect the negative (-) lead to MK1 terminals R, S, and T in sequence. Each reading must show open.
4. Connect the positive (+) meter lead to the negative (-) MK3 (C). Connect the negative (-) meter lead to MK1 terminals R, S, and T in sequence. Each reading must show a diode drop.
5. Reverse the meter leads with the negative (-) meter lead to the negative (-) MK3 (C). Connect the positive (+) meter lead to MK1 terminals R, S, and T in sequence. Each reading must show open.
6. Remove any temporary jumpers.
7. Reconnect the MK3 on the soft charge card.

Incorrect reading

An incorrect reading indicates that the soft charge rectifier is faulty. Since the rectifier is not serviced as a component, replace the entire soft charge card. Refer to *chapter 10.2.4 Soft Charge Card Replacement*.



1	MK1
2	MK3
3	MK4
4	MK2
Softcharge card description: 380–480/500 V: Blue MOV with 8 PTCs 525–690 V: Red MOV with 6 PTCs	

Illustration 8.15 Soft Charge Card Connectors

8.9 System Test

After any repair to a frequency converter or testing of a frequency converter suspected of being faulty, ensure that all frequency converter circuitry is functioning properly by performing the following steps:

1. Perform visual inspection procedures as described in *chapter 6.4.1 Visual Inspection*.
2. Perform static test on the frequency converter as described in *chapter 8.4 Static Tests for Rectifier Module*, *chapter 8.5 Static Tests for Inverter Module*, and *chapter 8.8 Module-level Static Test Procedures*.
3. Remove the 3 output motor bus bars from each inverter module.
4. Connect a 610–800 V DC supply to the switch mode supply (SMPS) input to each module using the test cable (176F8766).
5. Apply power to the SMPS and check that the LCP display lights up properly. (The fans do not operate when powered in this manner.)

6. Give the frequency converter a run command (press [Hand on]) and slowly increase the reference (speed command) to approximately 40 Hz.
7. Using the signal test board (176F8437) and an oscilloscope, check the waveform at pins 25–30 with the scope referenced to pin 4. This procedure must be performed on each inverter module. Each waveform must approximate the example in *Illustration 8.16*.
8. Connect a 24 V DC supply to the DC bus of the frequency converter. This step can be done on the DC bus output of the rectifier module or the bus bars connecting to the top side of the DC fuses on any of the inverter modules.
9. Observe the phase-to-phase waveform on the output bus bars of each phase of each inverter module. This waveform must appear the same as the normal output waveform of a properly operating frequency converter, except that the amplitude is 24 V instead of the full output voltage of a normal frequency converter.
10. Press [OFF] on the LCP.
11. Disconnect power from both supplies and reinstall jumper connectors to the SMPS input plugs on all modules.
12. Reinstall the motor output bus bars on all inverter modules.
13. Apply AC power to the frequency converter.
14. Apply a start command to the frequency converter. Adjust the speed to a nominal level. Observe that the motor is running properly.
15. Using a clamp-on style current meter, measure the output current on each phase. All currents must be balanced.

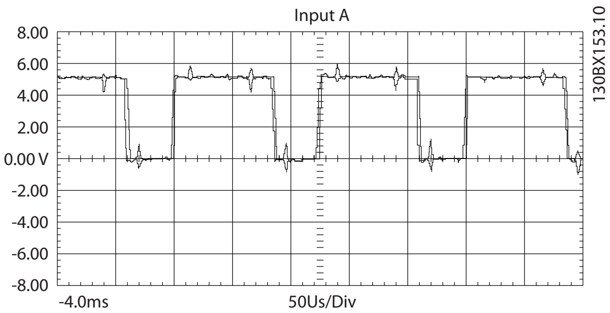


Illustration 8.16 System Test Waveform: 2 V/div 100us/div Run at 10 Hz

8

9 Top-level Component Disassembly/Reassembly

9.1 Before Proceeding

Review all safety warnings and cautions in *chapter 2.3 Safety Precautions*.

- DO NOT touch electrical parts of the frequency converter when connected to mains. Also make sure that other voltage inputs have been disconnected (linkage of DC intermediate circuit). There may be high voltage on the DC-link even when the indicator lights are turned off. Before touching any potentially live parts of the frequency converter, wait at least 40 minutes.
- Before conducting repair or inspection, disconnect mains.
- [Off] on the LCP does not disconnect mains.
- During operation and while programming parameters, the motor may start without warning. Press [Stop] when changing data.
- When operating on a PM motor, disconnect motor cable.

9.1.1 Top-Level Component Warning

WARNING

SHOCK AND INJURY HAZARD

Touching electrical parts of the frequency converter can be fatal even after the equipment has been disconnected from AC power. Perform the following steps before touching any internal components:

1. **Disconnect the mains power.**
2. **Disconnect the motor.**
3. **Disconnect any brake option.**
4. **Disconnect any load share/regeneration option.**
5. **Wait for the capacitors to discharge fully. Refer to the label on the front of the frequency converter door for the exact discharge time.**
6. **Ensure that the DC-bus capacitors have discharged fully by measuring the DC bus using a voltage meter.**

NOTICE

ELECTROSTATIC DISCHARGE (ESD)

Many electronic components within the frequency converter are sensitive to static electricity. Voltages so low that they cannot be felt, seen, or heard can be harmful to electronic components. Use standard ESD protective procedures whenever handling ESD sensitive components. Failure to conform to standard ESD procedures can reduce component life, diminish performance, or completely destroy sensitive electronic components.

9.1.2 Circuit Breaker or Disconnect Switch

WARNING

SHOCK AND INJURY HAZARD

The following options are powered before the optional circuit breaker or disconnect. Even with the circuit breaker or disconnect in the OFF position, mains voltage is still present inside the frequency converter enclosure.

Failure to turn off the main service line/power to the frequency converter before working on the following options can result in death or serious injury:

- **Door interlock**
- **Space heater**
- **Cabinet light and outlet**
- **RCD monitor**
- **IRM monitor**
- **Emergency stop**
- **24 V DC customer supply**

NOTICE

If supplied with a circuit breaker or disconnect switch, the cabinet doors are interlocked. To open the cabinet doors, set the circuit breaker and disconnect switch to the OFF position.

NOTICE

Inverter units contain 2 or 3 inverter modules. Drawings in this section show units with 2 inverter modules. Changes in instructions for units with 3 modules are noted.

Item	Description
ESD protection kit	Wrist strap and mat
Metric socket set	7–19 mm
Socket extensions	100–150 mm (4 inch and 6 inch)
Magnetic sockets	–
Ratchet wrench	–
Torque wrench	Torque range 0.5–19 Nm (6–170 in-lb)
Torx driver set	T10–T50
Needle nose pliers	–
Screwdrivers	Standard and Phillips

Table 9.1 Tools Required for Service of Frequency Converter

Item	Description
Digital volt-ohm meter (PWM compatible)	• Rated for true RMS • Supports diode mode • Rated for the mains voltage of the frequency converter
Analog voltmeter	–
Oscilloscope	–
Clamp-on ammeter	Clamp-on ammeter rated for true RMS
Split bus supply	p/n 130B3146
Signal test board	p/n 176F8437
Signal test board extension	p/n 130B3147
Test cable	p/n 176F8766

Table 9.2 Instruments Recommended for Testing of Frequency Converter

9.1.3 Module Service Shelf

The rectifier and inverter modules weigh up to 136 kg (300 lb) each and require special handling. A service shelf (p/n 176F8835) is available from Danfoss to provide support of the modules during removal from the frequency converter. This shelf, or other suitable support equipment, is recommended.

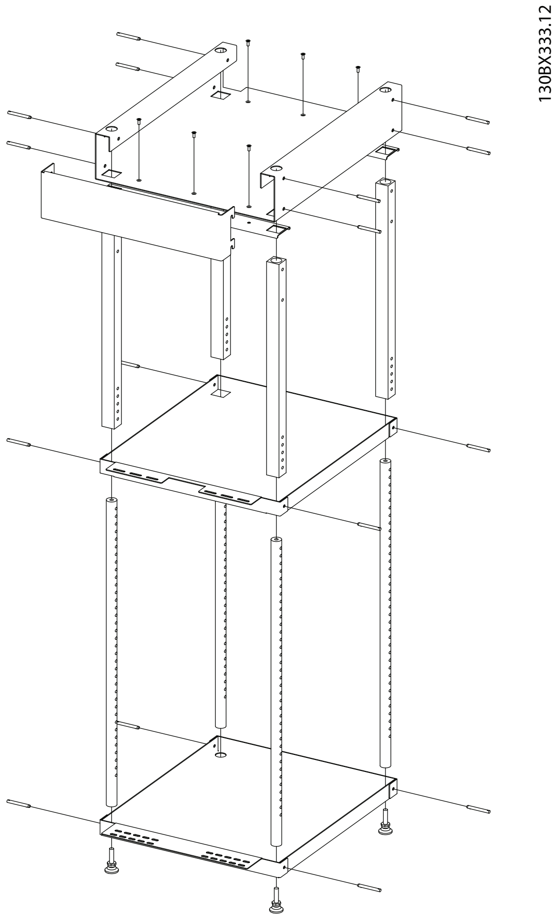


Illustration 9.1 Module Service Shelf Assembly Drawing

9

9.2 Disassembly/Reassembly

9.2.1 AC Line Input Fuse Replacement

AC main fuses are optional. If AC fuses are the only power option added to the frequency converter, they are located in the rectifier cabinet. If more power options are present, the AC fuses are located in the options cabinet.

Disassembly

AC fuses located in the rectifier cabinet (F1 and F2 enclosures)

1. Remove bottom safety cover from the rectifier cabinet.
2. Remove hex bolts (8 mm) securing the fuses in place. Refer to *Illustration 9.2*.
   Remove fuses sequentially, front to back. If only the fuse located in the back must be replaced, remove the front and middle fuses to gain access to the back fuse. If more access is necessary, the left-most inverter module can be removed from the inverter cabinet. Refer to *chapter 9.2.6 Inverter Module Replacement*.

AC fuses located in options cabinet

1. Remove covers from the options cabinet to access the fuses.
2. Remove hex bolts (8 mm) securing the fuses in place. Refer to *Illustration 9.3*.

Reassembly

Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

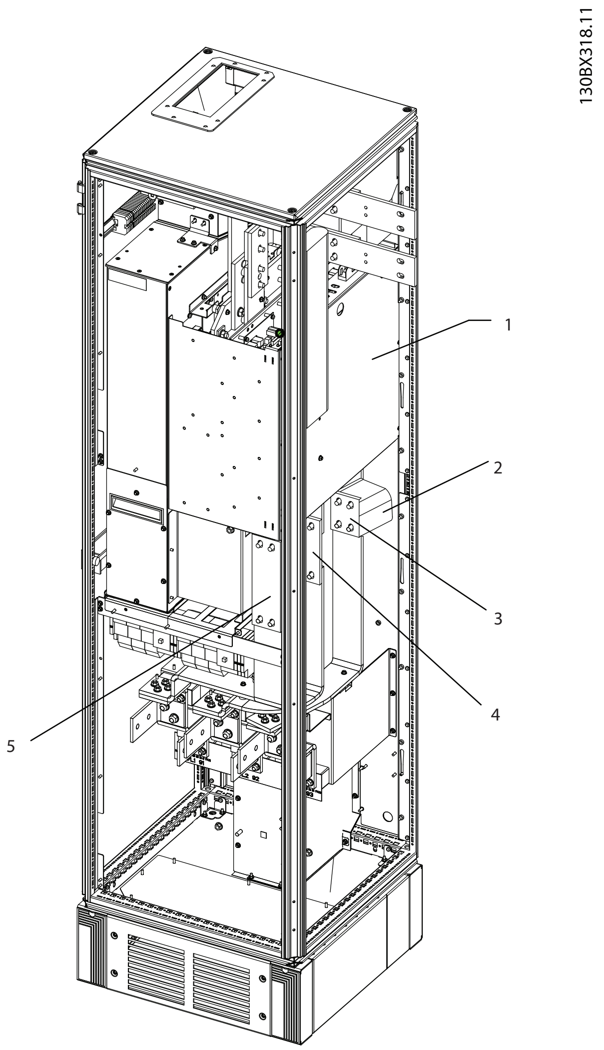
AC fuses located in the rectifier cabinet (F1 and F2 enclosures)

1. Install new fuses in the same order as they were removed.
2. Reinstall hex bolts (8 mm) securing the fuses in place. Refer to *Illustration 9.2*.
3. Reinstall bottom safety cover onto the rectifier cabinet.

AC fuses located in options cabinet

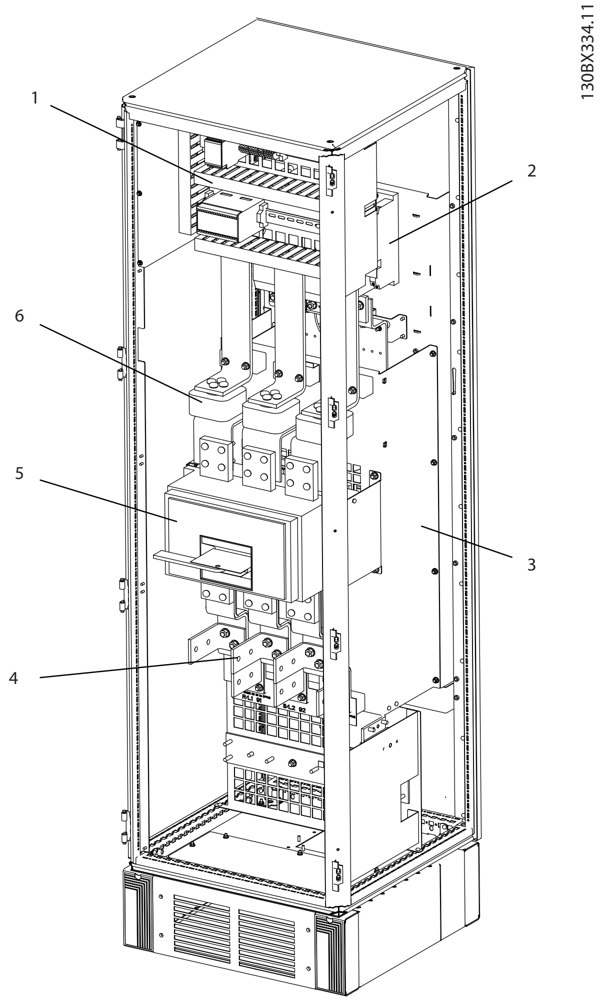
1. Install new fuses.
2. Reinstall hex bolts (8 mm) securing the fuses in place. Refer to *Illustration 9.3*.
3. Reinstall covers onto the options cabinet.

9



1	Rectifier module
2	AC mains input fuse
3	Back AC fuse mounting plate (T)
4	Middle AC fuse mounting plate (S)
5	Front AC fuse mounting plate (R)

Illustration 9.2 AC Fuses Located in the Rectifier Cabinet (F1 and F2 only)



1	Monitoring options (RCD, IRM, Pilz relay)
2	Contactor
3	RFI filter
4	Mains AC power input terminals
5	Circuit breaker or disconnect
6	AC mains/line fuses

Illustration 9.3 AC Fuses Located in the Options Cabinet (F3 and F4 shown)

9

9.2.2 DC Link Fuse Replacement

Each inverter contains 2 DC link fuses, which are on the top of the inverter.

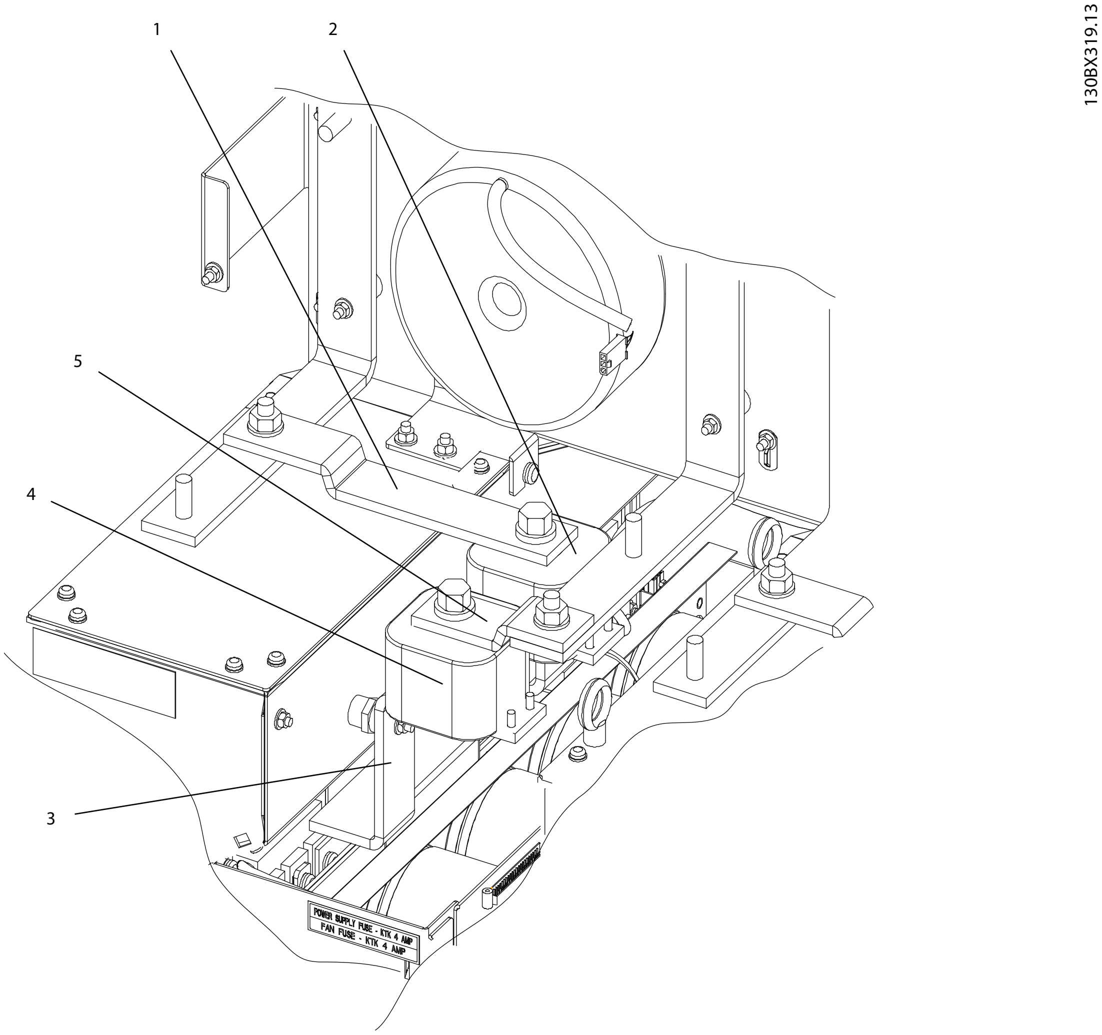
Disassembly

1. Remove covers from the inverter cabinet.
2. Remove the bus bars securing the top of fuses by removing attaching hex bolts (18 mm).
3. Remove hex bolts (18 mm) securing the bottom of the fuses. Refer to *Illustration 9.4*.

Reassembly

Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Install the fuses.
2. Reinstall hex bolts (18 mm) securing the bottom of fuses. Refer to *Illustration 9.4*.
3. Reinstall the bus bars securing the top of fuses with the attaching hex bolts (18 mm).
4. Reinstall covers onto the inverter cabinet.



1	Top (-) DC link fuse bus bar	4	(+) DC link fuse (none in F8/F9 enclosures)
2	(-) DC link fuse (none in F8/F9 enclosures)	5	Top (+) DC link fuse bus bar
3	Bottom (+) DC link fuse bus bar		

Illustration 9.4 DC Link Fuses on Top of Inverter

9.2.3 Door Fan Replacement

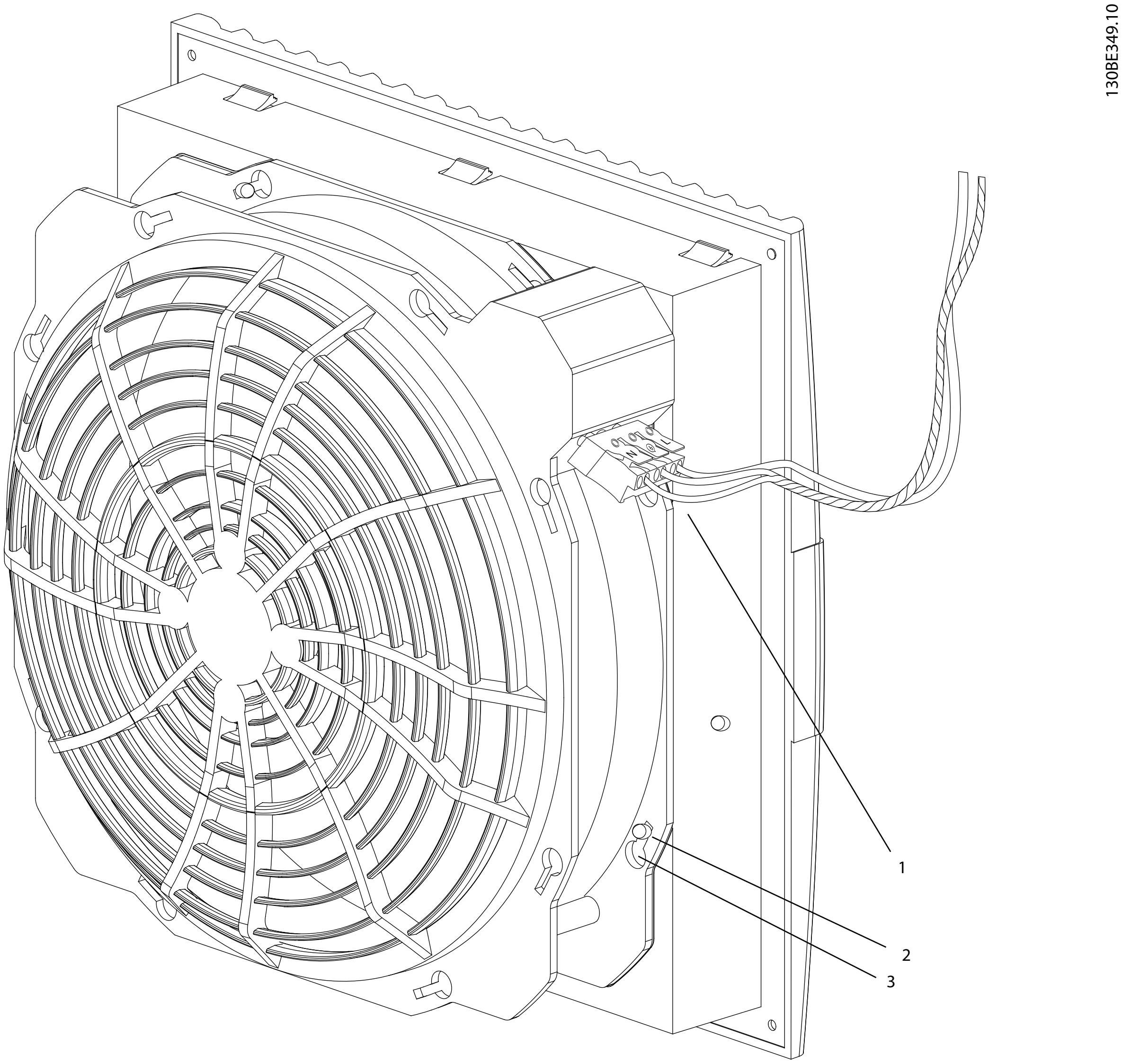
Door fans are in the top of the cabinet doors.

Disassembly

1. Unplug the electrical connector.
   Refer to *Illustration 9.5*.
2. Remove the fan by twisting the fan assembly counterclockwise so the widest part of the fastener opening moves over the plastic stud. Pull the fan off the door.

Reassembly

1. Center the widest part of the fastener opening on the plastic stud and twist the fan assembly clockwise to lock it in place.
2. Plug in the electrical connector.



1	Electrical connector	3	Fastener opening
2	Plastic stud		

Illustration 9.5 Door Fan Assembly Detail

9

9.2.4 Heat Sink Fan Replacement

There is 1 heat sink fan inside the bottom of each rectifier and inverter module. Refer to *Illustration 9.6*.

Disassembly

1. Remove access panel by removing 6 nuts (8 mm).
2. Unplug the fan electrical connector and remove 2 nuts (10 mm) securing the fan in place.

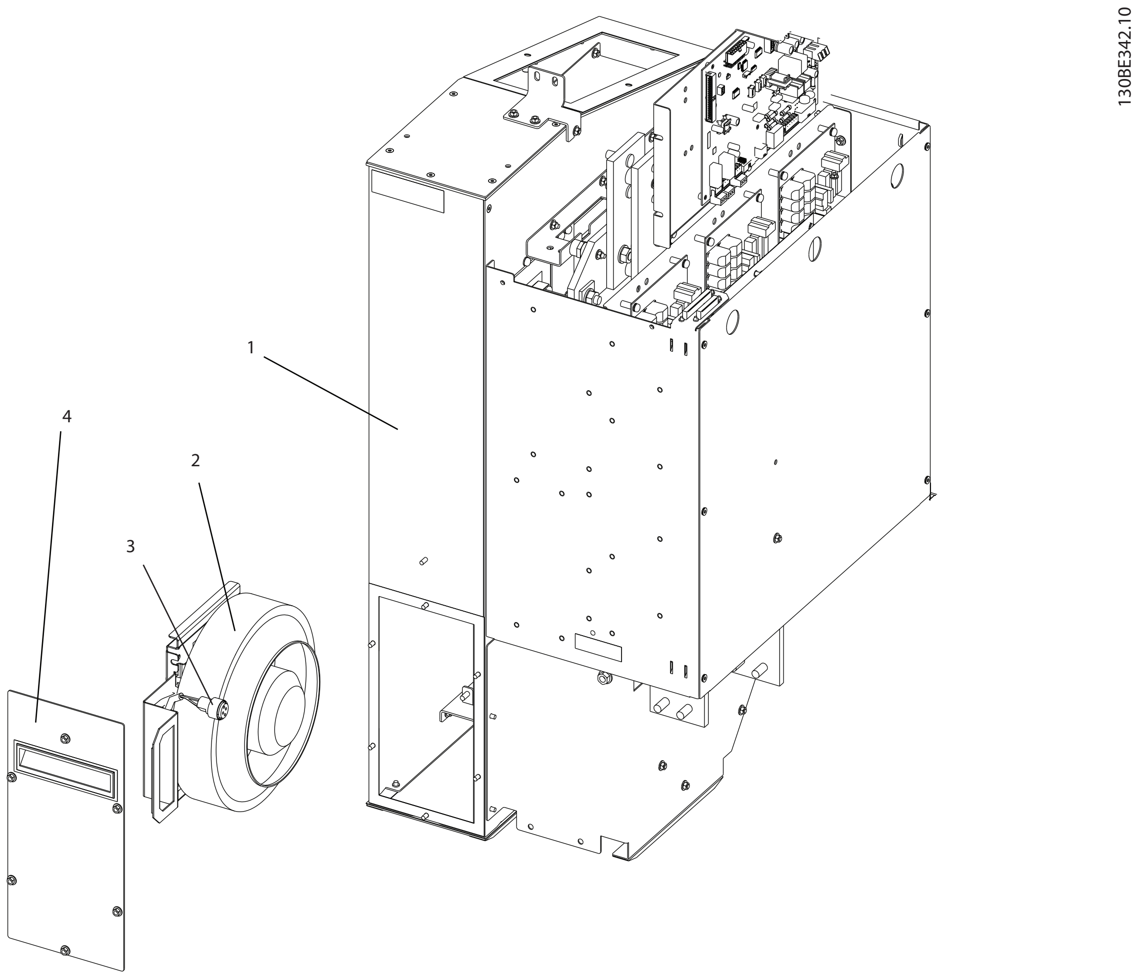
Reassembly

NOTICE

The fan plug fits only 1 way. However, if too much force is used, the plug can be forced the wrong way.

Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Secure the fan in place using 2 nuts (10 mm).
2. Reconnect the electrical connector.
3. Secure the access panel using 6 nuts (8 mm).



1	Module/heat sink	3	Connector
2	Fan	4	Access panel

Illustration 9.6 Removing Heat Sink Fan

9.2.5 Rectifier Module Replacement

⚠CAUTION

HEAVY WEIGHT

The rectifier module weighs 136 kg (300 lb). For use in lifting the rectifier, 4 eye bolts and washers are stored at the left bottom side of the rectifier cabinet. If required, attach bolts to holes provided at top of rectifier module. Failure to use some method of support while removing or installing the module can result in injury.

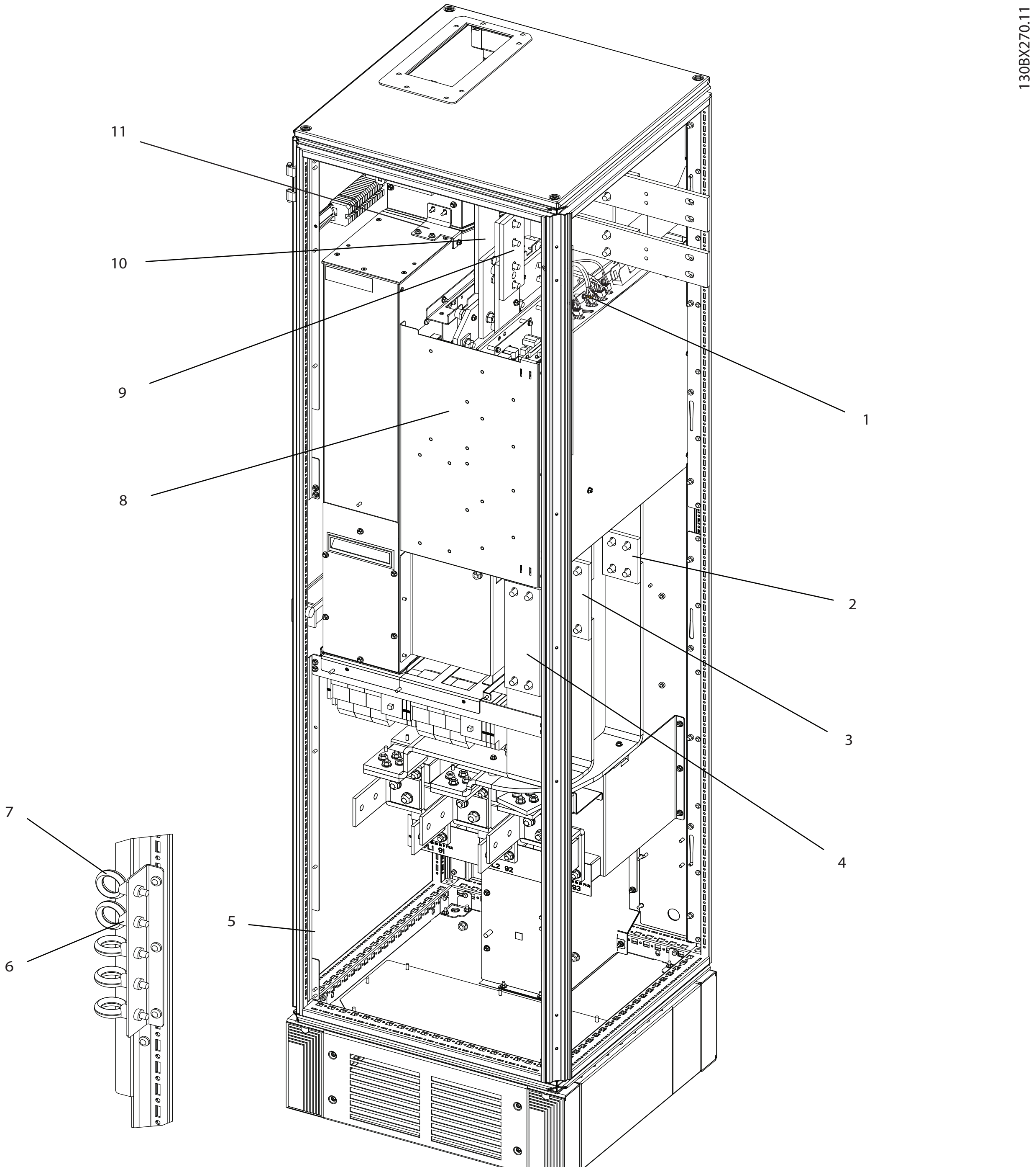
Disassembly

1. Remove center mounted safety cover from rectifier module by removing nuts (8 mm).
2. Remove top mounted safety cover from rectifier module by removing nuts (8 mm).
3. Remove DC bus bars.
   - 3a For F1–F4 and F10–F14 enclosures, remove the 2 DC bus bars from the top of the rectifier by removing the 4 nuts (17 mm) that secure each bus bar (2 at each end of bus bar).
   - 3b For F8–F9 enclosures, remove the 4 DC bus bars from the top of the rectifier by removing the 4 nuts (17 mm) that secure each bus bar (2 at each end of bus bar).
4. Remove the AC input power bus bars.
   - 4a For F1–F4 and F10–F14 enclosures, remove the 3 AC input power bus bars in order to free the module for removal. Refer to *Illustration 9.7*. The bus bars are stacked one behind the other. Four nuts (17 mm) secure each bus bar.
   - 4b For F8–F9 enclosures, remove the 6 AC input power bus bars to free the module for removal. Refer to *Illustration 9.7*. The bus bars are stacked one behind the other. Four nuts (17 mm) secure each bus bar.
5. Disconnect the 4 white connectors from the top of the rectifier module. Note that each connector is a different size for reassembly.
6. Remove the 2 nuts (10 mm) from the bracket at the back of the rectifier. The bracket secures the module to the cabinet.
7. Provide sufficient mechanical support to withstand the weight of the rectifier. Withdraw the rectifier from the cabinet.

Reassembly

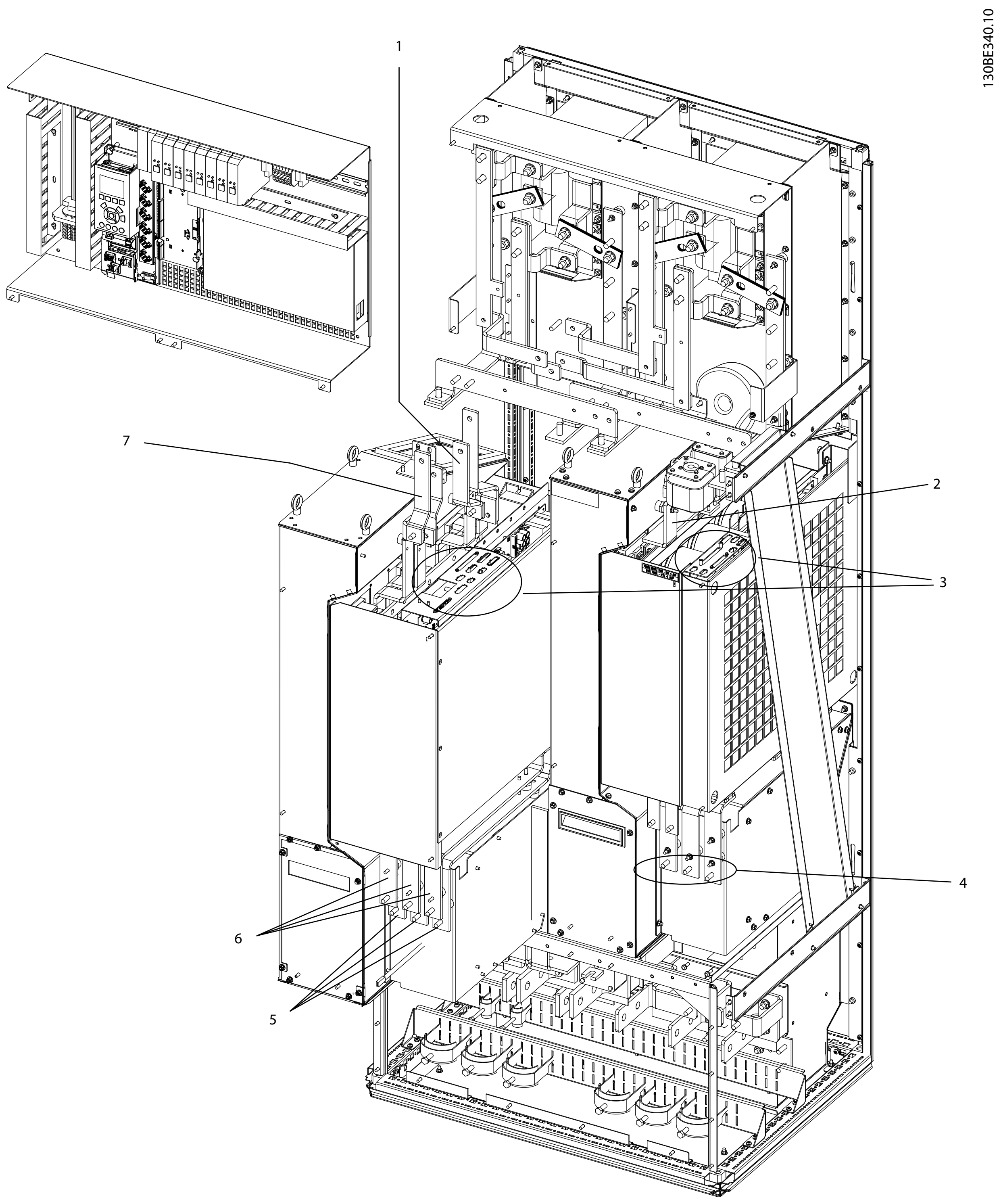
Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Using sufficient mechanical support to withstand the weight of the rectifier, place the rectifier into the cabinet.
2. Secure the module to the cabinet bracket using 2 nuts (10 mm).
3. Reconnect the 4 white connectors to the rectifier module. Note that each connector is a different size for reassembly.
4. Reinstall the 3 AC input power bus bars using 4 nuts (17 mm) per bus bar. Refer to *Illustration 9.7*. The bus bars are stacked one behind the other.
5. Reinstall the 2 DC bus bars to top of the rectifier using 4 nuts (17 mm) per bus bar.
6. Reinstall the top mounted safety cover to the rectifier module using nuts (8 mm).
7. Reinstall the center mounted safety cover to the rectifier module using nuts (8 mm).



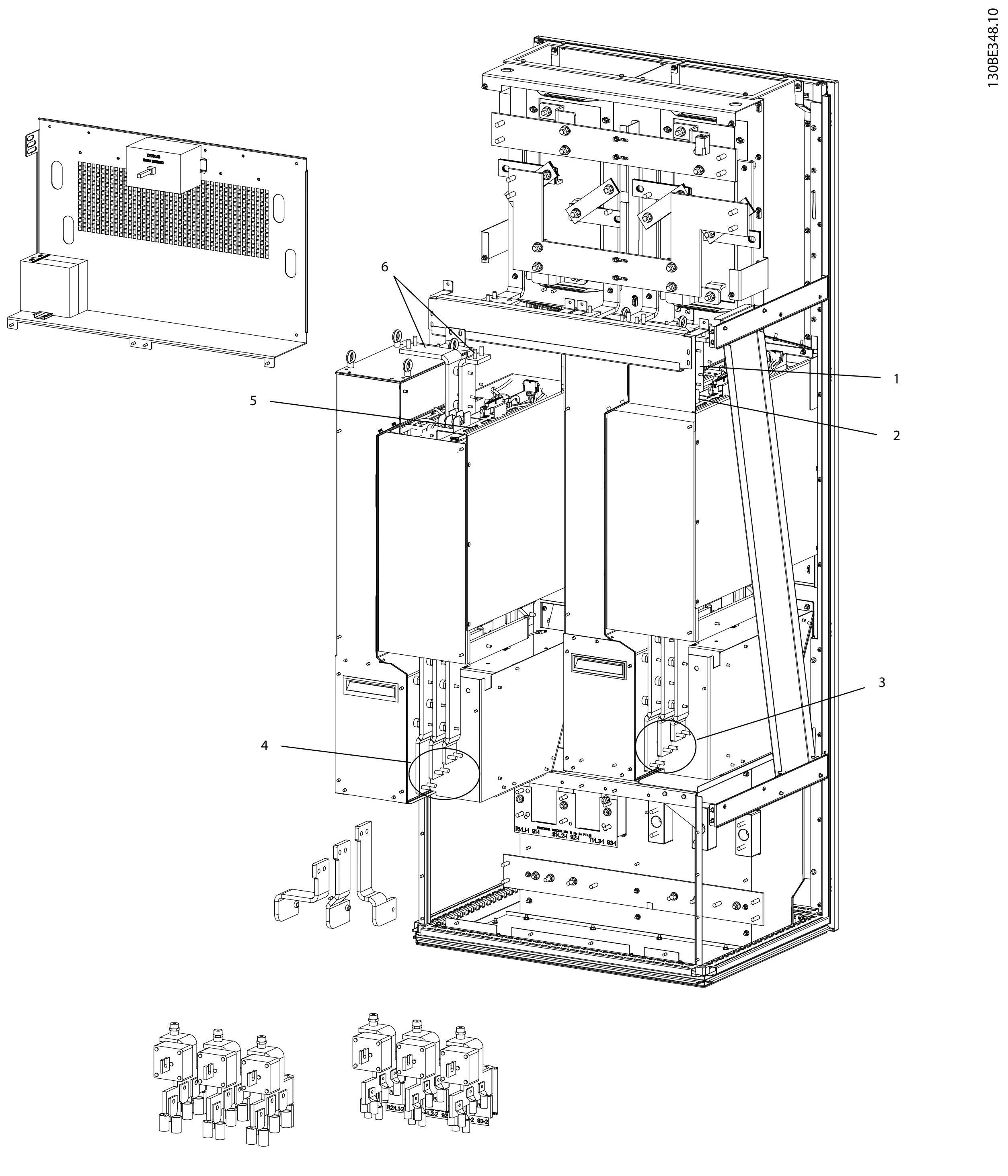
1	Connectors	7	Eye bolt
2	Back AC input power bus bar	8	Rectifier module
3	Middle AC input power bus bar	9	DC bus bar
4	Front AC input power bus bar	10	DC bus bar
5	Eye-bolt location	11	Mounting bracket
6	Eye-bolt washer		

Illustration 9.7 F1–F4 Rectifier Cabinet Detail



1	DC bus bar (rectifier 2)	5	Mains input
2	DC bus bar	6	Mains input
3	Signal plug connectors	7	DC bus bar (rectifier 1)
4	Motor output		

Illustration 9.8 F8–F9 Rectifier Cabinet Detail



1	DC bus bar (module 2)	4	Mains input (module 1)
2	Signal plug connectors (module 2)	5	Signal plug connectors (module 1)
3	Mains input (module 2)	6	DC bus bar (module 1)

Illustration 9.9 F10–F13 Rectifier Cabinet Detail

9.2.6 Inverter Module Replacement

NOTICE

F1–F4 BUILD DATES

For the F1-F4 enclosure sizes, the bus bar configuration that connects to the fuse differs according to the build date. To identify the build date, refer to *Illustration 3.1*.

CAUTION

HEAVY WEIGHT

The inverter module weighs 136 kg (300 lb). For use in lifting the inverter, 4 eye bolts and washers are stored at the left bottom side of the inverter cabinet. If required, attach bolts to holes provided at top of inverter module. Failure to use some method of support while removing or installing the module can result in injury.

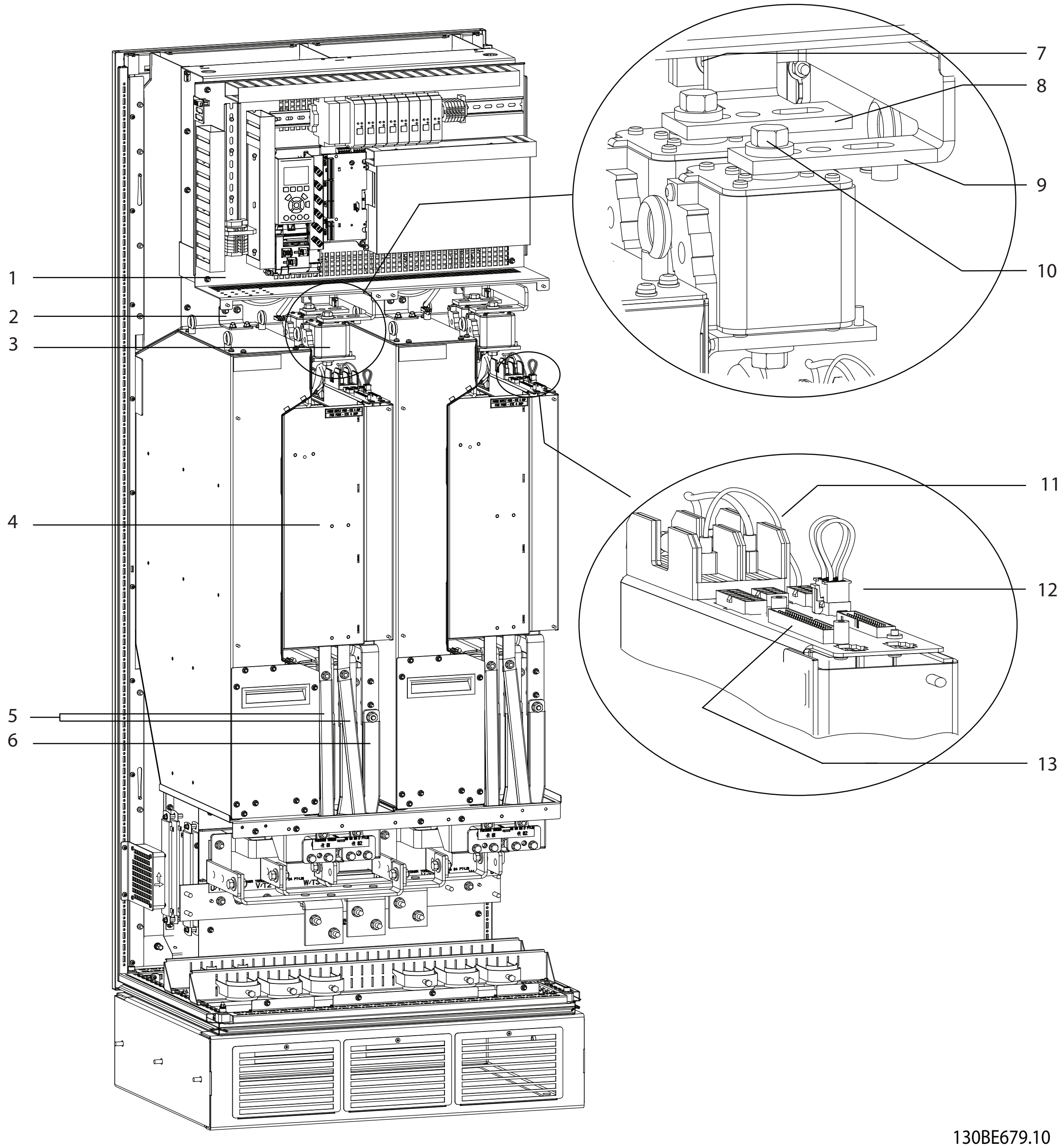
Disassembly

1. Remove the attaching screws and take off the safety covers from the front of the inverter module.
2. If the optional brake bus bars are present, remove the 4 screws (T40) and take off the 2 brake bus bars.
3. Remove the 6 screws (T40) and take off the 3 output AC bus bars.
4. Disconnect the 44-pin ribbon cable from the top of the inverter module.
5. Unplug the cable connectors (2 or 3, depending on unit) from the top of the inverter module. Each connector is a different size for reassembly.
6. For F1–F4 enclosures with a build date of 345 or later:
   - 6a Remove the nut (10 mm) that connects the (–) fuse bus bar to the DC bus, and then remove the hex bolt (18 mm) at the top of the DC fuse. Take off the (–) fuse bar.
   - 6b Remove the hex bolt (18 mm) from the top of the other DC fuse and take off the (+) fuse bus bar.
7. For all F8–F13 enclosures and any F1–F4 enclosures with a build date before 345:
   - 7a Remove the 2 hex bolts (18 mm) at the top of the fuses and take off the DC bus bars.
8. Remove 2 nuts (10 mm) from the bracket at the back of the inverter. The bracket secures the module to the cabinet.
9. Support the inverter module with sufficient mechanical support. Withdraw the inverter from the cabinet.

Reassembly

Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Using sufficient mechanical support, place the inverter into the cabinet.
2. Secure the module to the cabinet bracket using 2 nuts (10 mm).
3. For F1–F4 enclosures with a build date of 345 or later:
   - 3a Connect the (+) fuse bus bar to the top of the front DC fuse using 1 hex bolt (18).
   - 3b Connect the (–) fuse bus bar to the top of the back fuse using 1 hex bolt (18 mm). Then secure the (–) fuse bus bar to the DC bus using 1 nut (M10).
4. For all F8–F13 enclosures and any F1–F4 enclosures with a build date before 345:
   - 4a Connect the DC bus bars to the top of both fuses using 1 hex bolt (18 mm) at the top of each fuse.
5. Reconnect the cable connectors to the inverter module. Each connector is sized differently.
6. Reconnect the 44-pin ribbon cable to the top of the module.
7. Reinstall the 3 output AC bus bars using 6 screws (T40), 2 screws per bus bar.
8. If present, reinstall the 2 brake bus bars using 4 screws (T40), 2 per bus bar.
9. Reinstall the safety covers to the front of the inverter module using the attaching screws.



1	MDCIC mounting panel	8	Fuse bus bar (–)
2	Bracket	9	Fuse bus bar (+)
3	DC fuse (bus bar layout shown is from a 345 or later build date)	10	Hex bolt (18 mm)
4	Inverter module	11	SMPS fuse and fan fuse
5	Brake bus bars - optional	12	Cable connectors
6	Motor output bus bar (W)	13	44-pin ribbon connector
7	Nut (M10)		

Illustration 9.10 Inverter Cabinet Detail, F1–F4 Enclosure Sizes

9.2.7 MDCIC Mounting Panel Disassembly/Reassembly

This procedure applies only to F1–F4 and F10–F13 enclosure sizes.

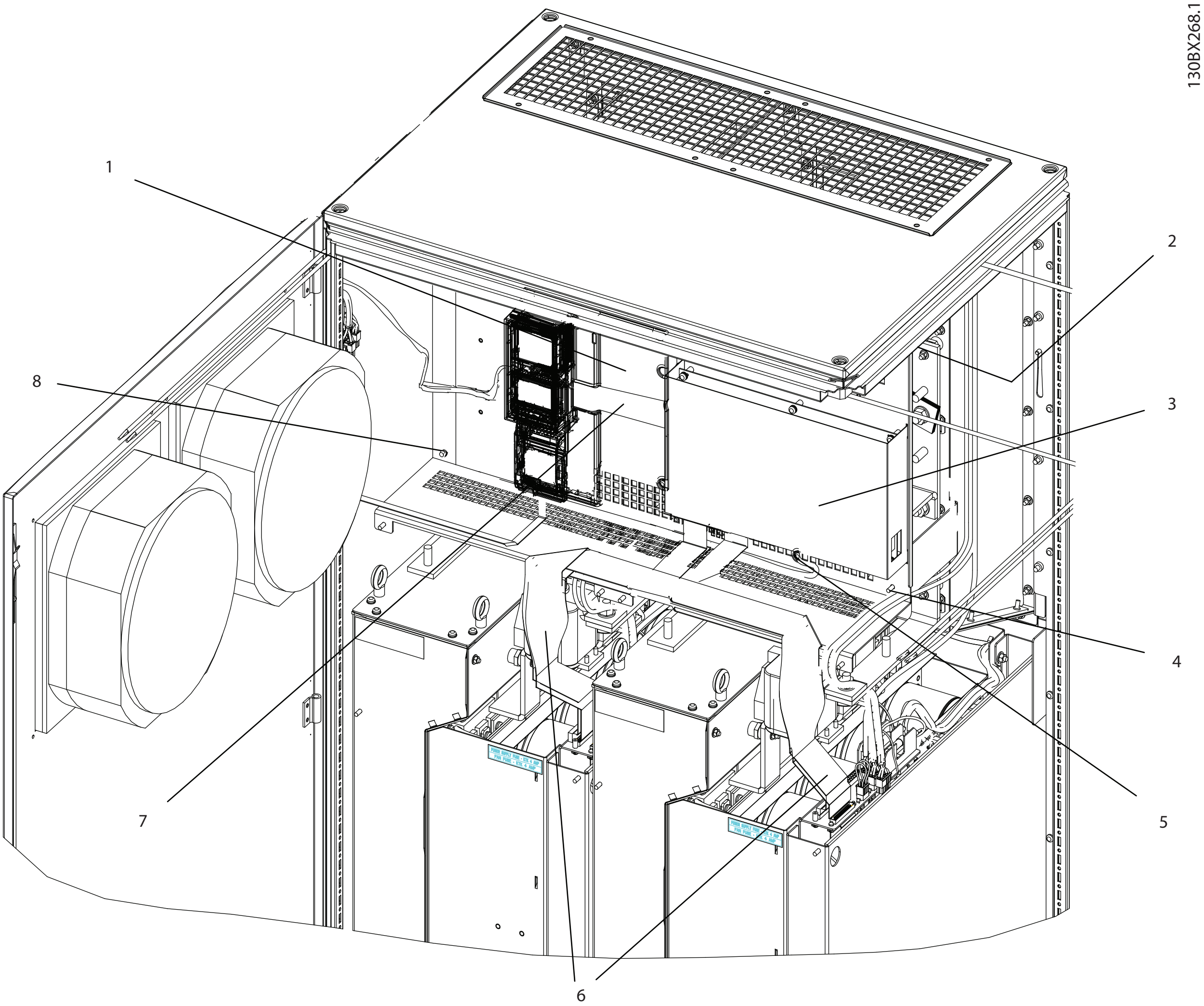
Disassembly

1. Remove the attaching screws (8 mm) that secure the top-mounted safety cover from the inverter module, and then take off the safety cover.
2. Disconnect the ribbon cable between the control card and the LCP.
3. Before removing the MDCIC ribbon cable, note which cable connects to each module for reassembly. Remove the MDCIC ribbon cable from each inverter module.
4. Before removing the rectifier control cable, note that the cable is the leftmost 6-pin connector on the MDCIC board. Remove the rectifier control cable from the MDCIC board.
5. Remove the relay connector from the MDCIC panel.
6. Remove any customer interconnect wiring.
7. Remove the 4 screws (T25) that secure the MDCIC panel, and take out the MDCIC mounting panel.

Reassembly

Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Reinstall the MDCIC mounting panel using 4 screws (T25) to attach the panel to the inverter cabinet.
2. Reinstall the customer interconnect wiring.
3. Reinstall the relay connector to the MDCIC panel.
4. Reconnect the rectifier control cable to the leftmost 6-pin connector on the MDCIC board.
5. Reconnect the MDCIC ribbon cables to the inverter modules.
6. Reattach the ribbon cable between the LCP and the control card.
7. Reinstall the top mounted safety cover to the inverter module using the attaching screws (8 mm).



1	MDCIC mounting panel	5	Rectifier control cable MK101
2	Relay connector (not shown)	6	MDCIC ribbon cable
3	MDCIC board cover plate	7	Control card to MDCIC ribbon cable
4	Attaching screw	8	Attaching screw

Illustration 9.11 Removing the MDCIC Mounting Panel

9.2.8 DC Link Inductor Replacement (F1–F4 Units with a 335 or Earlier Build Date)

To locate the build date, refer to *Illustration 3.1*.

CAUTION

HEAVY WEIGHT

The DC link inductor weighs 25 kg (55 lb). Failure to use some method of support while removing or installing the inductor can result in injury.

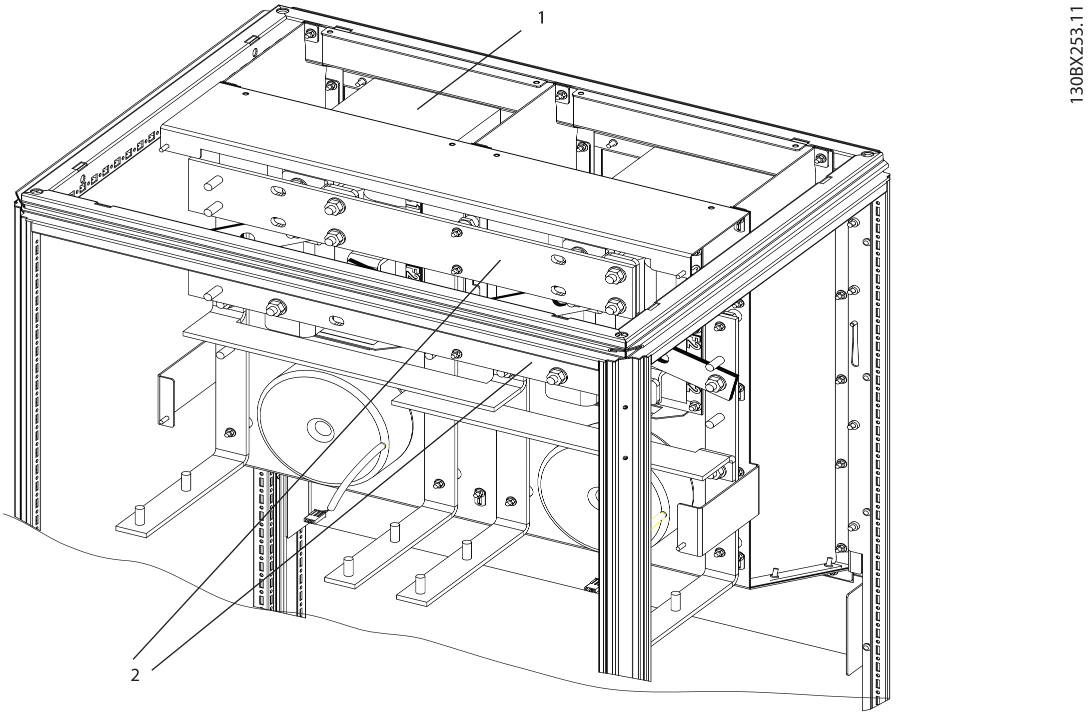
Disassembly

1. Remove the inverter modules. Refer to *chapter 9.2.6 Inverter Module Replacement*.
2. Remove the MDCIC panel. The fan transformers do not need to be removed. Refer to *chapter 9.2.7 MDCIC Mounting Panel Disassembly/Reassembly*.
3. Remove the 8 screws (8 mm) that secure the 2 bus bars covering the DC link inductor. Then remove the 2 bus bars.
4. Remove the 4 screws (8 mm) that secure the 4 mounting plate bus bars, and take out the 4 bus bars.
5. For each short bus bar that is attached to the angle bracket bus bar, remove the 2 screws (8 mm) per short bus bar. Remove the short bus bars.
6. Remove the attaching nuts (10 mm) that secure the DC link inductor to the cabinet, and take out the inductor.

Reassembly

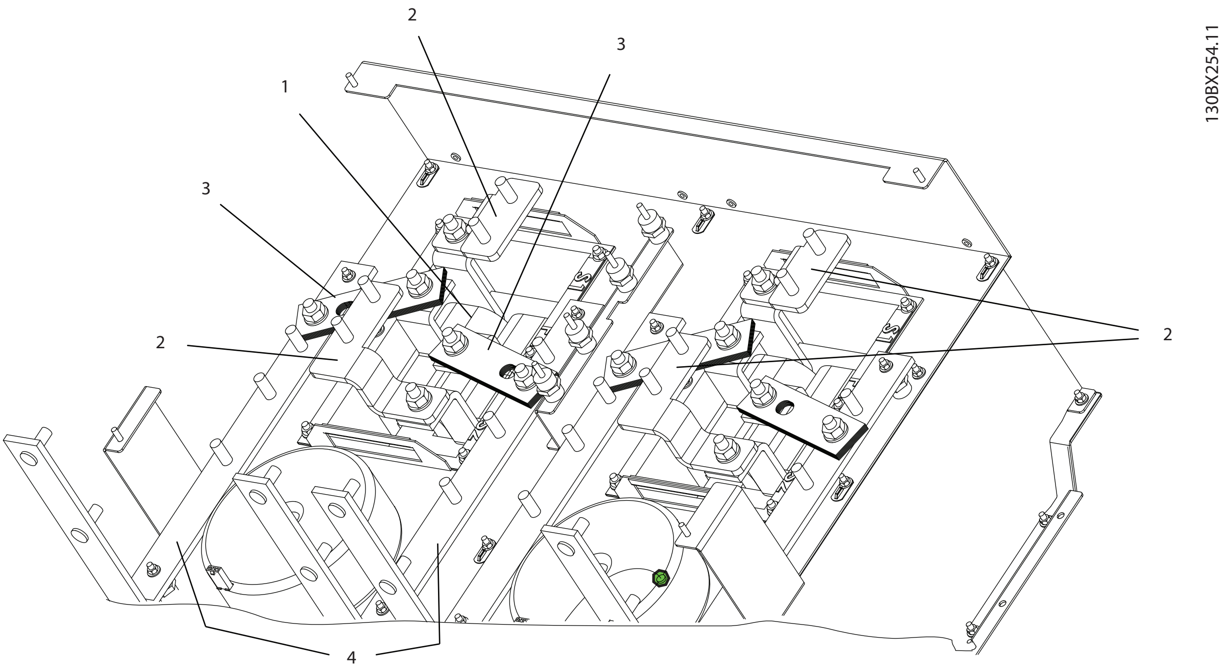
Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Install the DC link inductor into the cabinet. Secure the inductor to the cabinet using nuts (10 mm).
2. Reinstall the short bus bars to the angle bracket bus bars using 2 screws (8 mm) per bus bar.
3. Reinstall the 4 mounting plate bus bars using 1 screw (8 mm) per mounting plate bus bar.
4. Reinstall the 2 bus bars that cover the inductor using 4 screws (8 mm) per bus bar.
5. Reinstall the MDCIC panel.
6. Reinstall the inverter modules. Refer to *chapter 9.2.7 MDCIC Mounting Panel Disassembly/Reassembly*.



1	DC link inductor	2	Bus bar

Illustration 9.12 Removing the DC Link Inductor



1	DC link inductor	3	Short bus bars
2	Mounting plate bus bar	4	Angle bracket bus bar (not removed)

Illustration 9.13 DC Link Inductor Detail

9.2.9 DC Link Inductor Replacement (F1–F4 Units with a 345 or Later Build Date)

To locate the build date, refer to *Illustration 3.1*.

⚠CAUTION

HEAVY WEIGHT

The DC link inductor weighs 25 kg (55 lb). Failure to use some method of support while removing or installing the inductor can result in injury.

Disassembly

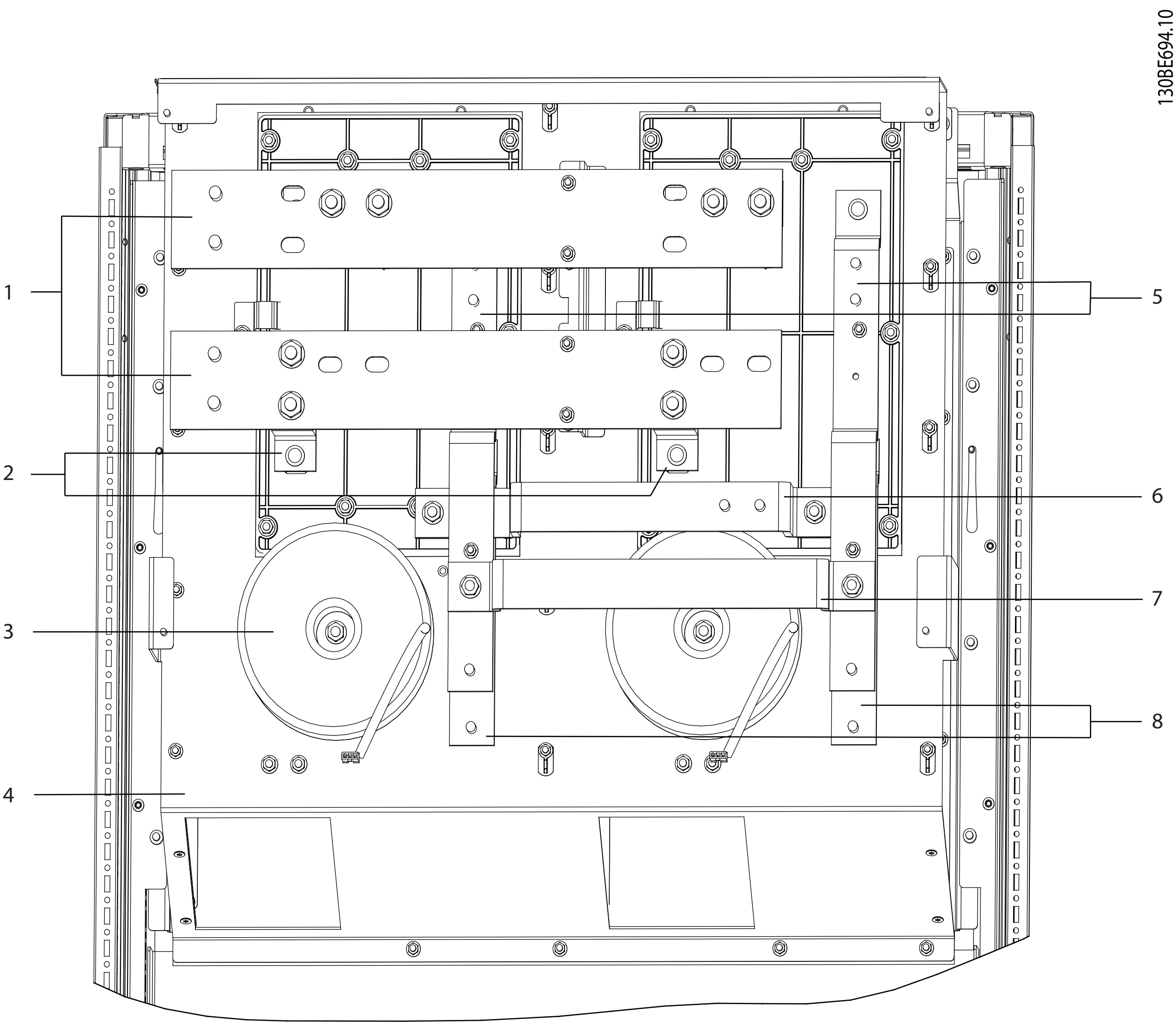
1. Remove the inverter modules. Refer to *chapter 9.2.6 Inverter Module Replacement*.
2. Remove the MDCIC mounting panel. Refer to *chapter 9.2.7 MDCIC Mounting Panel Disassembly/Reassembly*.
3. Remove the 2 DC main bus bars. See *Illustration 9.14*.
   - 3a Remove the 8 (2-inverter units) or 12 (3-inverter units) M10 nuts.
   - 3b Remove the 4 (2-inverter units) or 8 (3-inverter units) M6 nuts from the standoffs.
4. Remove 1 screw (M8) from each of the 2 jumper bars. Remove the 2 jumper bus bars.
5. Remove the 2 (2-inverter units) or 3 (3-inverter units) M8 nuts that secure the (–) regen bus bar. Remove the (–) regen bus bar.
6. Remove the 1 screw (M8) and 2 (M6) standoff nuts that secure the (–) inductor-to-fuse bus bar. Remove the (–) inductor-to-fuse bus bar.
7. Remove the 2 (2-inverter units) or 3 (3-inverter units) M8 nuts that secure the (+) regen bus bar. Remove the (+) regen bus bar.
8. Remove the 1 screw (M8) and 2 (M6) standoff nuts that secure the (+) inductor-to-fuse bus bar. Remove the (+) inductor-to-fuse bus bar.
9. Remove the fan transformers from the upper duct plate. See *Illustration 9.15*.
   - 9a Disconnect the electrical connector from the fan transformer.
   - 9b Remove the 1 nut (13 mm) from the center of the transformer.
10. Remove the inductor cover from the inductor.
    - 10a Remove the 10 nuts (M6) and the hold-down bracket.
    - 10b Remove the standoff using a 19 mm wrench.
11. Detach the inductor from the upper support bracket.
    - 11a Remove the M5 screws that secure the exterior exhaust grate to the top of the cabinet.
    - 11b For each inductor, remove the 2 screws (M6) from the upper support bracket.
12. Remove the upper duct plate. See *Illustration 9.16*.
    - 12a Remove the 19 (2-inverter units) or 26 (3-inverter units) M5 nuts securing the wire harness and the upper portion of the plate.
    - 12b Detach the wire harness and move it to the left side of the cabinet.
    - 12c Remove 4 screws (M5) along the bottom edge of the plate.
13. Remove the inductor module. See *Illustration 9.17*.
    - 13a Remove the 2 screws (M6) from the bottom support bracket on each inductor.
    - 13b Remove the 4 nuts (M8) securing the inductor to the cabinet.
    - 13c Using some method of support, pull out the inductor.

Reassembly

Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

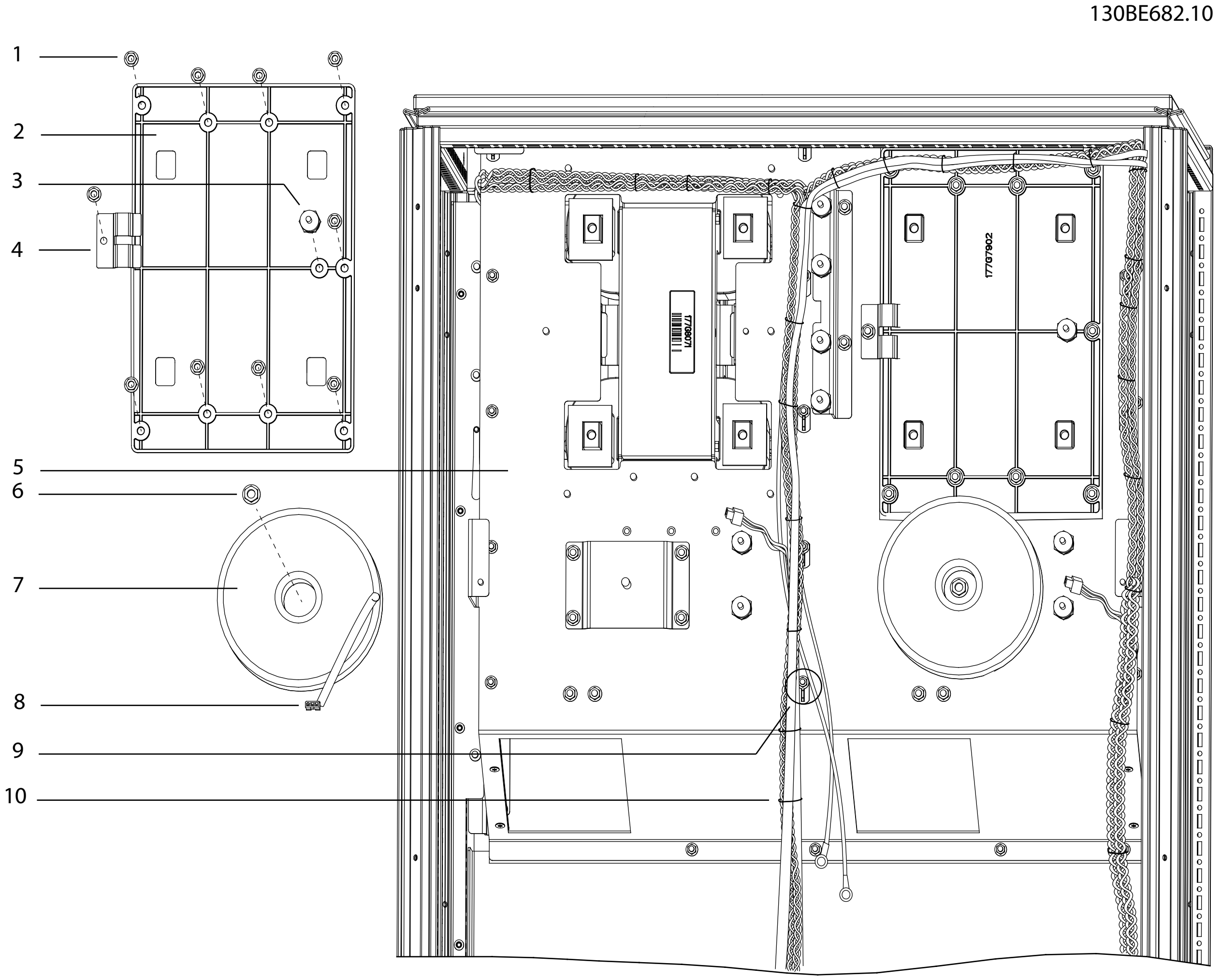
1. Using some method of support, reinstall the inductor module. See *Illustration 9.17*.
   - 1a Secure the inductor to the cabinet with 4 nuts (M8).
   - 1b Secure the inductor to the bottom support bracket using 2 screws (M6).
2. Reinstall the upper duct plate. See *Illustration 9.16*.
   - 2a Align the upper duct plate with the screw holes and loosely fasten the bottom edge of the plate using 4 screws (M5).
   - 2b Line up the wire harness along the middle and right side of the upper duct plate.
   - 2c Loosely fasten the upper portion of the plate and the wire harness using 19 (2-inverter units) or 26 (3-inverter units) M5 nuts.
   - 2d Tighten all upper duct plate fasteners according to proper torque rating.
3. Secure the inductor to the upper support bracket.
   - 3a Inside the top exhaust grate, secure each inductor to the upper support bracket using 2 screws (M6).
   - 3b Secure the top exhaust grate to the frequency converter using M5 screws.
4. Fasten the inductor cover to the inductor. See *Illustration 9.15*.
   - 4a Secure with 10 nuts (M6) and the hold-down bracket.
   - 4b Reattach the standoff using a 19 mm wrench. Tighten the standoff to 3.9 Nm (35 in-lb).
5. Reinstall the fan transformers to the upper duct plate.
   - 5a Secure the fan transformer to the plate using 1 nut (13 mm).
   - 5b Reconnect the electrical connector to the fan transformer.
6. Reinstall the (+) inductor-to-fuse bus bar using 1 screw (M8) and 2 nuts (M6) on the standoffs.
7. Reinstall the (+) regen bus bar using 2 (2-inverter units) or 3 (3-inverter units) M8 nuts.
8. Reinstall the (–) inductor-to-fuse bus bar using 1 screw (M8) and 2 nuts (M6) on the standoffs.
9. Reinstall the (–) regen bus bar using 2 (2-inverter units) or 3 (3-inverter units) M8 nuts.
10. Reinstall the 2 jumper bus bars to each inductor using 1 screw (M8) per bus bar.
11. Reinstall the 2 DC main bus bars. See *Illustration 9.14*.
    - 11a Reattach 4 (2-inverter units) or 8 (3-inverter units) M6 nuts to the standoffs.
    - 11b Secure the 2 DC main bus bars using 8 (2-inverter units) or 12 (3-inverter units) M10 nuts.
12. Reinstall the MDCIC mounting panel. Refer to *chapter 9.2.7 MDCIC Mounting Panel Disassembly/Reassembly*.
13. Reinstall the inverter modules. Refer to *chapter 9.2.7 MDCIC Mounting Panel Disassembly/Reassembly*.

9



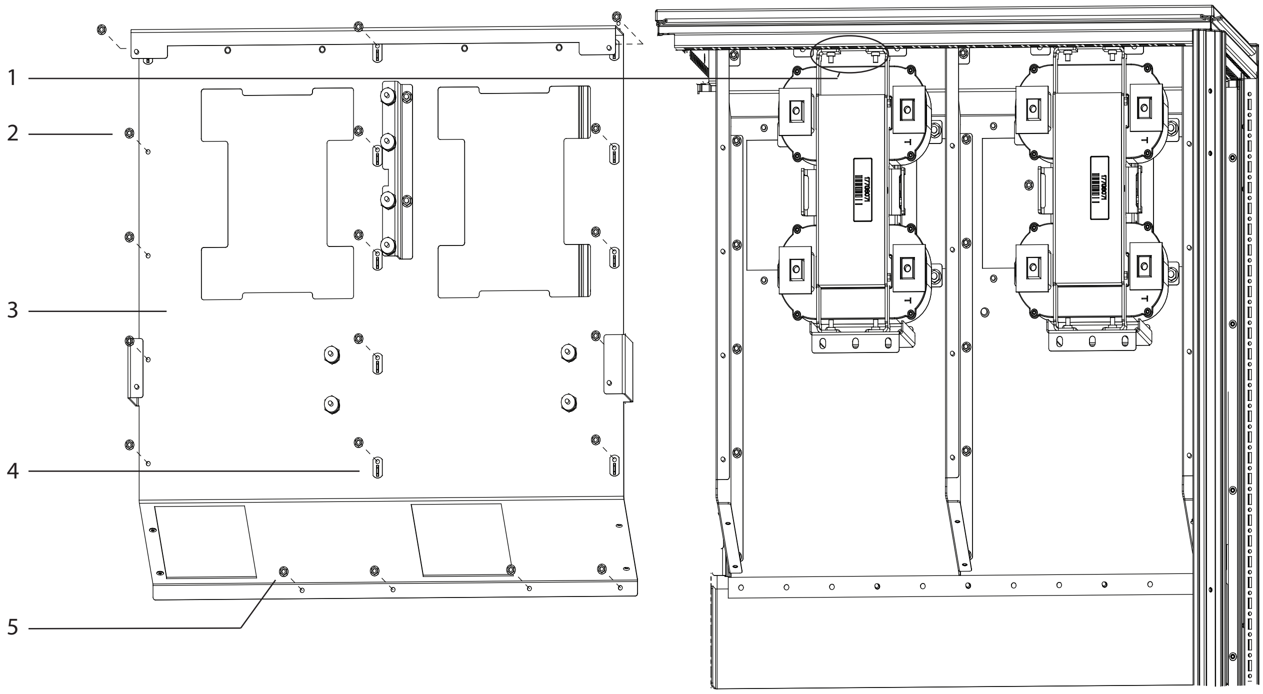
1	DC main bus bars	5	Inductor-to-fuse bus bar (–)
2	Inductor jumper bus bar (top jumper bus bars not shown)	6	Regen bus bar (+)
3	Fan transformer	7	Regen bus bar (–)
4	Upper duct plate	8	Inductor-to-fuse bus bar (+)

Illustration 9.14 Bus Bar Layout



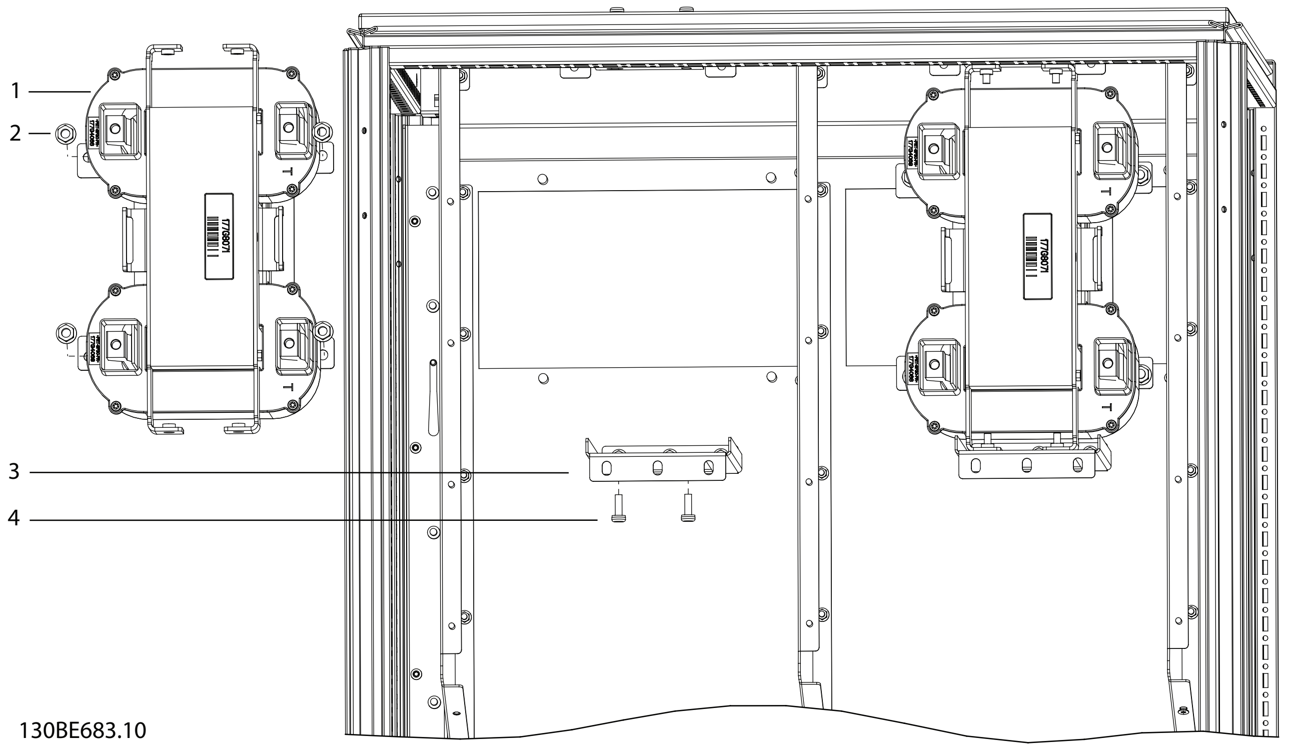
1	Nut (M6)	6	Nut (13 mm)
2	Plastic inductor cover	7	Fan transformer
3	Standoff	8	Electrical connector
4	Hold-down bracket	9	Wire clip/nut (M5)
5	Upper duct plate	10	Wire harness

Illustration 9.15 Removing the Inductor Cover and Fan Transformer from the Upper Duct Plate



1	Upper support bracket screws (M6)	4	Wire clip/nut (M5)
2	Nut (M5)	5	Screw (M5)
3	Upper duct plate		

Illustration 9.16 Removing Upper Duct Plate



1	DC link inductor	3	Bottom support bracket
2	Nut (M8)	4	Screw (M6)

Illustration 9.17 Removing the DC Link Inductor

9.2.10 MDCIC Board Replacement

This procedure applies only to F1–F4 and F10–F13 enclosure sizes.

NOTICE

PARTS REUSE

A replacement scaling card is not included with the replacement MDCIC board. Retain the scaling card (1 per module) so it can be reinstalled on the new MDCIC board.

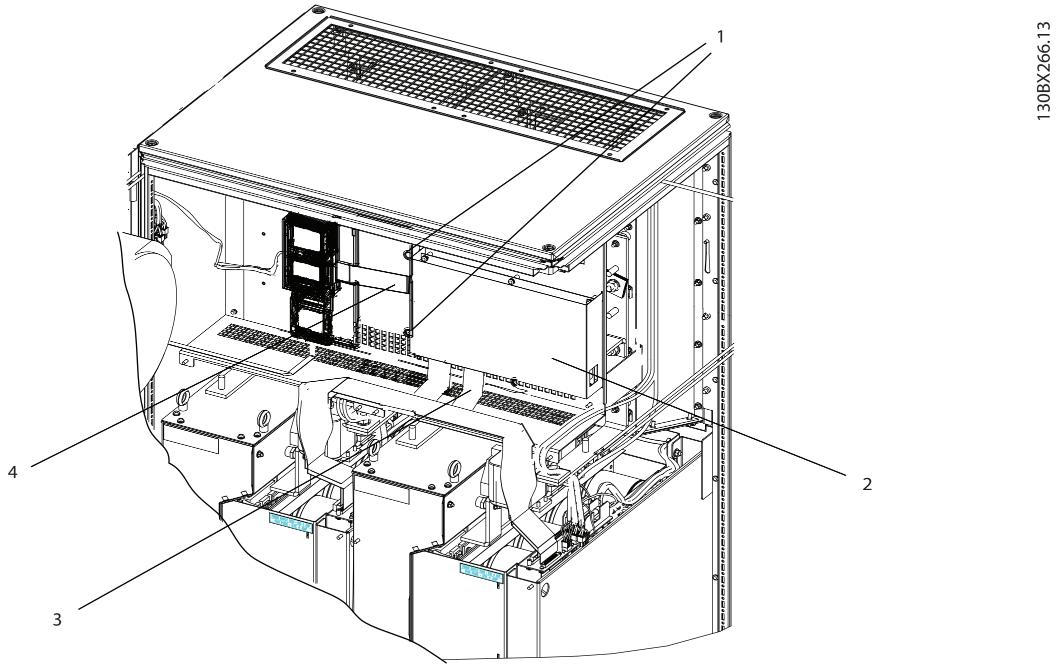
Disassembly

1. Remove 2 screws (8 mm) from the MDCIC safety cover and pull off the cover.
2. Disconnect the control card ribbon cable from the left side of the MDCIC board by gently pulling the connector to the left (as opposed to pulling the connector straight out).
3. Note position of the module ribbon cables for reinstallation. Remove the module ribbon cables.
4. Note position of the rectifier control cable that is connected to the 6-pin connector for reinstallation. There is 1 cable for F1–F4 enclosures and 2 cables for F10–F13 enclosures. Remove the rectifier control cable.
5. Remove the MDCIC board by removing the 9 screws (T25) securing the board to the panel standoffs.

Reassembly

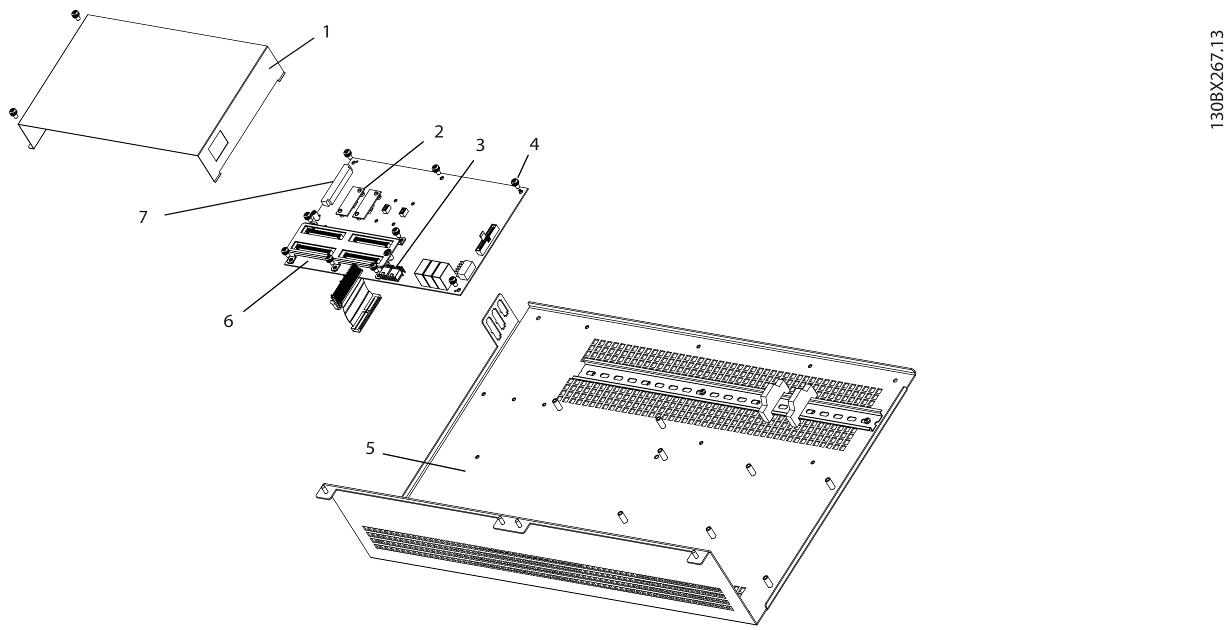
Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Reinstall the old scaling cards on the new MDCIC board.
2. Reattach the new MDCIC board to the panel standoffs using 9 screws (T25).
3. Reattach the rectifier control cable to the 6-pin connector. There is 1 cable for F1–F4 enclosures and 2 cables for F10–F13 enclosures.
4. Reattach the MDI module ribbon cables. Make sure that the MDI module ribbon cables are in their original position.
5. Reattach the control card ribbon cable to the MDCIC board.
6. Reinstall the MDCIC safety cover using 2 screws (8 mm).



1	Retaining screws	3	Ribbon cable
2	MDCIC board cover	4	Left-side ribbon cable

Illustration 9.18 Removing the MDCIC Board



1	MDCIC cover	5	MDCIC mounting panel
2	Scaling card	6	Ribbon cable
3	MK101 connector	7	Left-side ribbon cable
4	MDCIC board attaching screw		

Illustration 9.19 MDCIC Board Detail

9.2.11 Fan Transformer Replacement

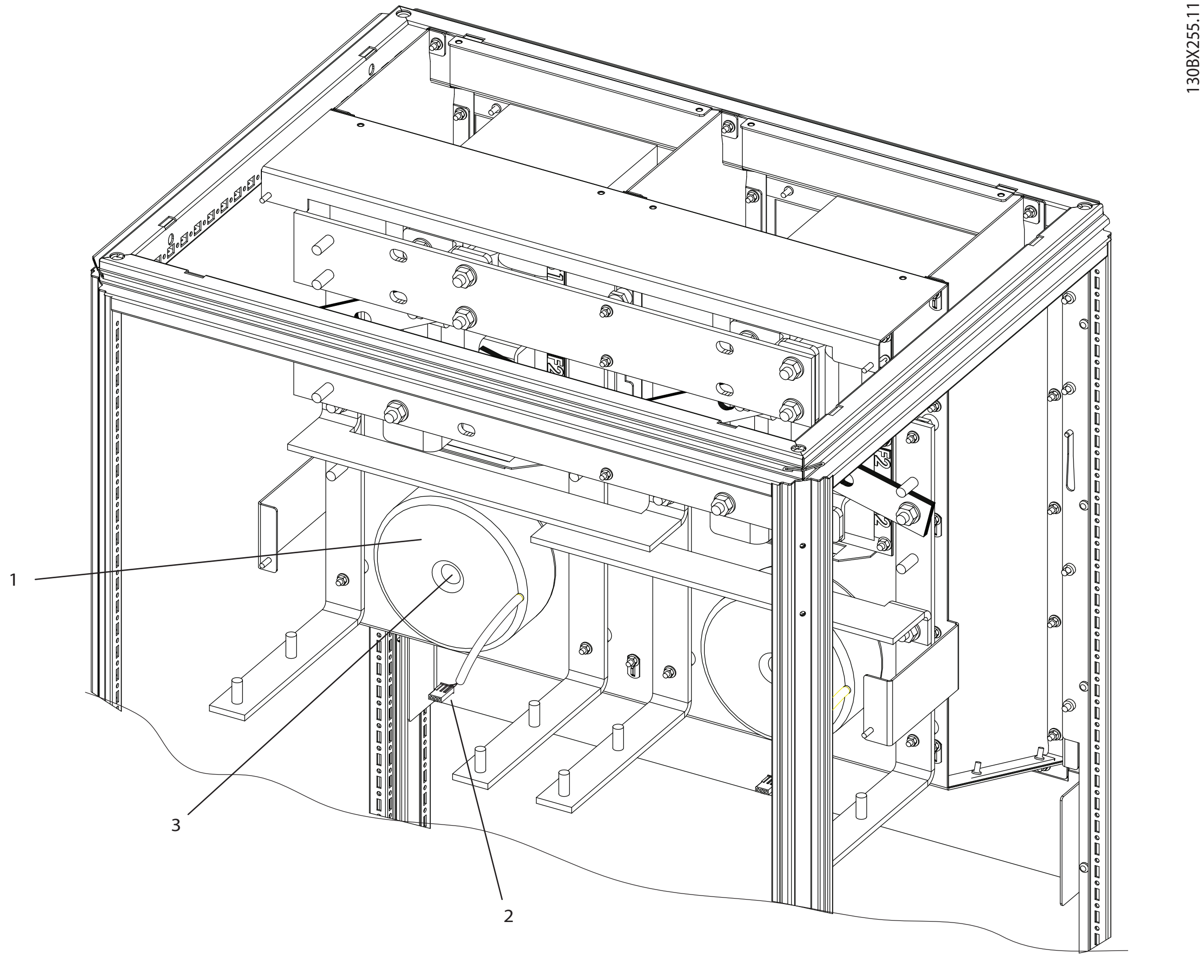
Disassembly

1. Remove the MDCIC panel.
   Refer to *chapter 9.2.7 MDCIC Mounting Panel Disassembly/Reassembly*.
2. Disconnect the electrical connector from the fan transformer.
3. Remove the nut (13 mm) from the center of the fan transformer securing transformer to panel.

Reassembly

Follow fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Reinstall the fan transformer to the panel. Secure with the nut (13 mm).
2. Reconnect the electrical connector to the fan transformer.
3. Reinstall the MDCIC panel.



1	Fan transformer
2	Fan transformer connector
3	Nut (13 mm)

Illustration 9.20 Removing the Fan Transformer

10 Module Disassembly/Reassembly

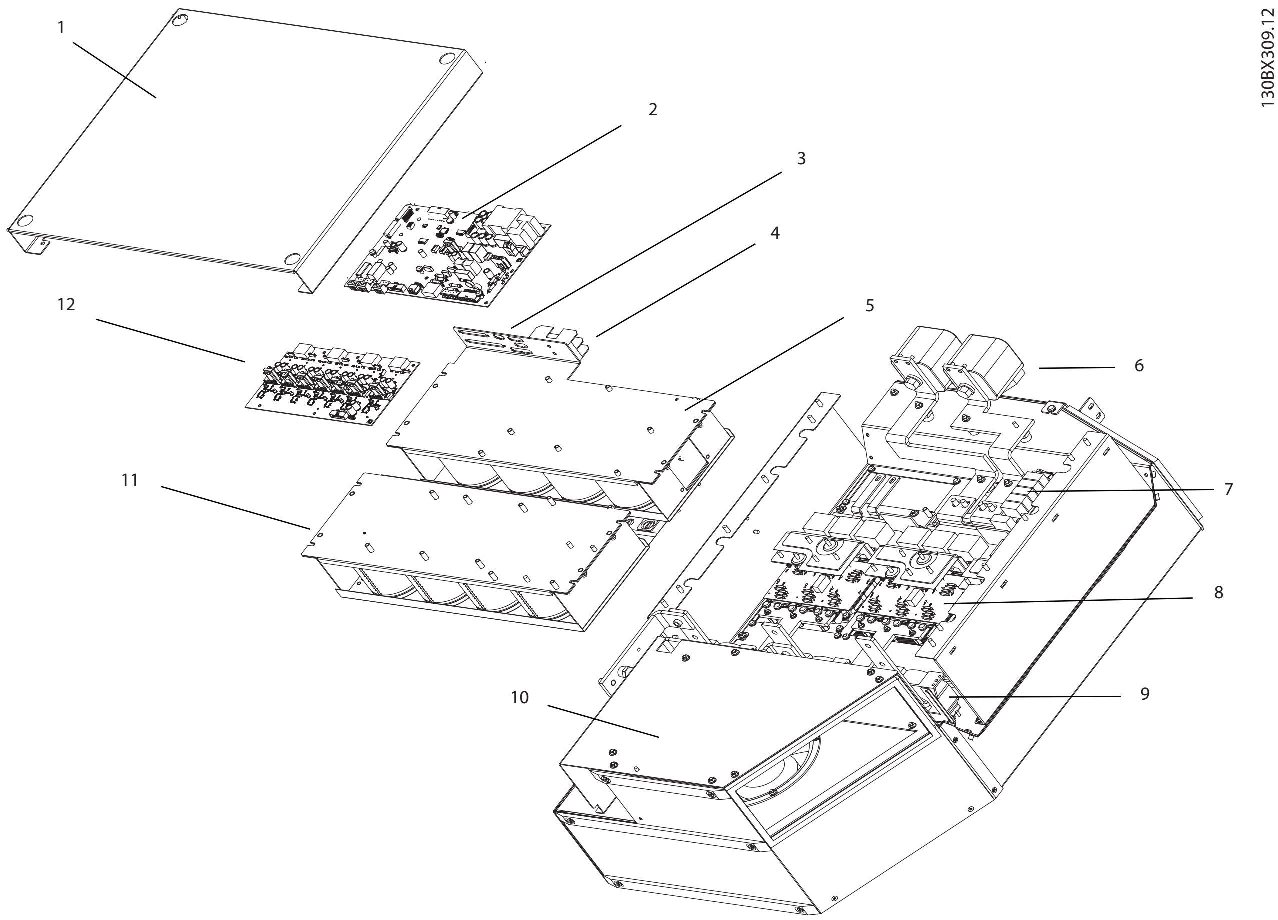
10.1 Inverter Module

CAUTION

TRAINING REQUIRED

Only certified technicians who are trained by Danfoss are permitted to test and repair module components. Repair work conducted by non-certified technicians can result in personal injury or equipment damage.

1. Remove the inverter module from the frequency converter. Refer to *chapter 9.2.6 Inverter Module Replacement*.
2. Remove the right side cover plate from the inverter module by removing 4 nuts (10 mm). For reassembly, note the 2 studs on the panel edge. This side mounts to the front of unit.



1	Right side cover plate	7	High-frequency board
2	Inverter power card	8	IGBT module
3	Panel connectors	9	Current sensor
4	SMPS fuse and fan fuse	10	Fan assembly
5	Upper capacitor bank assembly	11	Lower capacitor bank assembly (some power sizes have a blank plate)
6	DC bus fuses	12	Gatedrive card

Illustration 10.1 F1–F13 Inverter Module (Exploded View)

10.1.1 Power Card Replacement

When installing the power card, ensure that the insulator sheet is installed between the power card and the mounting plate.

Disassembly

1. Unplug the power card connectors.
   - 1a For F1–F4 or F10–13 enclosures, unplug MK102, FK103, MK104, MK105, MK106, MK107, MK109, MK110, and MK112. Refer to *Illustration 10.2*.
   - 1b For F8/F9 enclosures, unplug MK102, FK103, MK104, MK105, MK106, MK107, MK108, MK109, MK110, and MK112.
2. Remove the 7 power card mounting screws (T25).
3. Remove the power card from the plastic standoff.
4. Remove, but do not discard, the scaling card by pushing in the retaining clips on the standoffs.

NOTICE

PARTS REUSE

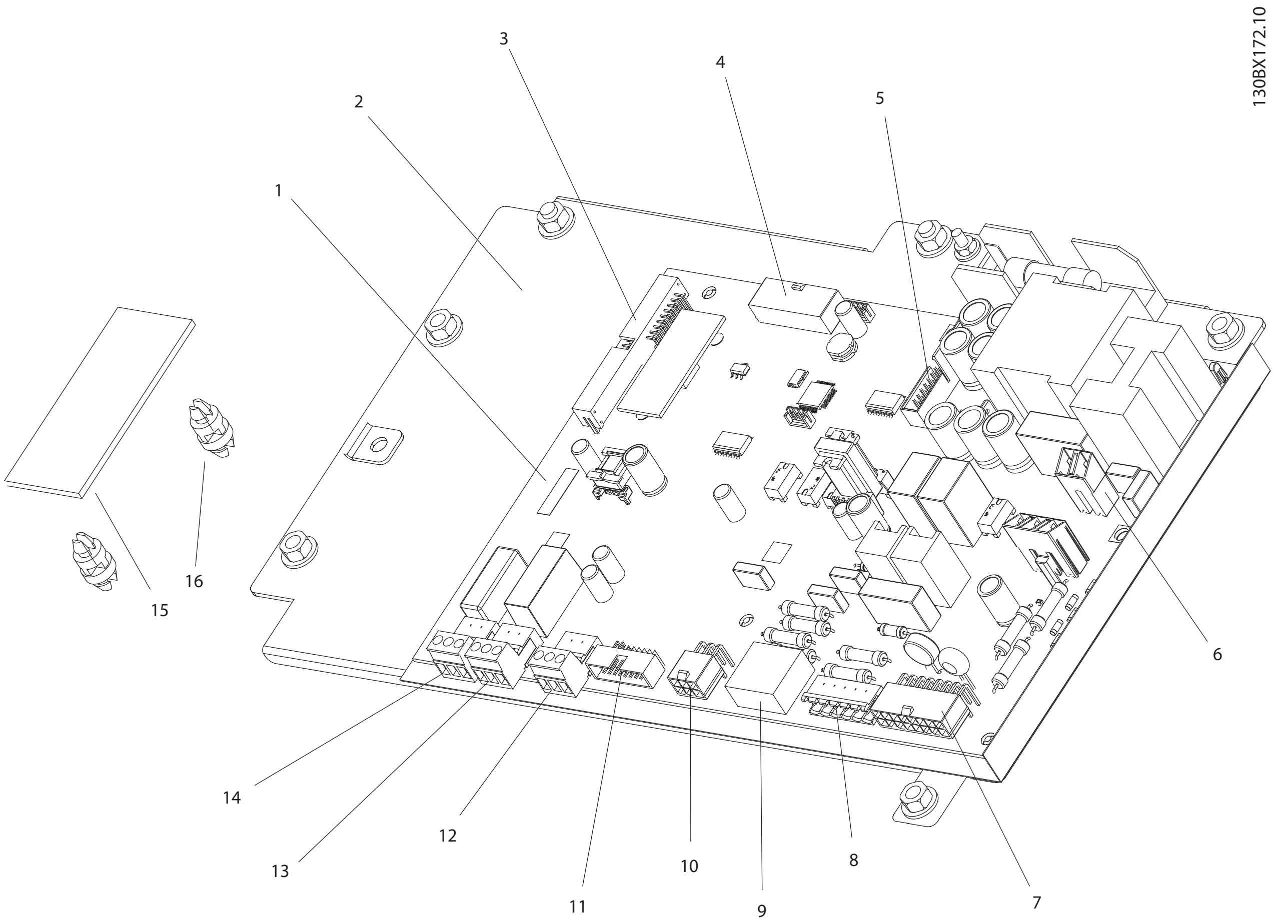
A replacement scaling card is not included with the replacement power card. Retain the scaling card so it can be reinstalled on the new power card.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Insert the scaling card into the standoffs on the new power card. Make sure that the current scaling card is secure.
2. Place the power card onto the plastic standoff at the top right corner of the power card.
3. Secure the power card using the 7 power card mounting screws (T25).
4. Plug in the power card connectors.
   - 4a For F1–F4 or F10–13 enclosures, connect MK102, FK103, MK104, MK105, MK106, MK107, MK109, MK110, and MK112. Refer to *Illustration 10.2*.
   - 4b For F8–F9 enclosures, connect MK102, FK103, MK104, MK105, MK106, MK107, MK108, MK109, MK110, and MK112.

10



1	Power card	9	MK106
2	Mounting plate	10	MK100
3	MK110	11	MK109
4	MK102	12	FK102
5	MK104	13	MK112 terminals 4,5,6
6	MK105	14	MK112 terminals 1,2,3
7	MK107	15	Current scaling card
8	FK103	16	Current scaling card standoff

Illustration 10.2 Power Card, F1–F13

10.1.2 Upper Capacitor Bank Assembly Replacement (without removing power card)

NOTICE

POWER CARD

The power card can remain attached to the capacitor bank cover during removal. If desired, remove the power card in accordance with instructions provided.

Disassembly

1. Unplug the following power card connectors:
   - 1a MK105
   - 1b MK107
   - 1c MK109
2. Remove the 2 red wires from the 15 A fuse block attached to the cover plate flange.
3. Free the cable with the 2 red wires attached to it by disconnecting the 10-pin connector next to the fuse block on the cover plate flange.
4. Disconnect the 2 white wires from the 4 A fuse block attached to the cover plate flange and free the cable by disconnecting the 6-pin connector on the opposite end of the cable.
5. Remove MK102 from the power card and ground lug. The power card can now remain fastened to the capacitor bank assembly.
6. Remove the 6 electrical connection nuts (8 mm) securing the electrical connection of the assembly. These nuts are recessed in the gap between the upper and lower capacitor banks.
7. Remove the 4 retaining nuts (10 mm) securing the capacitor bank assembly.
8. Remove the capacitor bank assembly.

NOTICE

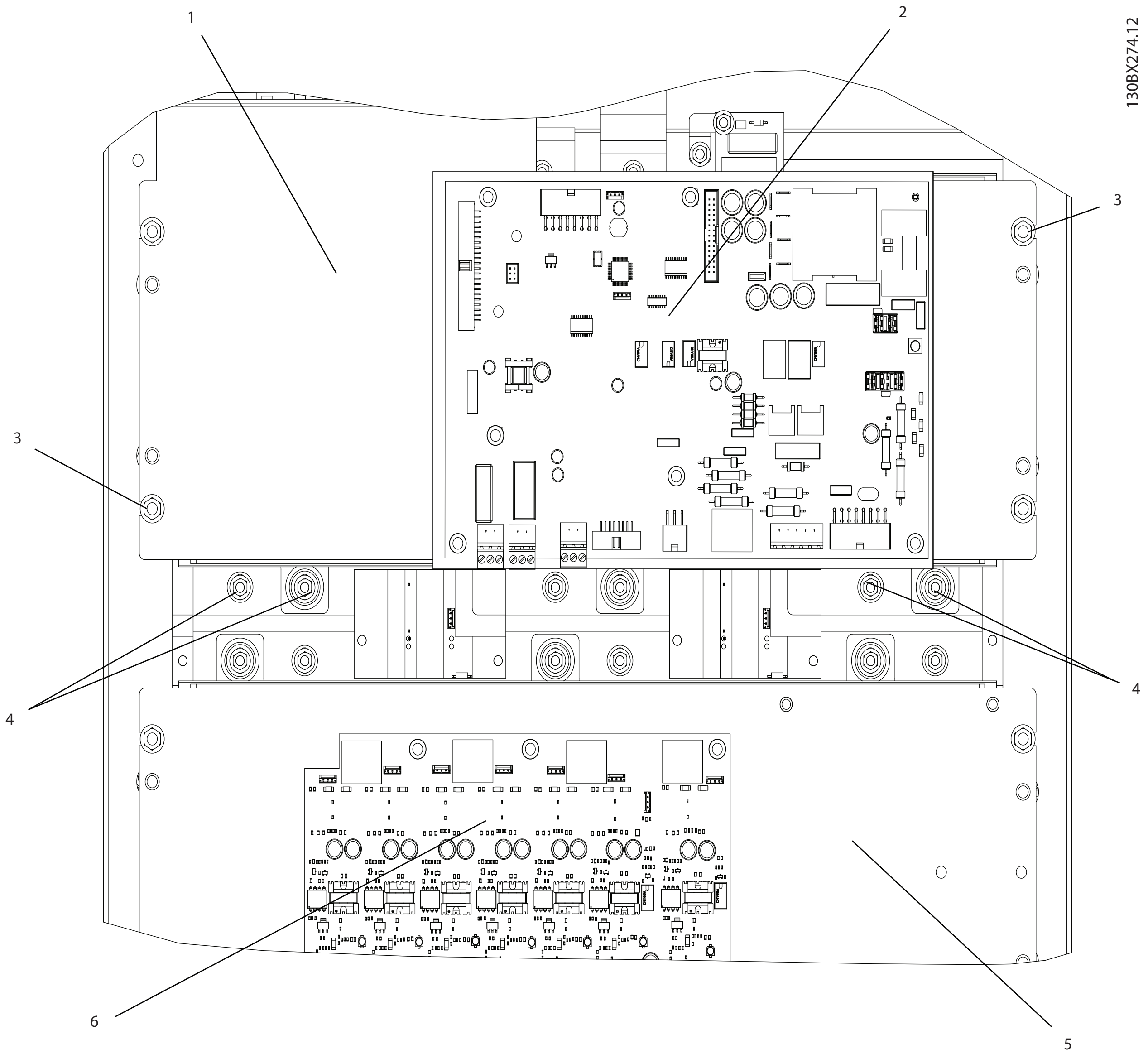
CAPACITOR ASSEMBLY WEIGHT

The capacitor bank assembly weighs 9 kg (20 lb).

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Reinstall the capacitor bank assembly in its original location.
2. Secure the capacitor bank assembly using 4 retaining nuts (10 mm).
3. Secure the electrical connection using 6 electrical connection nuts (8 mm).
4. Reinstall MK102 to the power card and ground lug.
5. Reinstall the cable with the 2 white wires by reconnecting the 6-pin connector on the opposite end of cable. Reattach the 2 white wires from the 4 A fuse block that attach to the cover plate flange.
6. Reinstall the cable with the 2 red wires by reconnecting it to the 10-pin connector next to the fuse block on the cover plate flange.
7. Reattach the 2 red wires to the 15 A fuse block, which is attached to the cover plate flange.
8. Plug in the following power card connectors:
   - 8a MK105
   - 8b MK107
   - 8c MK109



1	Upper capacitor bank assembly	4	Electrical connection nut (8 mm)
2	Inverter power card	5	Lower capacitor bank assembly
3	Retaining nut (10 mm)	6	IGBT gatedrive card

Illustration 10.3 Upper Capacitor Bank Assembly, F1–F13

10.1.3 Lower Capacitor Bank Assembly Replacement

For some power sizes, there is a blank plate in place of the lower capacitor bank assembly.

Disassembly

1. Disconnect the cables from the following gatedrive card connectors:
   - 1a MK100
   - 1b MK102
   - 1c MK103
   - 1d MK104
   - 1e MK106
   - 1f MK105 (if the unit has a brake option)

NOTICE

If there is a blank plate instead of a lower capacitor bank assembly, skip the next step.

2. Remove the 6 electrical connection nuts (8 mm) that secure the capacitor bank assembly. These nuts are recessed in the gap between the upper and lower capacitor banks.
3. Remove the 4 retaining nuts (10 mm) securing capacitor bank assembly.
4. Remove the capacitor bank assembly.

NOTICE

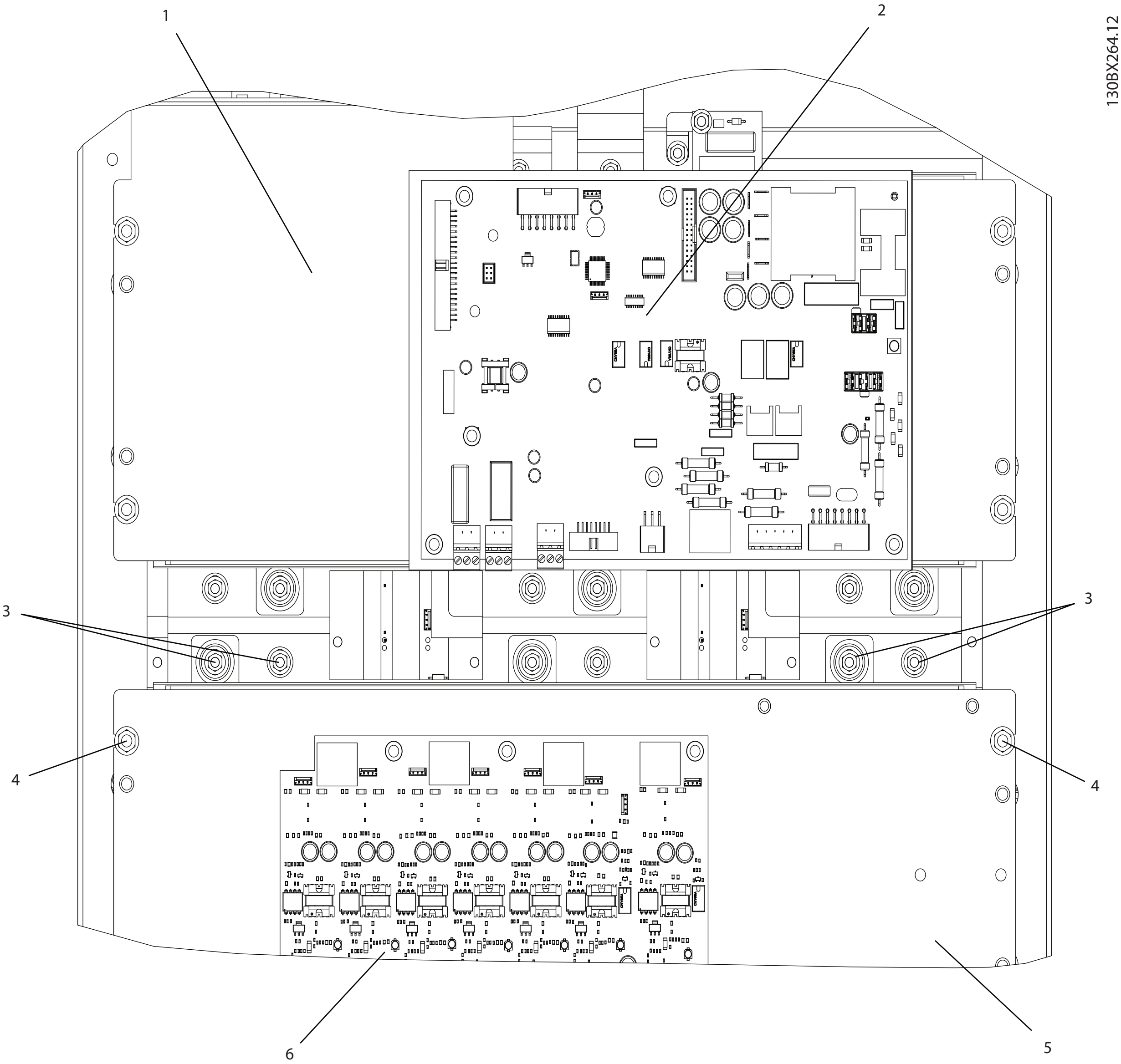
CAPACITOR ASSEMBLY WEIGHT

The capacitor bank assembly weighs 9 kg (20 lb).

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Reinstall the capacitor bank assembly in its original location.
2. Secure the capacitor bank assembly using 4 retaining nuts (10 mm).
3. If there is a blank plate instead of a lower capacitor bank assembly, skip this step. Otherwise, secure the electrical connection using 6 electrical connection nuts (8 mm).
4. Connect the following cables to the gatedrive card:
   - 4a MK100
   - 4b MK102
   - 4c MK103
   - 4d MK104
   - 4e MK106
   - 4f MK105 (if the unit has a brake option)



1	Upper capacitor bank assembly	4	Retaining nut (8 mm)
2	Inverter power card	5	Lower capacitor bank assembly
3	Electrical connection nut (8 mm)	6	IGBT gatedrive card

Illustration 10.4 Lower Capacitor Bank Assembly, F1–F13

10.1.4 High-frequency Board Replacement

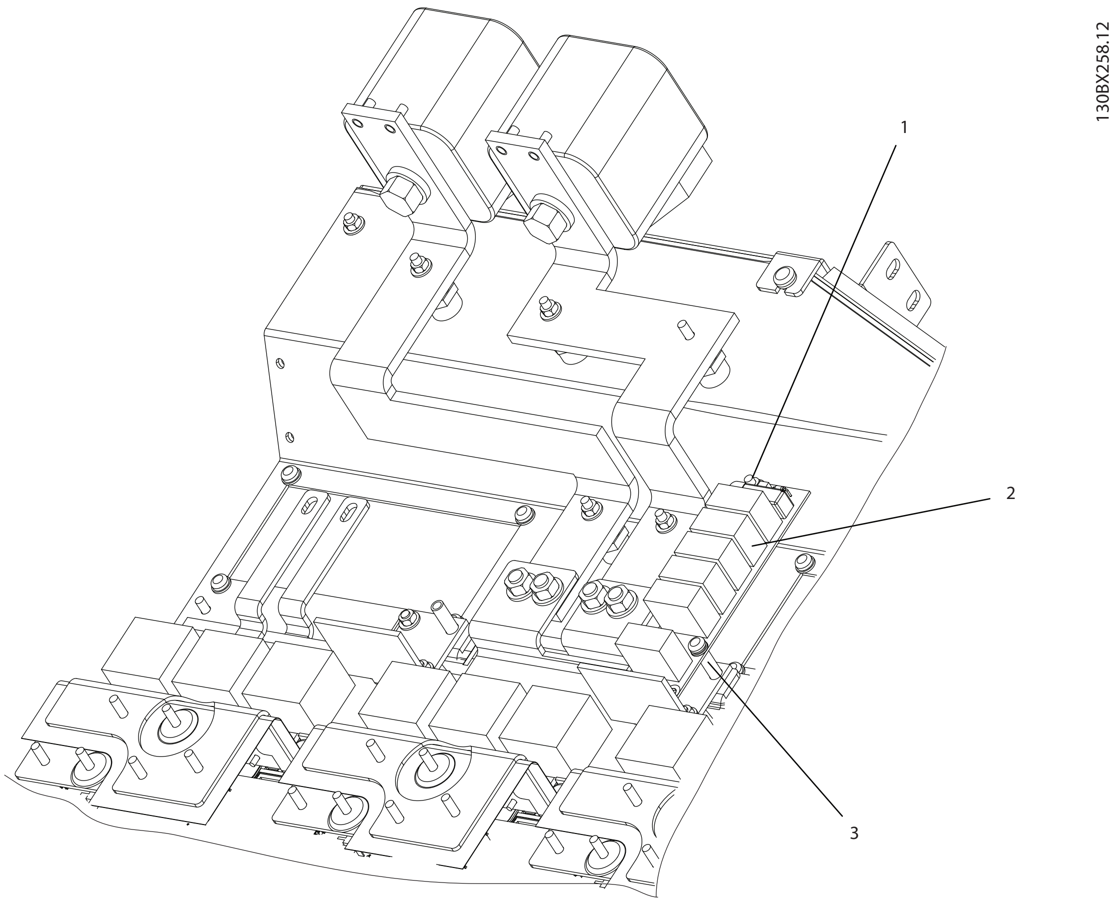
Disassembly

1. Remove the upper capacitor bank assembly. Refer to *chapter 10.1.2 Upper Capacitor Bank Assembly Replacement (without removing power card)*.
2. Disconnect cable from connector MK100 on the high-frequency board.
3. Remove the 2 screws (T25) from the high-frequency board.
4. Remove the 1 nut (8 mm) from the high-frequency board standoff and remove the board.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Reinstall the high-frequency board to its original position within the module. Secure the board to the standoff with the 1 nut (8 mm).
2. Reinstall the 2 screws (T25) at each end of the high-frequency board.
3. Reconnect the cable to the MK100 connector on the high-frequency board.
4. Reinstall the upper capacitor bank assembly.



1	Retaining nut (8 mm)	3	T25 screw
2	High-frequency board		

Illustration 10.5 High-frequency Board

10.1.5 Current Sensor Replacement

NOTICE

There are 2 types of current sensors, 500 A or 1000 A, depending on the size of the unit. Removal for both is the same except for an extra step for the 1000 A sensor.

Disassembly

1. Remove the lower capacitor bank assembly. Refer to *chapter 10.1.3 Lower Capacitor Bank Assembly Replacement*.
2. Remove 6 screws (T30) connecting the bus bar to the IGBT module at the IGBT end of the bus bar.
3. Remove 3 standoff nuts (7 mm) from the IGBT end of the bus bar.
4. Remove 1 screw (T40) from the opposite end of the bus bar that is attached to the output bus bar.
5. Unplug the wire from the current sensor.
6. Remove 2 nuts (7 mm) that attach the base of the current sensor to the back panel.
7. Remove the bus bar and slide off the current sensor.
8. For 1000 A units, remove the mounting plate from the back of the current sensor by removing 4 screws (8 mm).

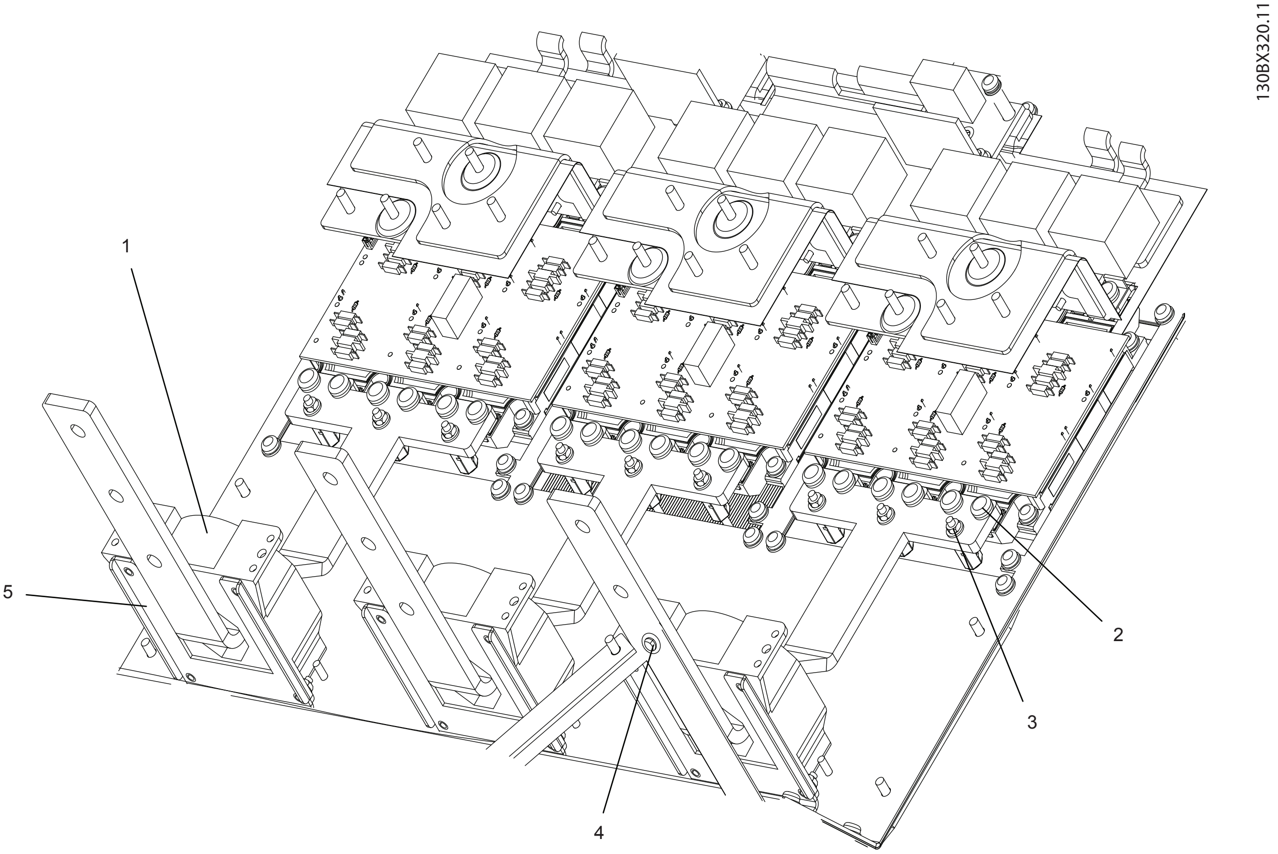
NOTICE

Retain the mounting plate and screws for reassembly of the current sensor.

Reassembly

The 6 screws (T30) connecting the bus bar to the IGBT module must be tightened to 4 Nm (35 in-lb). For other fastener torque values, refer to *chapter 1.6 General Torque Tightening Values*.

1. Slide the new current sensor onto the bus bar and into its original position. For 1000 A sensors, first reinstall the mounting plate onto the back of the sensor using 4 screws (8 mm).
2. Secure the current sensor base to the back panel using 2 nuts (7 mm).
3. Reconnect the wire to the current sensor.
4. Secure the output bus bar to the current sensor bus bar using 1 screw (T40).
5. Secure the IGBT end of the bus bar to the 3 standoffs using 3 nuts (7 mm).
6. Secure the IGBT end of the bus bar to the IGBT module using 6 screws (T30).
7. Reinstall the lower capacitor bank assembly.



1	Current sensor	4	Screw (T40)
2	Screw (T30)	5	Mounting plate (1000 A sensor)
3	Nut (7 mm)		

Illustration 10.6 Current Sensor Assembly

10.1.6 Brake IGBT Module Replacement

NOTICE

The brake IGBT is an option and is not present on all units.

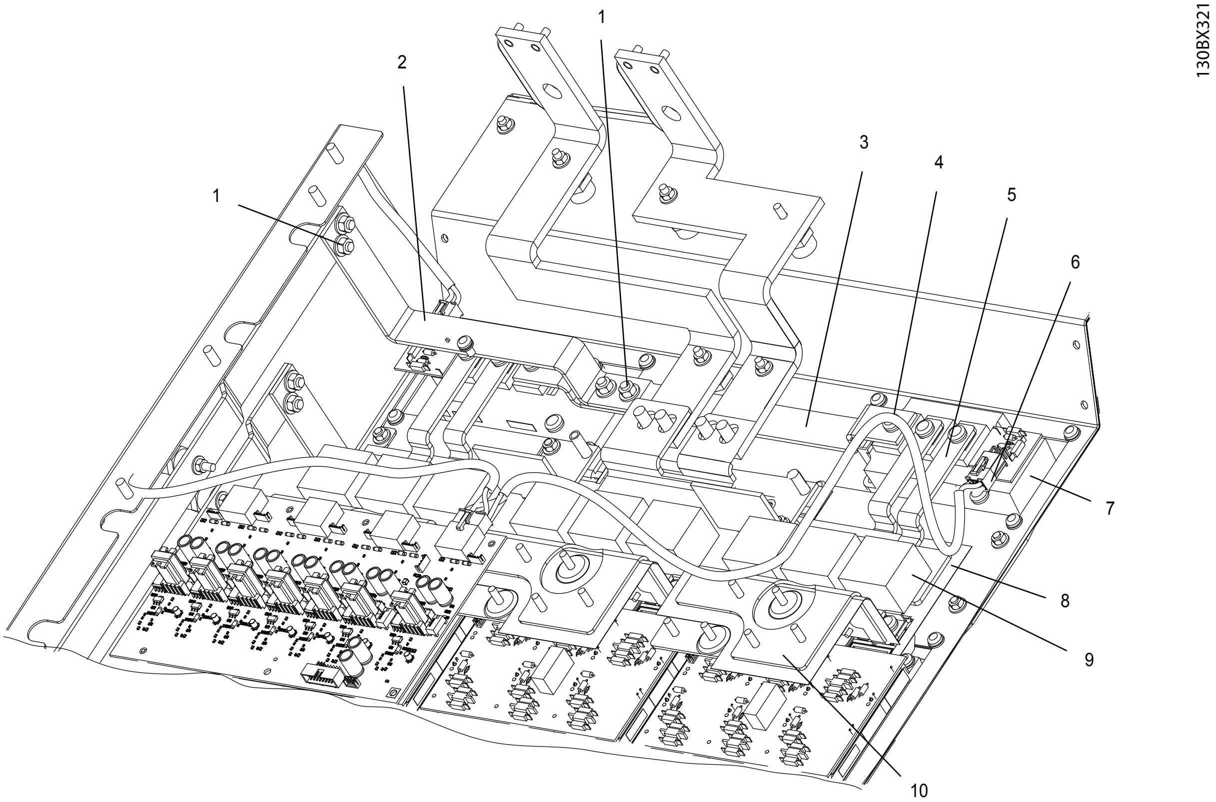
Disassembly

1. Remove both the upper and lower capacitor bank assemblies. Refer to *chapter 10.1.2 Upper Capacitor Bank Assembly Replacement (without removing power card)* and *chapter 10.1.3 Lower Capacitor Bank Assembly Replacement*.
2. Remove the high-frequency board. Refer to *chapter 10.1.4 High-frequency Board Replacement*.
3. Unplug the brake IGBT cable from the connector on each of the 2 brake IGBT modules.
4. Remove the bus bar that is attached to the left side of the panel and to the left most brake IGBT by removing 2 nuts at each end of the bus bar.
5. Remove the jumper bus bar between the 2 brake IGBTs by removing the retaining nut on each end of the jumper bus bar.
6. Remove the 2 screws (T30) connecting the IGBT-inductor bus bar assembly to each brake IGBT module.
7. Remove the 9 snubber capacitors by removing 2 screws (T30) from each capacitor.
8. Remove the 3 IGBT bus bars under the snubber capacitors.
9. Remove the 4 retaining nuts (13 mm) connecting the IGBT-inductor base bar assembly to the 2 DC bus bars from the inductor.
10. Remove the IGBT-inductor bus bar assembly.
11. Remove the brake IGBT by removing the 4 mounting screws that attach each brake IGBT to the back panel.

Reassembly

Follow the special torque requirements on the instructions included with the replacement module.

1. Reinstall the brake IGBT to the back panel using the 4 mounting screws per brake IGBT.
2. Place the IGBT-inductor bus bar assembly to its original position.
3. Connect the IGBT-inductor base bar assembly to the 2 DC bus bars from the inductor. Secure the assembly using 4 retaining nuts (13 mm).
4. Place the 3 IGBT bus bars back to their original position.
5. Reinstall the 9 snubber capacitors on top of the IGBT bus bars. Secure the snubber capacitors using 2 screws (T30) per snubber capacitor.
6. Secure the IGBT-inductor bus bar assembly to each brake IGBT module using 2 screws (T30).
7. Reinstall the jumper bus bar between the 2 brake IGBTs using a retaining nut at each end of the jumper bus bars.
8. Reinstall the bus bar to the left side of the panel and to the left most brake IGBT using 2 nuts at each end of the bus bar.
9. Reconnect the brake IGBT cable to the connector on each of the 2 brake IGBT modules.
10. Reinstall the high-frequency board.
11. Reinstall both the upper and lower capacitor bank assemblies.



1	Attaching nut	6	Brake IGBT cable
2	Left attached bus bar	7	Brake IGBT module
3	Jumper bus bar between brakes	8	IGBT-inductor bus bar assembly
4	Attaching nut	9	Snubber capacitor
5	IGBT-inductor bus bar assembly	10	IGBT capacitor bus bar

Illustration 10.7 Brake IGBT Module

10.1.7 IGBT Module Replacement

Disassembly

1. Remove both the upper and lower capacitor bank assemblies. Refer to *chapter 10.1.2 Upper Capacitor Bank Assembly Replacement (without removing power card)* and *chapter 10.1.3 Lower Capacitor Bank Assembly Replacement*.
2. Remove the high-frequency board. Refer to *chapter 10.1.4 High-frequency Board Replacement*.
3. Remove the 3 current sensors. Refer to *chapter 10.1.5 Current Sensor Replacement*.
4. If the optional brake IGBT is present, complete this step. Otherwise, continue to the next step.
   - 4a Remove the bus bar attached to the left side of the panel and to the left most brake IGBT by removing 2 nuts at each end of the bus bar. Refer to *chapter 10.1.6 Brake IGBT Module Replacement*.
   - 4b Remove the 2 screws (T30) connecting the IGBT-inductor bus bar assembly to each brake IGBT module.
5. Remove the 9 snubber capacitors by removing 2 screws (T30) for from each capacitor.
6. Remove the 3 IGBT capacitor bus bars under the snubber capacitors.
7. Remove the 4 retaining nuts (13 mm) connecting the IGBT-inductor bus bar assembly to the 2 DC bus bars from the inductor.
8. Remove the IGBT-inductor bus bar assembly.
9. Remove the IGBT module by removing the 8 retaining screws (T25) that secure the IGBT module to the back panel.

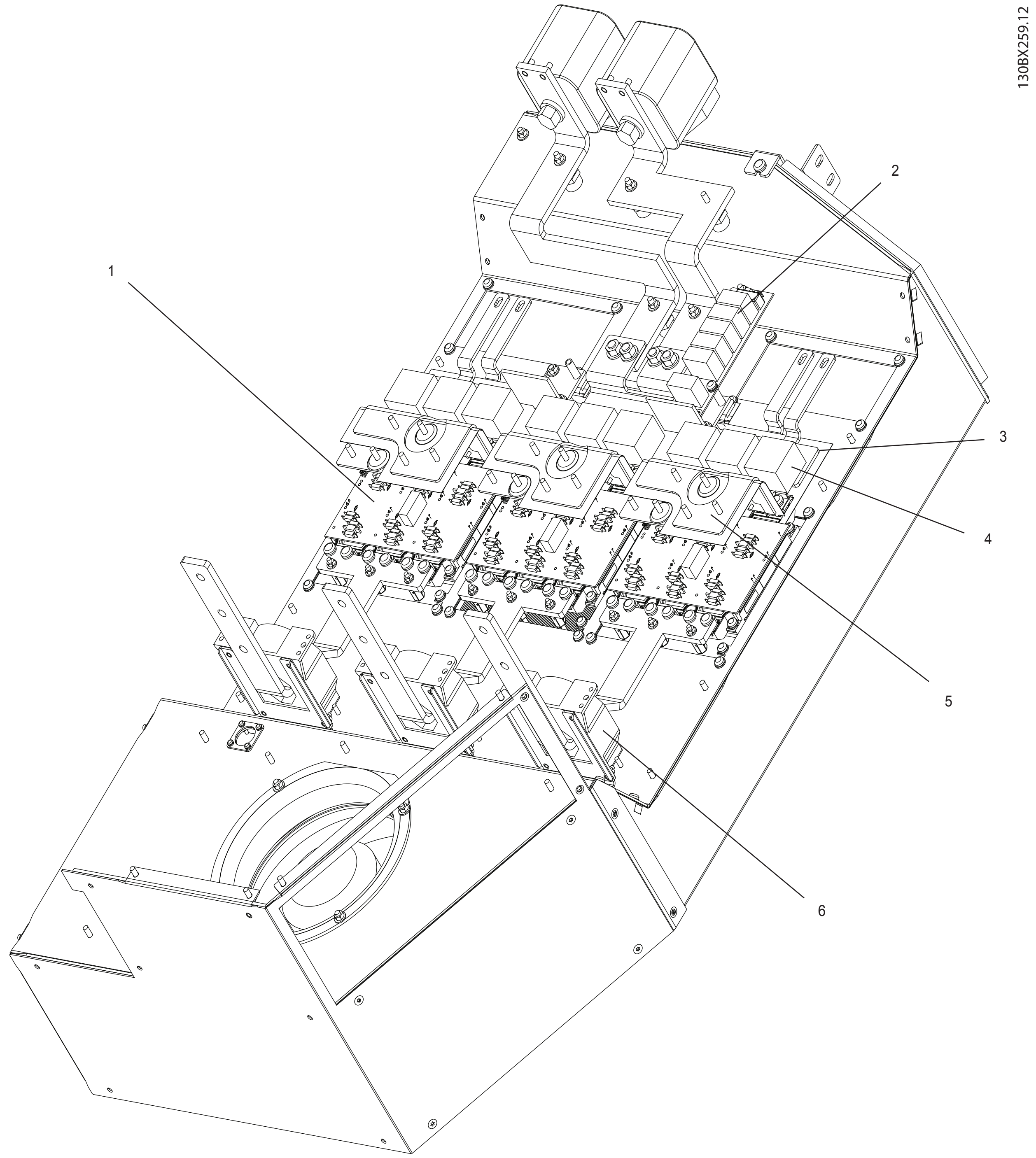
Reassembly

Follow the special torque requirements on the instructions included with the replacement module.

1. Reinstall the IGBT module to the back panel using the 8 retaining screws (T25).
2. Place the IGBT-inductor bus bar assembly to its original position.
3. Connect the IGBT-inductor base bar assembly to the 2 DC bus bars from the inductor. Secure the assembly using 4 retaining nuts (13 mm).
4. Place the 3 IGBT bus bars back to their original position.
5. Reinstall the 9 snubber capacitors on top of the IGBT bus bars. Secure the snubber capacitors using 2 screws (T30) per snubber capacitor.
6. If the optional brake IGBT is present, complete this step. Otherwise, continue to the next step.
   - 6a Connect the IGBT-inductor bus bar assembly to each brake IGBT module using 2 screws (T30).
   - 6b Reinstall bus bar to left side of panel and to left most brake IGBT using 2 nuts at each end of bus bar.
7. Reinstall the high-frequency board.
8. Reinstall both the upper and lower capacitor bank assemblies.

NOTICE

Connect the temperature sensor cable from the gatedrive card MK100 to the center IGBT module connector (MK103).



1	IGBT module	4	Snubber capacitor
2	High-frequency board	5	IGBT capacitor bus bar
3	IGBT-inductor bus bar assembly	6	Current sensor

Illustration 10.8 IGBT Module

10.1.8 Gatedrive Card Replacement

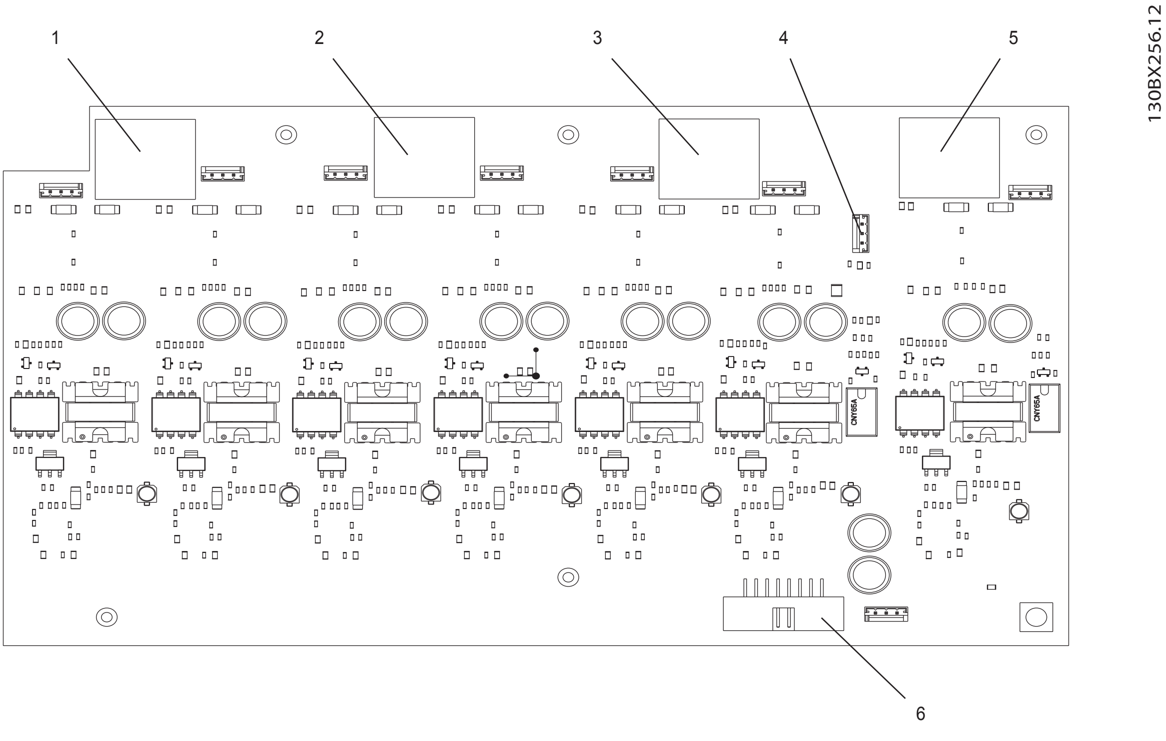
Disassembly

1. Unplug the gatedrive card connectors.
   - 1a For F1–F4 or F10–13 enclosures, unplug MK100, MK102, MK103, MK104, and MK106. If the unit has a brake option, unplug MK105. Refer to *Illustration 10.2*.
   - 1b For F8–F9 enclosures, unplug MK100, MK101, MK102, MK103, MK104, and MK106. If the unit has a brake option, unplug MK105.
2. Remove the gatedrive card by removing the 6 mounting screws (T25) from the standoffs.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Reinstall the new gatedrive card to its original position within the module. Secure the card to the standoffs with 6 screws (T25).
2. Plug in the cables to the gatedrive card connectors.
   - 2a For F1–F4 or F10–13 enclosures, connect MK100, MK102, MK103, MK104, and MK106. If the unit has a brake option, connect MK105. Refer to *Illustration 10.2*.
   - 2b For F8–F9 enclosures, connect MK100, MK101, MK102, MK103, MK104, and MK106. If the unit has a brake option, connect MK105.



1	MK104	4	MK100
2	MK103	5	MK105 (optional)
3	MK102	6	MK106

Illustration 10.9 Gatedrive Card, F1–F13

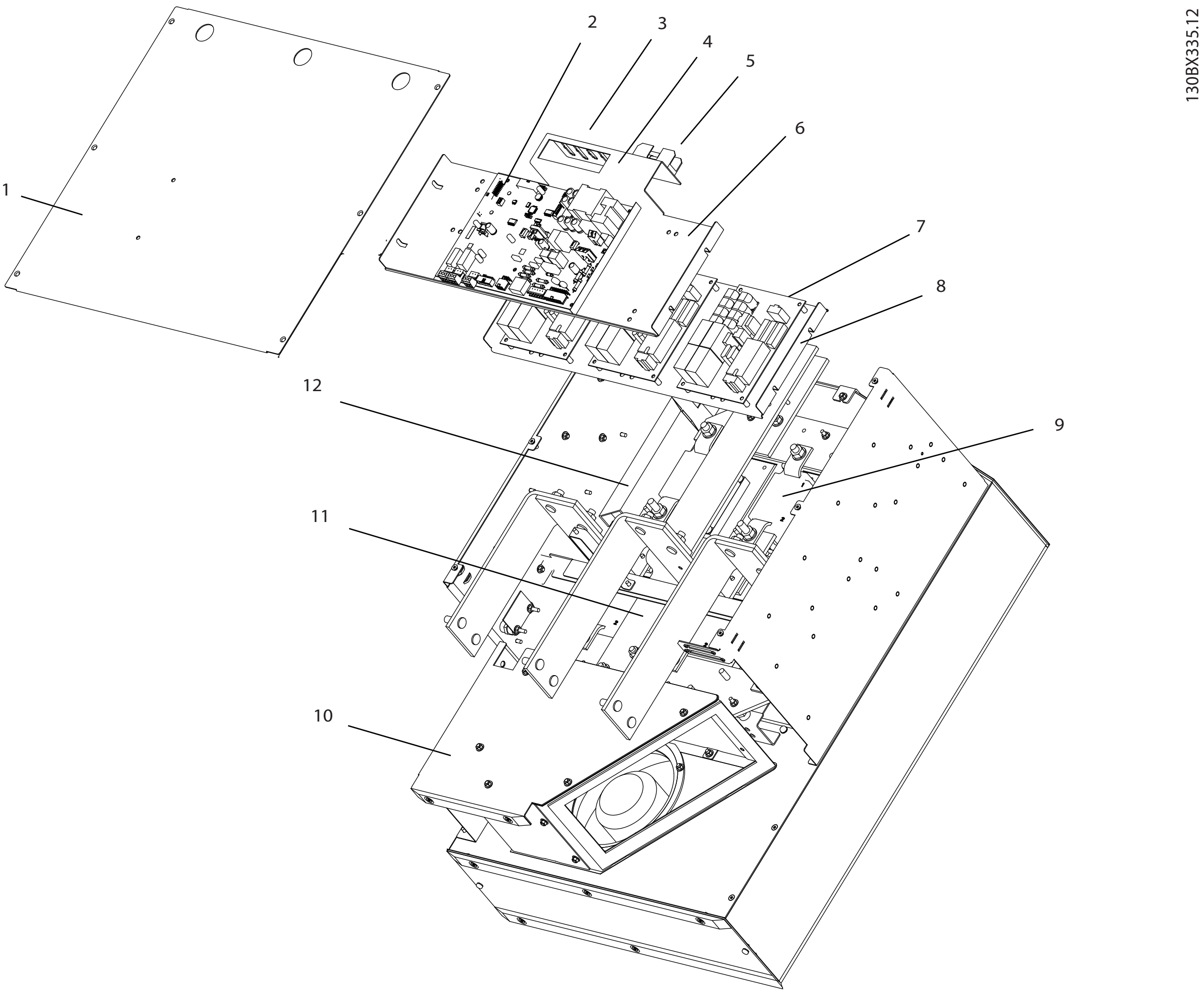
10.2 Rectifier Module

CAUTION

TRAINING REQUIRED

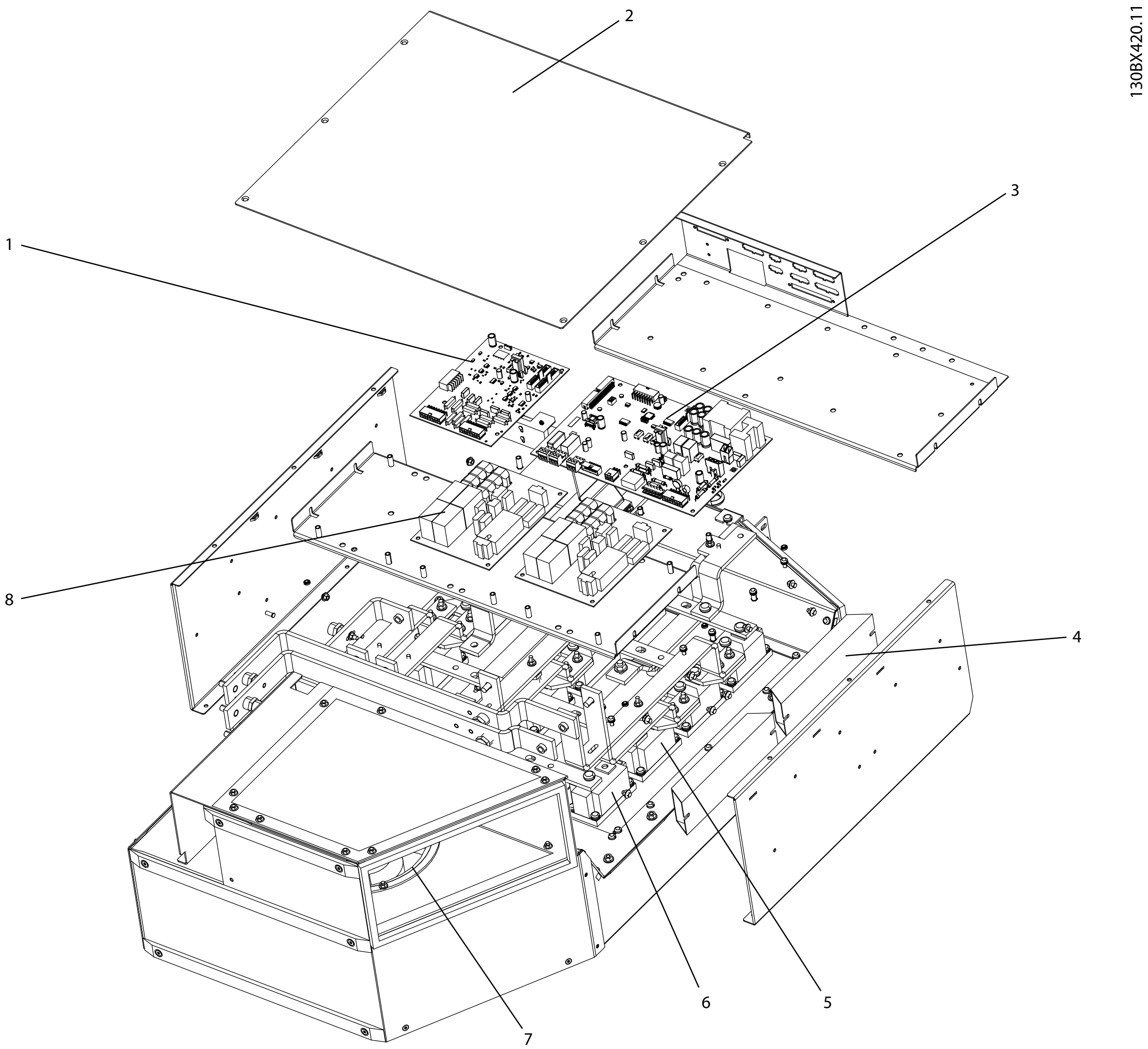
Only certified technicians who are trained by Danfoss are permitted to test and repair module components. Repair work conducted by non-certified technicians can result in personal injury or equipment damage.

1. Remove the rectifier module from the frequency converter. Refer to *chapter 9.2.5 Rectifier Module Replacement*.
2. Remove the right side panel from the rectifier module by removing 6 nuts (T25) and 1 nut (8 mm).



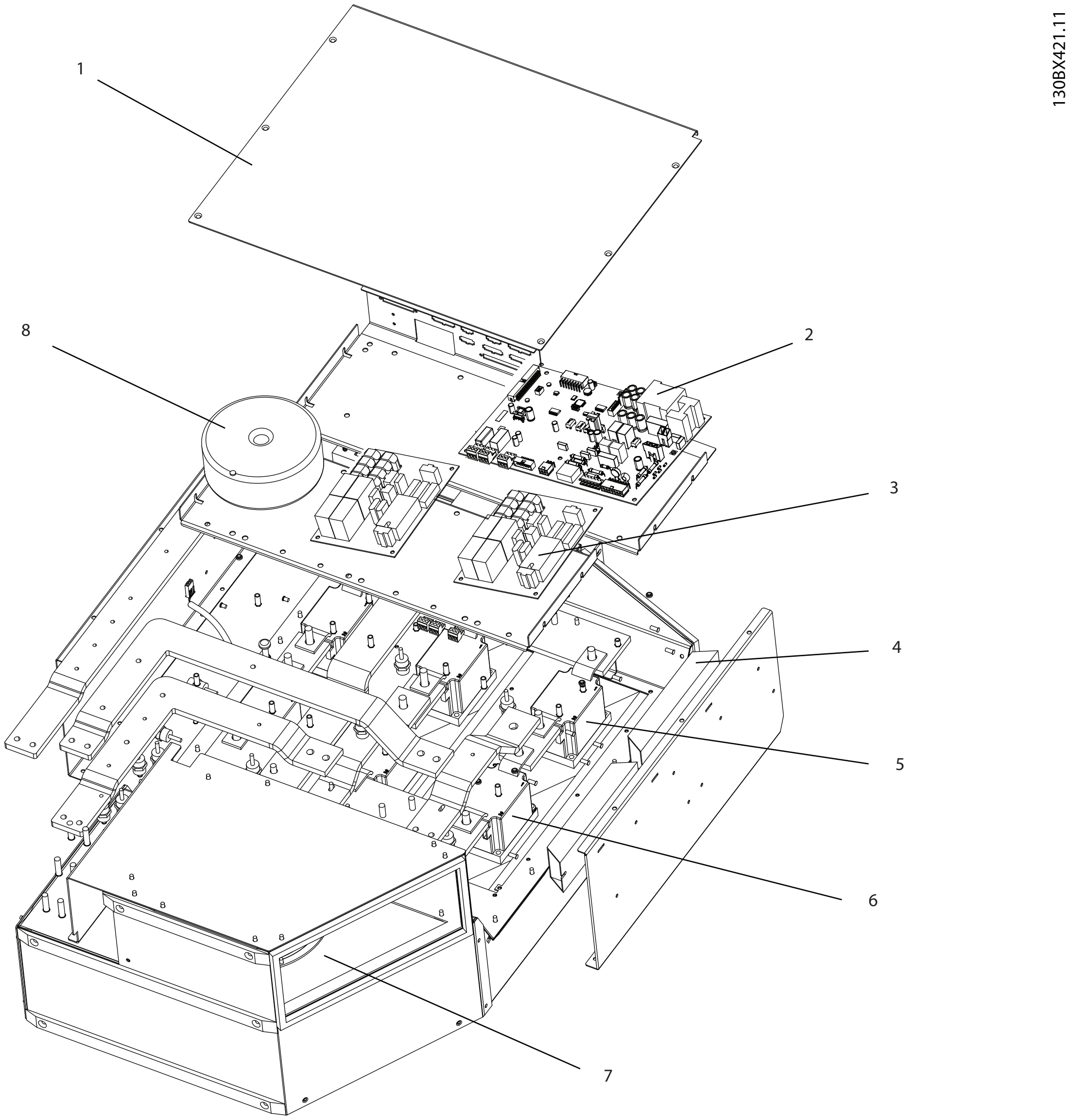
1	Rectifier module cover plate	7	Soft charge cards
2	Power card	8	Soft charge card mounting plate
3	Panel connectors	9	SCR module
4	SMPS fuse	10	Fan assembly
5	Power card mounting plate flange	11	Diode module
6	Power card mounting plate	12	Soft charge resistor

Illustration 10.10 Exploded View of Rectifier Module, F1–F4



1	MPIC card	5	Diode
2	Rectifier module cover plate	6	SCR
3	Power card	7	Fan assembly
4	Soft charge resistor	8	Soft charge card

Illustration 10.11 Exploded View of Rectifier Module, F8–F9



1	Rectifier module cover plate	5	Diode
2	Power card	6	SCR
3	Soft charge card	7	Fan assembly
4	Soft charge resistor	8	Transformer

Illustration 10.12 Exploded View of Rectifier Module, F10–F13

10.2.1 Power Card Replacement

These instructions are the same for 6-pulse and 12-pulse units, with the exception that 12-pulse units can vary in the number of SCR and diode modules. F8–F9 enclosures contain an extra MPIC card that is connected to the power card to provide control to the extra SCRs.

NOTICE

The power card can remain installed if the power card mounting plate is removed to access the soft charge boards. Remember to disconnect the cables.

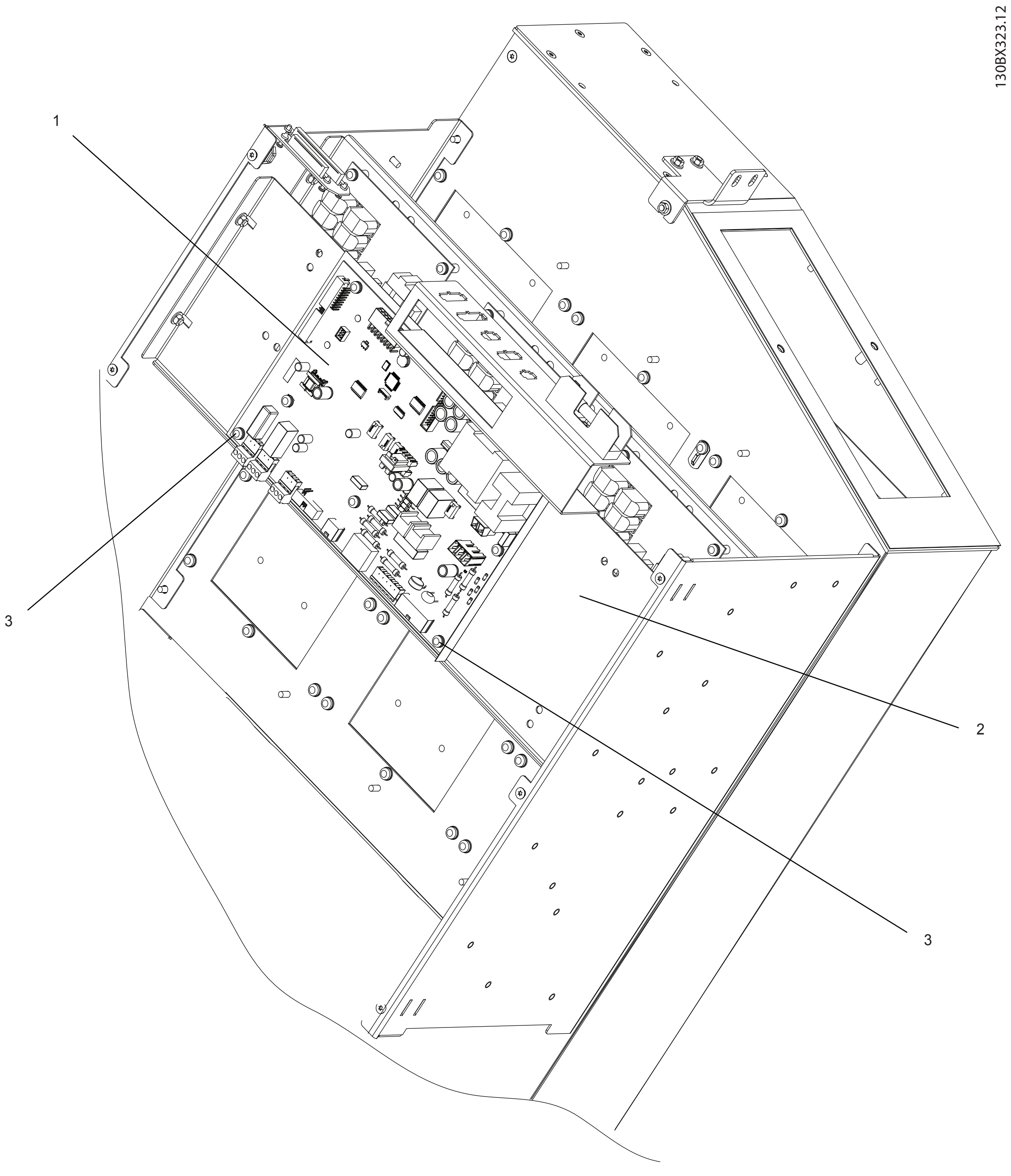
Disassembly

1. Disconnect the following cables from the power card:
   - 1a MK100
   - 1b MK102
   - 1c MK103
   - 1d MK104
   - 1e MK105
   - 1f MK106
   - 1g MK107 (F8–F13 only)
   - 1h MK108
   - 1i MK110
   - 1j MK112
   - 1k FK102
   - 1l FK103 (F8–F13 only)
2. Remove the power card by removing 7 screws (T25) and detaching the plastic standoff at the top right corner of the power card.
3. The insulation sheet behind the power card can be left in place. Ensure the sheet is in place for reassembly.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Verify that the insulation sheet is in place on the module.
2. Place the new power card on top of the insulation sheet and align the power card openings with the screw holes.
3. Attach the plastic standoff to the power card.
4. Secure the power card using 7 screws (T25).
5. Reconnect the following cables to the power card:
   - 5a MK100
   - 5b MK102
   - 5c MK103
   - 5d MK104
   - 5e MK105
   - 5f MK106
   - 5g MK107 (F8–F13 only)
   - 5h MK108
   - 5i MK110
   - 5j MK112
   - 5k FK102



1	Power card
2	Power card mounting plate
3	Power card attaching screw

Illustration 10.13 Power Card

10.2.2 12-pulse MPIC Replacement

The 12-pulse F8–F9 enclosures have a multi-pulse interface card (MPIC) mounted on the power card mounting plate.

NOTICE

The MPIC can remain installed if the power card mounting plate is removed to access the soft charge boards.

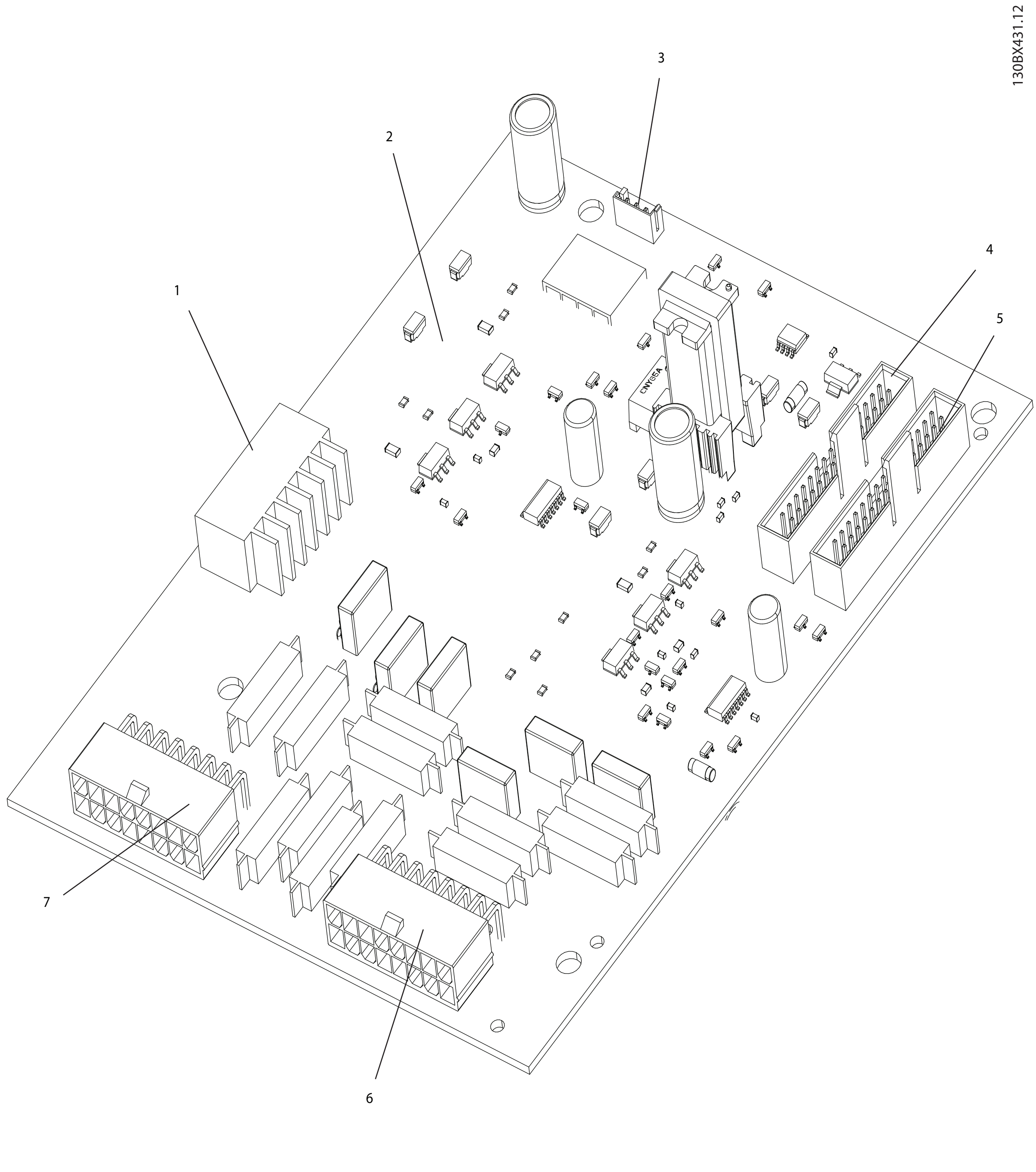
Disassembly

1. Disconnect the following cables from the MPIC:
   - 1a MK100
   - 1b MK102
   - 1c MK104
   - 1d MK105
   - 1e MK106
   - 1f MK110
2. Remove the MPIC by removing 4 screws (T25).
3. The insulation sheet behind the MPIC can be left in place. Ensure that the sheet is in place for reassembly.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Verify that the insulation sheet is in place on the module.
2. Place the new MPIC on top of the insulation sheet and align the MPIC openings with the screw holes.
3. Secure MPIC using 4 screws (T25).
4. Reconnect the following cables to the MPIC:
   - 4a MK100
   - 4b MK102
   - 4c MK104
   - 4d MK105
   - 4e MK106
   - 4f MK110



1	MK110	5	MK104
2	MPIC	6	MK102
3	MK106	7	MK101
4	MK105		

Illustration 10.14 Multi-pulse Interface Card (MPIC)

10.2.3 Power Card Mounting Plate Disassembly/Reassembly

Disassembly

1. Disconnect the 2 fast-on connectors from the fuse block that is attached to the power card mounting plate flange.
2. Disconnect the following cables from the power card:
   - 2a MK100
   - 2b MK103
   - 2c MK104
   - 2d MK105
   - 2e MK106
   - 2f MK110
3. Disconnect the 3 cable connectors (6-pin, 8-pin, and 12-pin) from the power card mounting panel flange. The cable connectors disconnect from the back side of the flange.
4. Remove the power card mounting plate by removing the 4 retaining nuts (8 mm) that secure the plate.

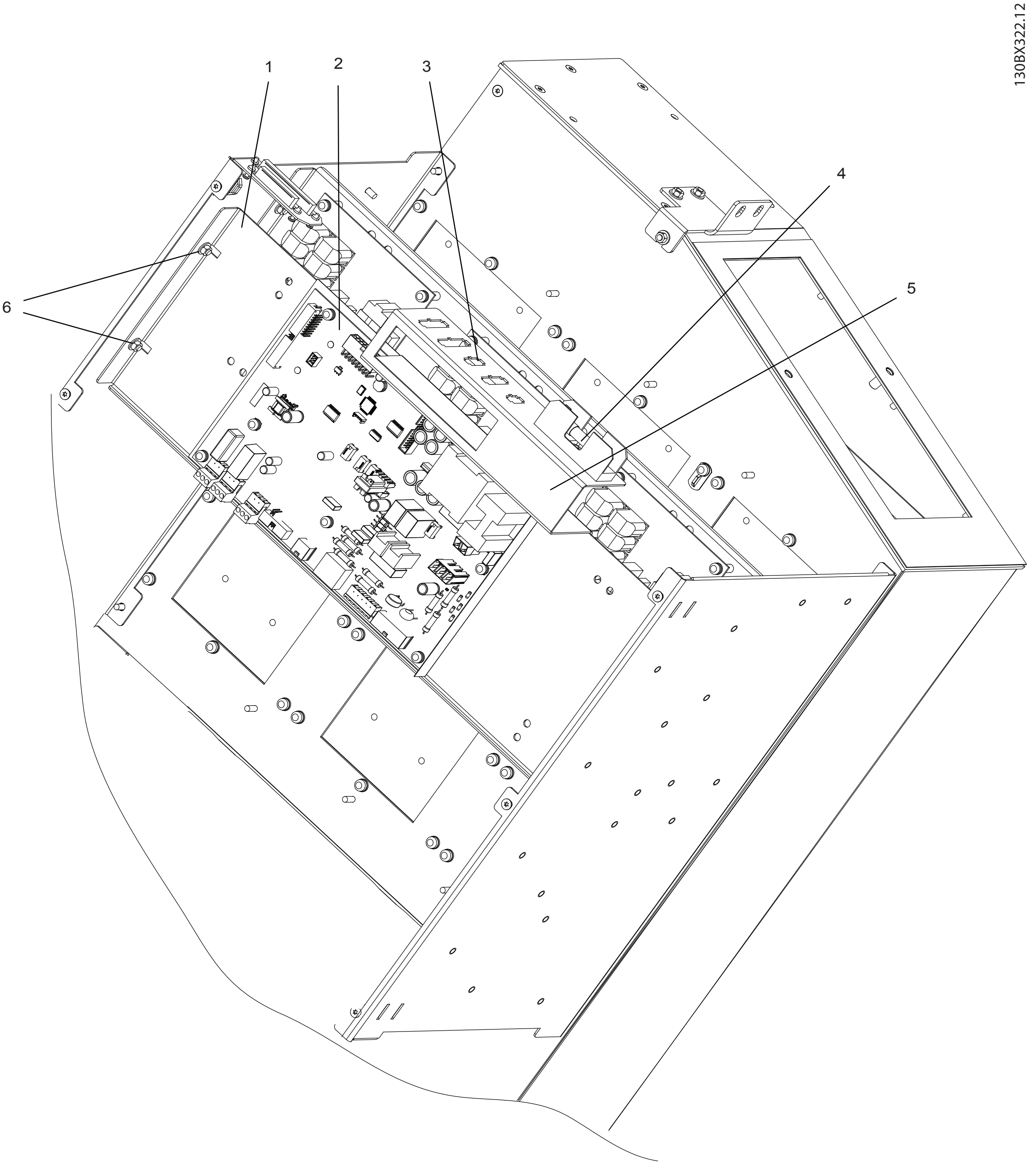
NOTICE

The soft charge cards are accessible now for changing fuses. There is 1 soft charge card per inverter module.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Position the mounting plate on the module and secure with 4 retaining nuts (8 mm).
2. Reconnect the 3 cable connectors (6-pin, 8-pin, and 12-pin) to the back side of the flange.
3. Reconnect the following cables to the power card:
   - 3a MK100
   - 3b MK103
   - 3c MK104
   - 3d MK105
   - 3e MK106
   - 3f MK110
4. Reconnect the 2 fast-on connectors to the fuse block.



1	Power card mounting plate	4	Fuse block
2	Power card	5	Power card mounting plate flange
3	Cable connectors	6	Retaining nuts (8 mm)

Illustration 10.15 Power Card Mounting Plate

10.2.4 Soft Charge Card Replacement

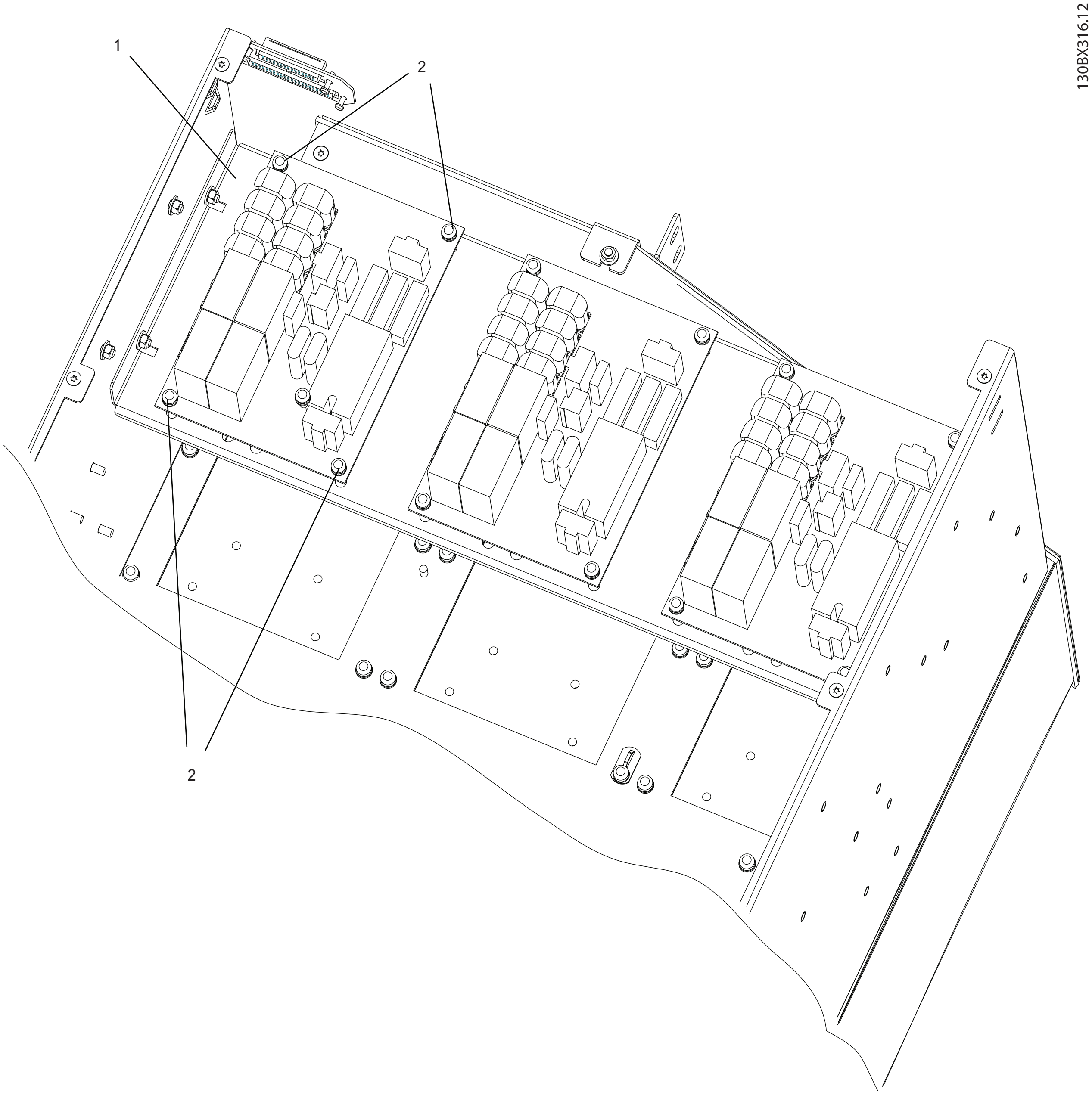
Disassembly

1. Remove the power card mounting plate. Refer to *chapter 10.2.3 Power Card Mounting Plate Disassembly/Reassembly*.
2. Disconnect the following cables from the soft charge card:
   - 2a MK1
   - 2b MK2
   - 2c MK3
   - 2d MK4
3. Remove the soft charge card from the mounting plate by removing the 4 screws (T25) securing the card to the mounting plate. Note the insulation sheet below the soft charge card. Remove and keep the insulation sheet for reinstallation.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Verify that the insulation sheet is in place on the power card mounting plate.
2. Place the new soft charge card on the insulation sheet and align the card with the screw holes in the mounting plate.
3. Secure the soft charge card using 4 screws (T25).
4. Reconnect the following cables from the soft charge card:
   - 4a MK1
   - 4b MK2
   - 4c MK3
   - 4d MK4
5. Reinstall the power card mounting plate.



1	Soft charge card
2	Attaching screw

Illustration 10.16 Soft Charge Card

10.2.5 Soft Charge Card Mounting Plate Disassembly/Reassembly

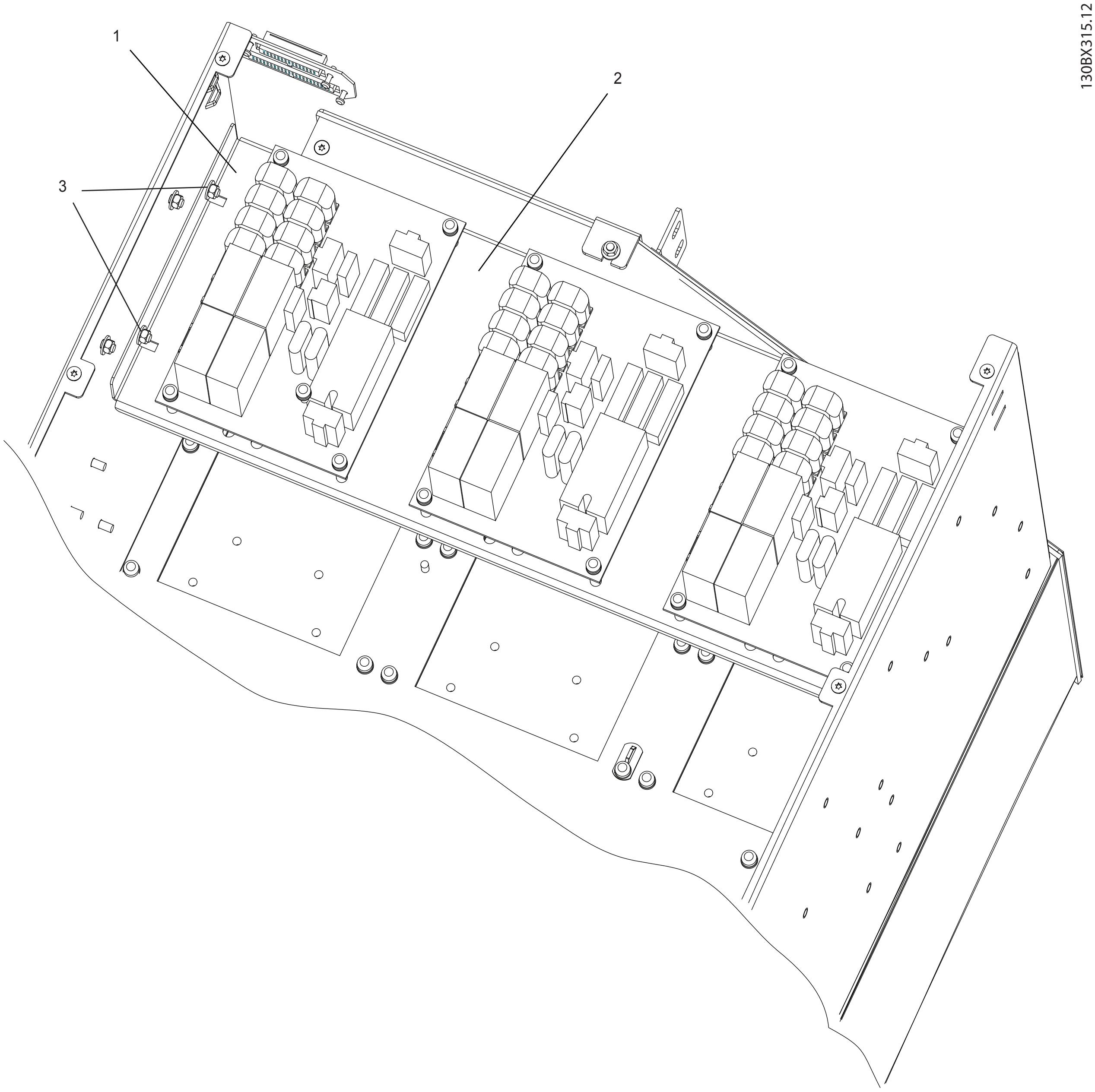
Disassembly

1. Remove the power card mounting plate.
   Refer to *chapter 10.2.3 Power Card Mounting Plate Disassembly/Reassembly*.
2. Remove the R (red), S (white), and T (black) ring lugs from the input power bus bar. There is 1 soft charge card per inverter module.
3. Disconnect the MK3 and MK4 cables from each soft charge card.
4. Remove the soft charge card mounting plate by removing the 4 nuts (8 mm) that secure the mounting plate. The soft charge cards can remain attached to the mounting plate.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Secure the soft charge mounting plate with 4 nuts (8 mm).
2. Reconnect the MK3 and MK4 cables to each soft charge card.
3. Reinstall the R (red), S (white), and T (black) ring lugs to the input power bus bar. There is 1 soft charge card per inverter module.
4. Reinstall the power card mounting plate.



1	Soft charge card
2	Soft charge card mounting plate
3	Attaching nut (8 mm)

Illustration 10.17 Soft Charge Card Mounting Plate

10.2.6 Soft Charge Resistor Replacement

Units with 2 inductors contain 2 resistors, 1 on each side of the mounting plate. Units with 3 inductors contain an extra resistor.

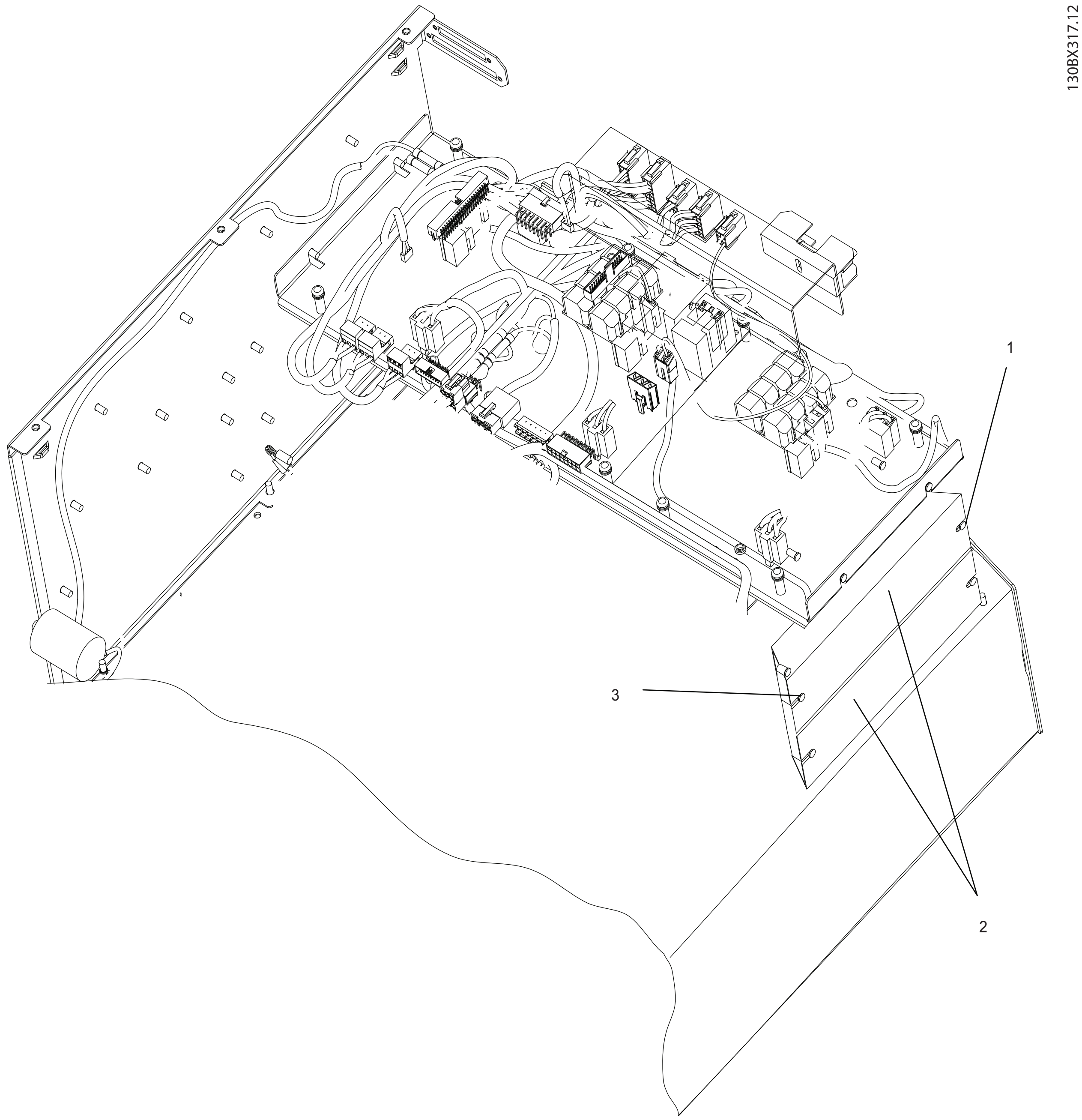
Disassembly

1. Remove the power card mounting plate.
   Refer to *chapter 10.2.3 Power Card Mounting Plate Disassembly/Reassembly*.
2. Remove the soft charge mounting plate.
   Refer to *chapter 10.2.5 Soft Charge Card Mounting Plate Disassembly/Reassembly*.
3. Loosen the nut (8 mm) on the bottom of the soft charge resistor.
4. Remove the nut (8 mm) on the top of the resistor.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Secure the new soft charge resistor with a nut (8 mm) on the top of the soft charge resistor.
2. Tighten the nut (8 mm) on the bottom of the resistor.
3. Reinstall the soft charge mounting plate.
4. Reinstall the power card mounting plate.



1	Top nut (8 mm)
2	Soft charge resistors
3	Bottom nut (8 mm)

Illustration 10.18 Soft Charge Resistor for a Unit Containing 3 Inverters

10.2.7 SCR Module Replacement

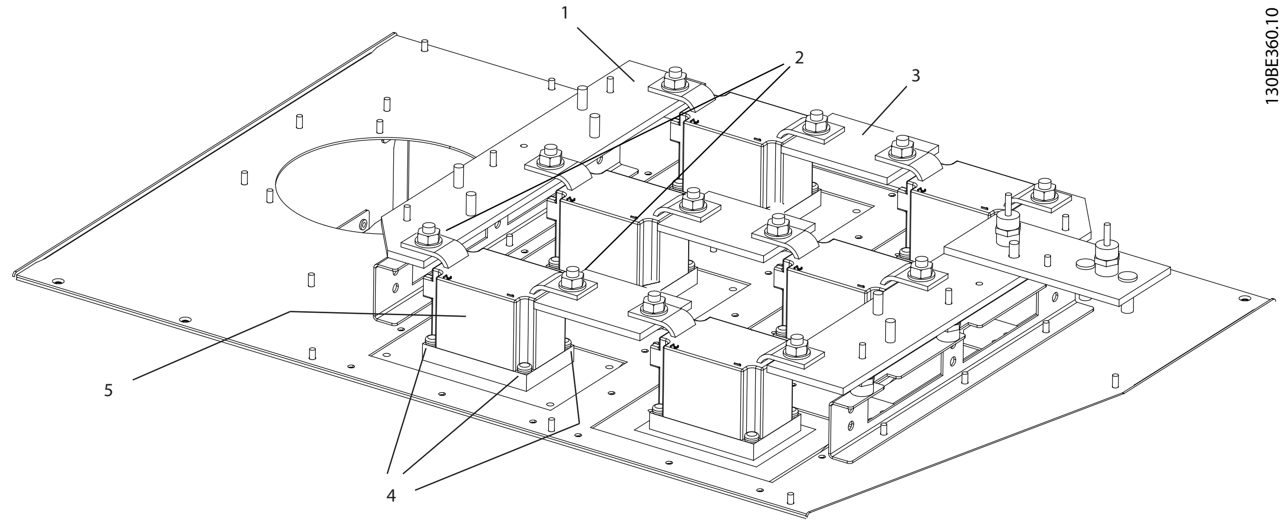
Disassembly

1. Remove the power card mounting plate.
   Refer to *chapter 10.2.3 Power Card Mounting Plate Disassembly/Reassembly*.
2. Remove the soft charge mounting plate.
   Refer to *chapter 10.2.5 Soft Charge Card Mounting Plate Disassembly/Reassembly*.
3. Remove the 6 nuts (13 mm) that secure the SCR modules to the (+) DC bus bar.
4. Remove the 2 nuts (17 mm) that secure the (+) DC bus bar to the output bus bar and remove the (+) DC bus bar.
5. Remove 6 nuts (13 mm), 2 from each SCR module, from the AC input bus bar.
6. If removing more than 1 SCR module, note which gate lead attaches to which module. Unplug gate lead from SCR module.
7. Remove the 4 mounting screws (T30) and washers attaching the SCR module to the heat sink back panel.

Reassembly

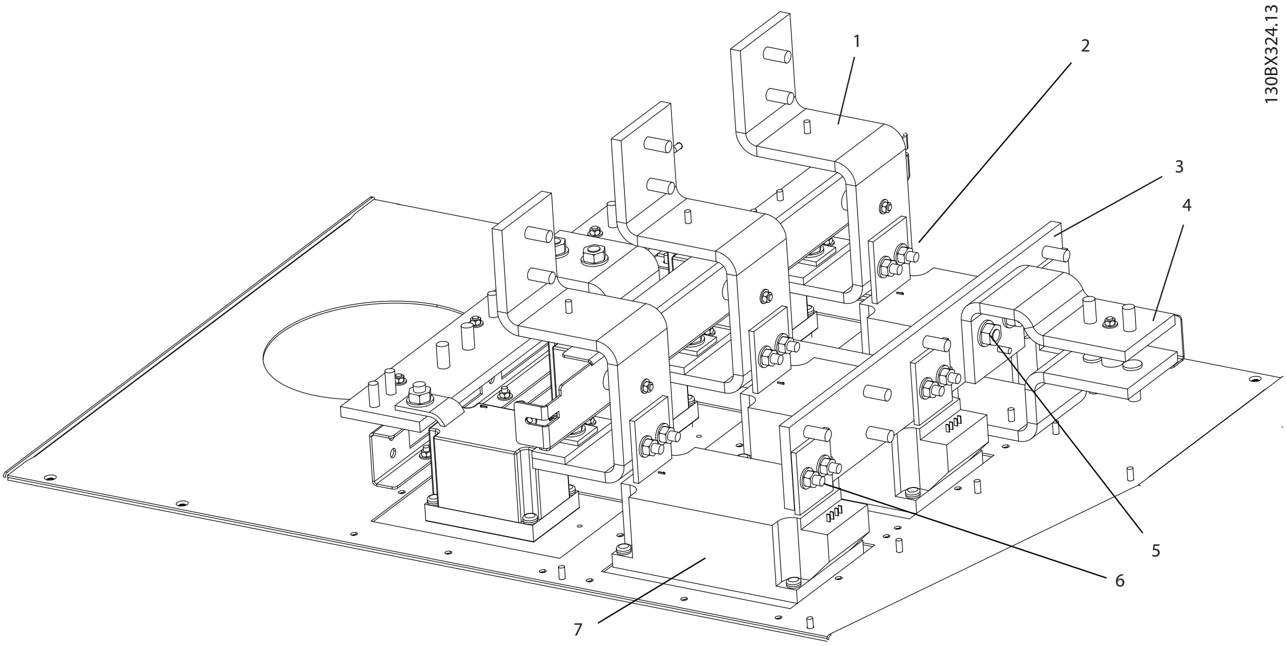
Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Attach the SCR module to the heat sink back panel with 4 mounting screws (T30) and washers.
2. Reattach the gate lead to the SCR module. If reassembling more than 1 SCR module, make sure that the gate leads are reattached in their original positions.
3. Secure the SCR modules to the AC input bus bar with 6 nuts (13 mm), 2 for each SCR module.
4. Attach the (+) DC bus bar to the output bus bar with 2 nuts (17 mm).
5. Secure the SCR modules to the (+) DC bus bars with 6 nuts (13 mm), 2 for each SCR module.
6. Reinstall the soft charge mounting plate.
7. Reinstall the power card mounting plate.



1	(+) DC bus bar	4	Retaining nuts (13 mm)
2	Retaining nuts (17 mm)	5	SCR module
3	AC input bus bar		

Illustration 10.19 SCR Module, F1 and F3



1	AC input bus bar	5	Retaining nut (17 mm)
2	Retaining nut (13 mm)	6	Retaining nut (13 mm)
3	(+) DC bus bar	7	SCR module
4	Output bus bar		

Illustration 10.20 SCR Module, F2 and F4

10.2.8 Diode Module Replacement

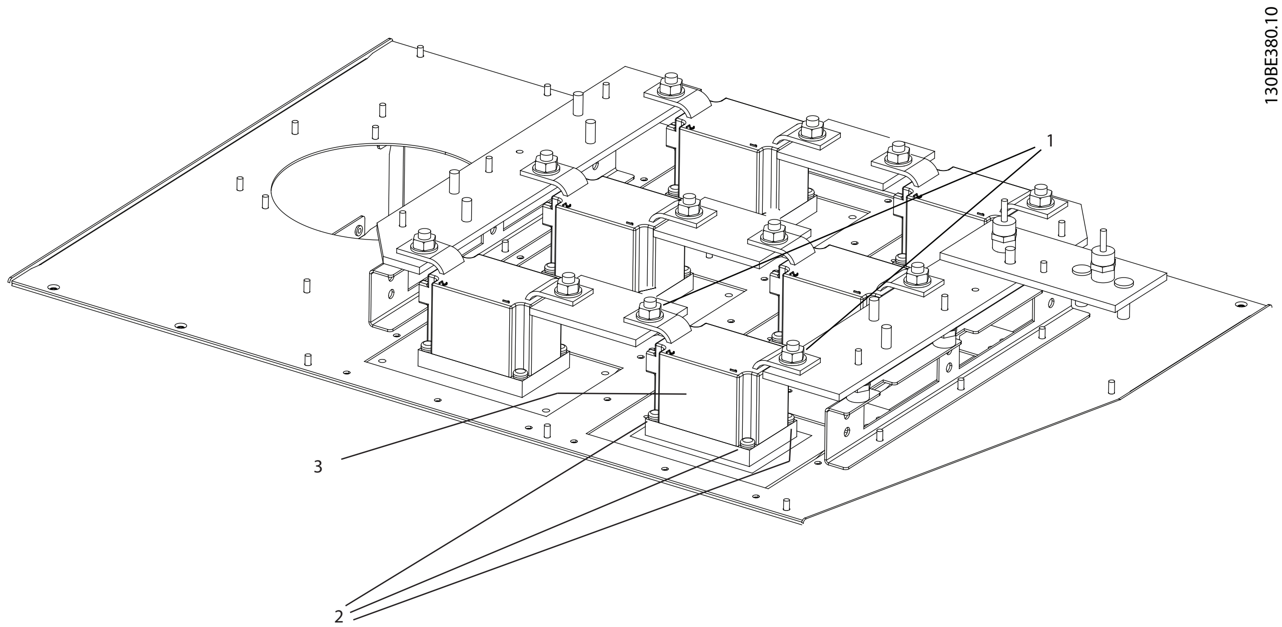
Disassembly

1. Remove the power card mounting plate.
   Refer to *chapter 10.2.3 Power Card Mounting Plate Disassembly/Reassembly*.
2. Remove the soft charge mounting plate.
   Refer to *chapter 10.2.5 Soft Charge Card Mounting Plate Disassembly/Reassembly*.
3. Remove the 2 mounting nuts (17 mm) from the diode module, 1 on the AC input side and 1 on the (-) DC side of module.
4. Remove the diode module by removing 4 retaining screws (T30) and washers from the corners of module.

Reassembly

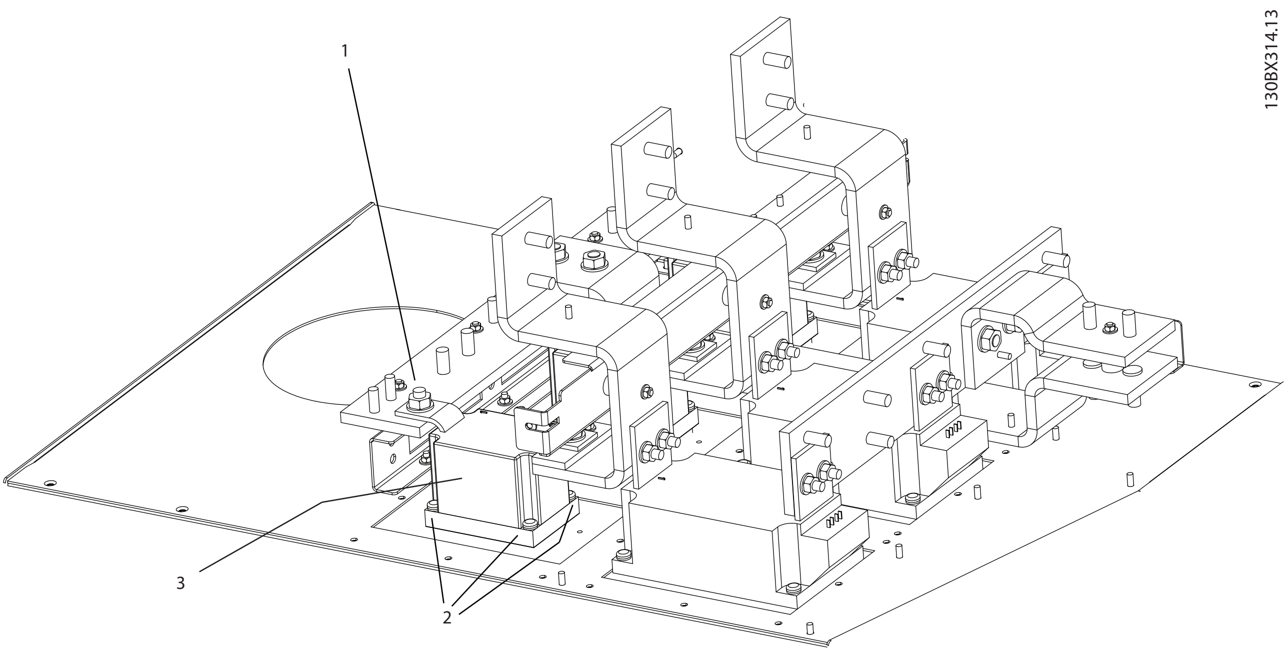
Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Secure the new diode to the module using 4 retaining screws (T30) and washers.
2. Secure the diode module to the bus bars using 1 mounting nut (17 mm) on the AC input side and 1 mounting nut (17 mm) on the (-) DC side of the module.
3. Reinstall the soft charge mounting plate.
4. Reinstall the power card mounting plate.



1	Retaining nut (17 mm)	3	Diode module
2	Screws (T30)		

Illustration 10.21 Diode Module, F1 and F3



1	Retaining nut (17 mm)	3	Diode module
2	Screws (T30)		

Illustration 10.22 Diode Module, F2 and F4

10.2.9 Heat Sink Thermal Sensor Replacement

Disassembly

1. Remove the power card mounting plate.
   Refer to *chapter 10.2.3 Power Card Mounting Plate Disassembly/Reassembly*.
2. Remove the soft charge mounting plate.
   Refer to *chapter 10.2.5 Soft Charge Card Mounting Plate Disassembly/Reassembly*.
3. Remove the heat sink thermal sensor by removing the 1 screw (T20) securing the sensor to the heat sink.

Reassembly

Follow the fastener torque values as described in *chapter 1.6 General Torque Tightening Values*.

1. Attach the new heat sink thermal sensor to the heat sink using 1 screw (T20).
2. Reinstall the soft charge mounting plate.
3. Reinstall the power card mounting plate.

11 Special Test Equipment

11.1 Test Equipment

It is highly recommended that technicians have access to the test equipment described in this chapter. Without the test equipment, some troubleshooting procedures cannot be carried out. The test equipment described here is available from Danfoss.

11.1.1 Split Bus Supply

In split bus mode, the DC bus is split into 2 parts. One part powers up the SMPS on the power card, allowing the various logic circuits to be tested without the risk of damaging the power components.

The other part can be used to provide low-voltage power to the DC capacitors and output IGBTs for test purposes. A low-voltage supply connected to the DC bus allows safe testing of the output.

Connecting the frequency converter in split bus mode:

1. Ensure that AC power has been removed and all DC capacitors are fully discharged.
2. Remove the top and bottom safety covers from each inverter module.
3. Remove the top safety cover from the rectifier modules.
4. If a motor is connected to the frequency converter, remove all output bars from each inverter module.
5. If a brake resistor is connected, remove the brake bus bars.
6. Remove the plugs from the 6-pin sockets on the top of each inverter and rectifier module.
7. Connect the supply cable (p/n 176F8766) to the 6-pin sockets on each module.
8. Connect a DC supply to the input of the supply cable. The supply must provide DC voltage between 610–750 V and have a minimum current rating of 250 mA. The Danfoss split bus supply (p/n 130B3146) is designed for this application.
9. Apply the voltage to the unit. The LCP indicator lights must illuminate as if the frequency converter was powered normally.

⚠WARNING

PERSONAL INJURY RISK

Do not apply AC mains voltage to the frequency converter when it is wired in split bus mode.

11.1.2 Signal Test Board

The signal test board provides access to various signals that can be helpful in troubleshooting the frequency converter.

The signal test board is plugged into the 30-pin panel connector on the top of each inverter module. Points on the signal test board can be monitored with or without the DC bus disabled. Sometimes, the frequency converter needs the DC bus enabled and operating a load to verify certain test signals.

The following is a description of the signals available on the signal test board. *Chapter 8 Test Procedures* describes when these tests would be called for and what the signal must be at that given test point.

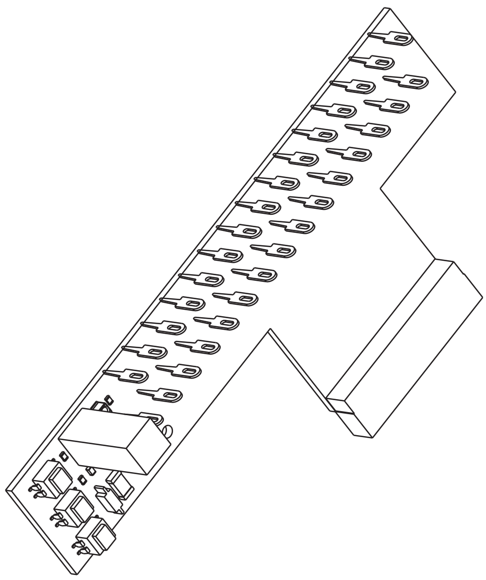
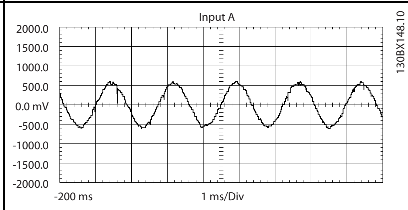
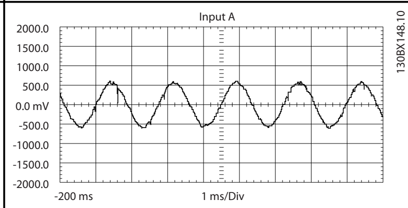
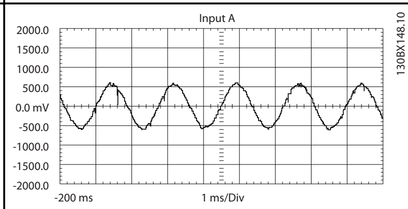


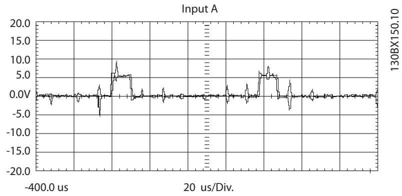
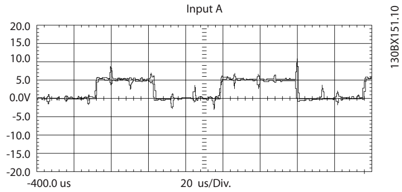
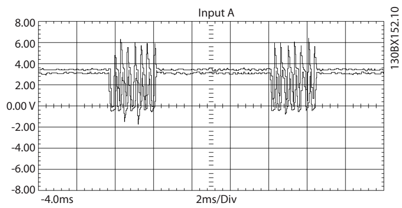
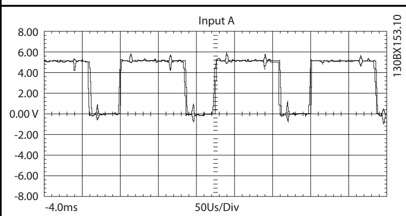
Illustration 11.1 Signal Test Board

11.1.3 Signal Test Board Pin Outs: Description and Voltage Levels

Table 11.1 lists the pins on the signal test board. For each pin, its function, description, and voltage levels are provided. How and when to perform the tests are described in *chapter 8 Test Procedures*.

Other than supply measurements, most of the signals being measured are made up of waveforms. Sometimes a digital voltmeter can be used to verify the presence of such signals, however it cannot be relied on to verify that the waveform is correct. An oscilloscope is the preferred test instrument. However, when similar signals are being measured at multiple points, a digital voltmeter can be used. By comparing several signals to each other and obtaining similar readings, it can be concluded that each of the waveforms matches one another and are therefore correct.

Pin	Schematic acronym	Function	Description	Reading using a digital voltmeter
1	IU1	Current sensed in U phase, not conditioned	 ~ 400 mv RMS @100% load	0.937 V AC_{peak} @ 165% of CT current rating. AC waveform @ output frequency of the frequency converter.
2	IV1	Current sensed in V phase, not conditioned	 ~ 400 mv RMS @100% load	0.937 V AC_{peak} @ 165% of CT current rating. AC waveform @ output frequency of the frequency converter
3	IW1	Current sensed in W phase, not conditioned	 ~ 400 mv RMS @100% load	0.937 V AC_{peak} @ 165% of CT current rating. AC waveform @ output frequency of the frequency converter.
4	COMMON	Logic common	Used for all signals.	–
5	AMBT	Ambient temperature	Used to control high and low fan speeds.	1 V DC approximately equal to 25 °C (77 °F)
6	FANO	Control card signal	Signal from the control card to turn the fans on and off.	0 V DC, ON command 5 V DC, OFF command
7	INRUSH	Control card signal	Signal from the control card to start gating the SCR front end.	3.3 V DC, SCRs disabled 0 V DC, SCRs enabled
8	RL1	Control card signal	Signal from control card to provide status of Relay 01.	0 V DC, relay active 0.7 V DC, inactive
9	–	Not used	–	–
10	–	Not used	–	–
11	VPOS	+18 V DC regulated supply +16.5 V DC to +19.5 V DC	Red indicator light indicates that voltage is present between VPOS and VNEG terminals.	+18 V DC regulated supply +16.5 V DC to +19.5 V DC
12	VNEG	-18 V DC regulated supply -16.5 V DC to -19.5 V DC	Red indicator light indicates that voltage is present between VPOS and VNEG terminals.	-18 V DC regulated supply -16.5 V DC to -19.5 V DC

Pin	Schematic acronym	Function	Description	Reading using a digital voltmeter
13	DBGATE	Brake IGBT gate pulse train	 Varies w/ brake duty cycle.	Voltage drops to 0 when brake is turned off. Voltage increases to 4.04 V DC as brake duty cycle reaches maximum.
14	BRT_ON	Brake IGBT 5 V logic level signal	 Varies with brake duty cycle.	5.10 V DC level with the brake turned off. Voltage decreases to 0 as brake duty cycle reaches maximum.
15	–	Not used	–	–
16	FAN_TST	Control signal for fans	Indicates that fan test switch is activated to force the fans on high.	+5 V DC, disabled 0 V DC, fans on high
17	FAN_ON	Pulse train to gate SCRs for fan voltage control. In sync with line frequency.	 7 trigger pulses at 3 kHz.	5 V DC, fans off
18	HI_LOW	Control signal from power card	Signal to switch fan speeds between high and low.	+5 V DC = fans on high, Otherwise, 0 V DC
19	SCR_DIS	Control signal for SCR front end	Indicates that SCR front end is enabled or disabled.	0.6 V DC to 0.8 V DC, SCRs enabled 0 V DC, SCR disabled
20	INV_DIS	Control signal from power card	Disables IGBT gate voltages.	5 V DC, inverter disabled 0 V DC, inverter enabled
21	–	Not used	–	–
22	UINVEX	Bus voltage scaled down	Signal proportional to UDC.	OV switch must be off - 1 V DC = 450 V DC [T4/T5] - 1 V DC = 610 V DC [T7]
23	VDD	+24 V DC supply	Yellow indicator light indicates that voltage is present.	+24 V DC regulated supply +23 to +25 V DC
24	VCC	+5.0 V DC regulated supply. +4.75 to +5.25 V DC.	Green indicator light indicates that voltage is present.	+5.0 V DC regulated supply +4.75 V DC to +5.25 V DC
25	GUP_T	IGBT gate signal, buffered, U phase, positive. Signal originates on control card.	 2 V/div 100 us/div Run@10 Hz.	2.2–2.5 V DC Equal on all phases TP25–TP30

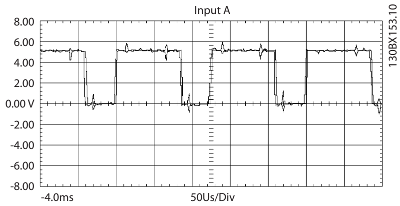
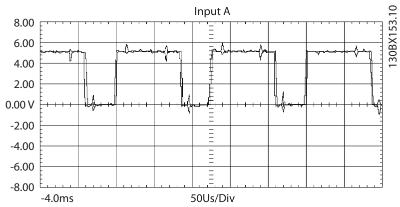
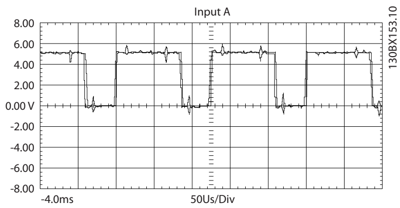
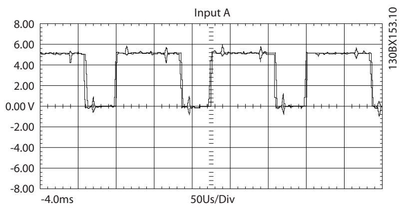
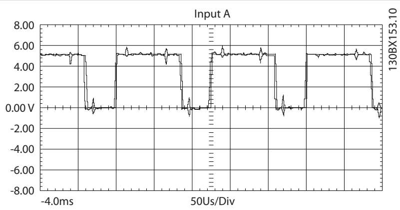
Pin	Schematic acronym	Function	Description	Reading using a digital voltmeter
26	GUN_T	IGBT gate signal, buffered, U phase, negative. Signal originates on control card.	 2 V/div 100 us/div Run@10 Hz.	2.2–2.5 V DC Equal on all phases TP25–TP30
27	GVP_T	IGBT gate signal, buffered, V phase, positive. Signal originates on control card.	 2 V/div 100 us/div Run@10 Hz.	2.2–2.5 V DC Equal on all phases TP25–TP30
28	GVN_T	IGBT gate signal, buffered, V phase, negative. Signal originates on control card.	 2 V/div 100 us/div Run@10 Hz.	2.2–2.5 V DC Equal on all phases TP25–TP30
29	GWP_T	IGBT gate signal, buffered, W phase, positive. Signal originates on control card.	 2 V/div 100 us/div Run@10 Hz.	2.2–2.5 V DC Equal on all phases TP25–TP30
30	GWN_T	IGBT gate signal, buffered, W phase, negative. Signal originates on control card.	 2 V/div 100 us/div Run@10 Hz.	2.2–2.5 V DC Equal on all phases TP25–TP30

Table 11.1 Signal Test Board Pin Descriptions

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12 Power-dependent Specifications

12.1 F1–F4 Enclosures

12.1.1 FC 102, 380–480 V

FC 102	**P500**	**P560**	**P630**	**P710**	**P800**	**P1M0**
Normal load*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Typical shaft output at 400 V [kW]	500	560	630	710	800	1000
Typical shaft output at 460 V [hp]	700	750	900	1000	1200	1350
Enclosure size	F1, F3				F2, F4	
Output current						
Continuous (at 3x380–440 V) [A]	880	990	1120	1260	1460	1720
Intermittent (at 3x380–440 V) [A]	968	1089	1232	1386	1606	1892
Continuous (at 3x441–480 V) [A]	780	890	1050	1160	1380	1530
Intermittent (at 3x441–480 V) [A]	858	979	1155	1276	1518	1683
Continuous kVA (at 400 V AC) [kVA]	610	686	776	873	1012	1192
Continuous kVA (at 460 V AC) [kVA]	621	709	837	924	1100	1219
Maximum input current						
Continuous (3x380–440 V) [A]	857	964	1090	1227	1422	1675
Continuous (3x441–480 V) [A]	159	867	1022	1129	1344	1490
Maximum pre-fuses[1] [A]	1600		2000		2500	
Maximum cable cross-section[2]						
Motor [mm² (AWG)]	8x150 (8x300 mcm)				12x150 (12x300 mcm)	
Mains [mm² (AWG)]	8x240 (8x500 mcm)					
Load share [mm² (AWG)]	4x120 (4x350 mcm)					
Brake [mm² (AWG)]	4x185 (4x350 mcm)				6x185 (6x350 mcm)	
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1318 (2242/2905)				1260/1561 (2778/3441)	
Heat sink overtemperature trip [°C (°F)]	95 (203)					
Power card ambient trip [°C (°F)]	85 (185)					
*Normal overload=110% current for 60 s						

Table 12.1 Technical Specifications, F1–F4, Mains Supply 3x380–480 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

12.1.2 FC 102, 525–690 V

FC 102	P710	P800	P900	P1M0	P1M2	P1M4
Normal load*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Typical shaft output at 550 V [kW]	560	670	750	850	1000	1100
Typical shaft output at 575 V [hp]	750	950	1050	1150	1350	1550
Typical shaft output at 690 V [kW]	710	800	900	1000	1200	1400
Enclosure size	F1, F3			F2, F4		
Output current						
Continuous (at 550 V) [A]	763	889	988	1108	1317	1479
Intermittent (60 s overload) (at 550 V) [A]	839	978	1087	1219	1449	1627
Continuous (at 575/690 V) [A]	730	850	945	1060	1260	1415
Intermittent (60 s overload) (at 575/690 V) [kVA]	803	935	1040	1166	1386	1557
Continuous kVA (at 550 V) [kVA]	727	847	941	1056	1255	1409
Continuous kVA (at 575 V) [kVA]	727	847	941	1056	1255	1409
Continuous kVA (at 690 V) [kVA]	872	1016	1129	1267	1506	1691
Maximum input current						
Continuous (at 550 V) [A]	743	866	962	1079	1282	1440
Continuous (at 575 V) [A]	711	828	920	1032	1227	1378
Continuous (at 690 V) [A]	711	828	920	1032	1227	1378
Maximum external mains fuses[1)] [A]	1600				2000	2500
Maximum cable cross-section[2)]						
Motor [mm^2 (AWG)]	8x150 (8x300 mcm)			12x150 (12x300 mcm)		
Mains [mm^2 (AWG)]	8x240 (8x500 mcm)			8x240 (8x500 mcm)		
Load share [mm^2 (AWG)]	4x185 (4x350 mcm)			6x185 (6x300 mcm)		
Brake [mm^2 (AWG)]						
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1038 (2242/2288)			1260/1561 (1278/3441)	1294/1595 (2853/3516)	
Heat sink overtemperature trip [°C (°F)]	95 (203)	105 (221)	95 (203)		105 (221)	95 (203)
Power card ambient trip [°C (°F)]	85 (185)					
*Normal overload=110% current for 60 s.						

Table 12.2 Technical Specifications, F1–F4, Mains Supply 3x525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

12.1.3 FC 202, 380–480 V

FC 202	**P500**		**P560**		**P630**		**P710**		**P800**		**P1M0**	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 400 V [kW]	450	500	500	560	560	630	630	710	710	800	800	1000
Typical shaft output at 460 V [hp]	600	650	650	750	750	900	900	1000	1000	1200	1200	1350
Enclosure size	F1, F3								F2, F4			
Output current												
Continuous (at 3x380–440 V) [A]	800	880	880	990	990	1120	1120	1260	1260	1460	1460	1720
Intermittent (at 3x380–440 V) [A]	1200	968	1320	1089	1485	1232	1680	1386	1890	1606	2190	1892
Continuous (at 3x441–480 V) [A]	730	780	780	890	890	1050	1050	1160	1160	1380	1380	1530
Intermittent (at 3x441–480 V) [A]	1095	858	1170	979	1335	1155	1575	1276	1740	1518	2070	1683
Continuous kVA (at 400 V AC) [kVA]	554	610	610	686	686	776	776	873	873	1012	1012	1192
Continuous kVA (at 460 V AC) [kVA]	582	621	621	709	709	837	837	924	924	1100	1100	1219
Maximum input current												
Continuous (3x380–440 V) [A]	779	857	857	964	964	1090	1090	1227	1227	1422	1422	1675
Continuous (3x441–480 V) [A]	711	759	759	867	867	1022	1022	1129	1129	1344	1344	1490
Maximum pre-fuses[1)] [A]	1600				2000				2500			
Maximum cable cross-section[2)]												
Motor [mm^2 (AWG)]	8x150 (8x300 mcm)								12x150 (12x300 mcm)			
Mains, F1 and F2 [mm^2 (AWG)]	8x240 (8x500 mcm)											
Mains, F3 and F4 [mm^2 (AWG)]	8x456 (8x900 mcm)											
Load share [mm^2 (AWG)]	4x120 (4x250 mcm)											
Brake [mm^2 (AWG)]	4x185 (4x350 mcm)								6x185 (6x350 mcm)			
Other information												
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1318 (2242/2905)								1260/1561 (2778/3441)			
Weight, rectifier module [kg (lb)]	102 (224)								136 (299)			
Weight, inverter module [kg (lb)]	102 (224)						136 (299)		102 (224)			
Heat sink overtemperature trip [°C (°F)]	95 (203)											
Power card ambient trip [°C (°F)]	75 (167)											
*High overload=150% current for 60 s, normal overload=110% current for 60 s												

Table 12.3 Technical Specifications, F1–F4, Mains Supply 3x380–480 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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12.1.4 FC 202, 525–690 V

FC 202	P710		P800		P900	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	500	560	560	670	670	750
Typical shaft output at 575 V [hp]	650	750	750	950	950	1050
Typical shaft output at 690 V [kW]	630	710	710	800	800	900
Enclosure size	F1, F3					
Output current						
Continuous (at 550 V) [A]	659	763	763	889	889	988
Intermittent (60 s overload) (at 550 V) [A]	989	839	1145	978	1334	1087
Continuous (at 575/690 V) [A]	630	730	730	850	850	945
Intermittent (60 s overload) (at 575/690 V) [kVA]	945	803	1095	935	1275	1040
Continuous kVA (at 550 V) [kVA]	628	727	727	847	847	941
Continuous kVA (at 575 V) [kVA]	627	727	727	847	847	941
Continuous kVA (at 690 V) [kVA]	753	872	872	1016	1016	1129
Maximum input current						
Continuous (at 550 V) [A]	642	743	743	866	866	962
Continuous (at 575 V) [A]	613	711	711	828	828	920
Continuous (at 690 V) [A]	613	711	711	828	828	920
Maximum external mains fuses[1] [A]	1600					
Maximum cable cross-section[2)]						
Motor [mm^2 (AWG)]	8x150 (8x300 mcm)					
Mains, F1 [mm^2 (AWG)]	8x240 (8x500 mcm)					
Mains, F3 [mm^2 (AWG)]	8x456 (8x900 mcm)					
Load share [mm^2 (AWG)]	4x120 (4x250 mcm)					
Brake [mm^2 (AWG)]	4x185 (4x350 mcm)					
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1318 (2242/2905)					
Weight, rectifier module [kg (lb)]	102 (224)					
Weight, inverter module [kg (lb)]	102 (224)				136 (299)	
Heat sink overtemperature trip [°C (°F)]	95 (203)		105 (221)		95 (203)	
Power card ambient trip [°C (°F)]	85 (185)					
*High overload=150% current for 60 s, normal overload=110% current for 60 s.						

Table 12.4 Technical Specifications, F1–F4, Mains Supply 3x525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

FC 202	P1M0		P1M2		P1M4	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	750	850	850	1000	1000	1100
Typical shaft output at 575 V [hp]	1050	1150	1150	1350	1350	1550
Typical shaft output at 690 V [kW]	900	1000	1000	1200	1200	1400
Enclosure size	F2, F4					
Output current						
Continuous (at 550 V) [A]	988	1108	1108	1317	1317	1479
Intermittent (60 s overload) (at 550 V) [A]	1482	1219	1662	1449	1976	1627
Continuous (at 575/690 V) [A]	945	1060	1060	1260	1260	1415
Intermittent (60 s overload) (at 575/690 V) [kVA]	1418	1166	1590	1386	1890	1557
Continuous kVA (at 550 V) [kVA]	941	1056	1056	1255	1255	1409
Continuous kVA (at 575 V) [kVA]	941	1056	1056	1255	1255	1409
Continuous kVA (at 690 V) [kVA]	1129	1267	1267	1506	1506	1691
Maximum input current						
Continuous (at 550 V) [A]	962	1079	1079	1282	1282	1440
Continuous (at 575 V) [A]	920	1032	1032	1227	1227	1378
Continuous (at 690 V) [A]	920	1032	1032	1227	1227	1378
Maximum external mains fuses[1)] [A]	1600		2000		2500	
Maximum cable cross-section[2)]						
Motor [mm^2 (AWG)]	12x150 (12x300 mcm)					
Mains, F2 [mm^2 (AWG)]	8x240 (8x500 mcm)					
Mains, F4 [mm^2 (AWG)]	8x456 (8x900 mcm)					
Load share [mm^2 (AWG)]	4x120 (4x250 mcm)					
Brake [mm^2 (AWG)]	6x185 (6x350 mcm)					
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1260/1561 (2778/3441)				1294/1595 (2852/3516)	
Weight, rectifier module [kg (lb)]	136 (299)					
Weight, inverter module [kg (lb)]	102 (224)				136 (299)	
Heat sink overtemperature trip [°C (°F)]	95 (203)		105 (221)		95 (203)	
Power card ambient trip [°C (°F)]	85 (185)					
*High overload=150% current for 60 s, normal overload=110% current for 60 s.						

Table 12.5 Technical Specifications, F1–F4, Mains Supply 3x525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

12.1.5 FC 302, 380–500 V

FC 302	**P450**		**P500**		**P560**		**P630**		**P710**		**P800**	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 400 V [kW]	450	500	500	560	560	630	630	710	710	800	800	1000
Typical shaft output at 460 V [hp]	600	650	650	750	750	900	900	1000	1000	1200	1200	1350
Typical shaft output at 500 V [kW]	530	560	560	630	630	710	710	800	800	1000	1000	1100
Enclosure size	F1, F3								F2, F4			
Output current												
Continuous (at 400 V) [A]	800	880	880	990	990	1120	1120	1260	1260	1460	1460	1720
Intermittent (60 s overload) (at 400 V) [A]	1200	968	1320	1089	1485	1232	1680	1386	1890	1606	2190	1892
Continuous (at 460/500 V) [A]	730	780	780	890	890	1050	1050	1160	1160	1380	1380	1530
Intermittent (60 s overload) (at 460/500 V) [A]	1095	858	1170	979	1335	1155	1575	1276	1740	1518	2070	1683
Continuous kVA (at 400 V) [kVA]	554	610	610	686	686	776	776	873	873	1012	1012	1192
Continuous kVA (at 460 V) [kVA]	582	621	621	709	709	837	837	924	924	1100	1100	1219
Continuous kVA (at 500 V) [kVA]	632	675	675	771	771	909	909	1005	1005	1195	1195	1325
Maximum input current												
Continuous (at 400 V) [A]	779	857	857	964	964	1090	1090	1227	1227	1422	1422	1675
Continuous (at 460/500 V) [A]	711	759	759	867	867	1022	1022	1129	1129	1344	1344	1490
Maximum external mains fuses[1] [A]	1600				2000				2500			
Maximum cable cross-section[2]												
Motor [mm^2 (AWG)]	8x150 (8x300 mcm)								12x150 (12x300 mcm)			
Mains, F1 and F4 [mm^2 (AWG)]	8x240 (8x500 mcm)											
Mains, F3 and F4 [mm^2 (AWG)]	8x456 (8x900 mcm)											
Load share [mm^2 (AWG)]	4x120 (4x250 mcm)											
Brake [mm^2 (AWG)]	4x185 (4x350 mcm)								6x185 (6x350 mcm)			
Other information												
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1318 (2242/2910)								1260/1561 (2778/3441)			
Weight, rectifier module [kg (lb)]	102 (225)								136 (300)			
Weight, inverter module [kg (lb)]	102 (225)						136 (300)		102 (225)			
Heat sink overtemperature trip [°C (°F)]	110 (230)											
Control card ambient trip [°C (°F)]	85 (185)											
* High overload=160% torque during 60 s, normal overload=110% torque during 60 s.												

Table 12.6 Technical Specifications, F8–F13, Mains Supply 380–500 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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12.1.6 FC 302, 525–690 V

FC 302	P630		P710		P800	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	500	560	560	670	670	750
Typical shaft output at 575 V [hp]	650	750	750	950	950	1050
Typical shaft output at 690 V [kW]	630	710	710	800	800	900
Enclosure size	F1, F3					
Output current						
Continuous (at 550 V) [A]	659	763	763	889	889	988
Intermittent (60 s overload) (at 550 V) [A]	989	839	1145	978	1334	1087
Continuous (at 575/690 V) [A]	630	730	730	850	850	945
Intermittent (60 s overload) (at 575/690 V) [A]	945	803	1095	935	1275	1040
Continuous kVA (at 550 V) [kVA]	628	727	727	847	847	941
Continuous kVA (at 575 V) [kVA]	627	727	727	847	847	941
Continuous kVA (at 690 V) [kVA]	753	872	872	1016	1016	1129
Maximum input current						
Continuous (at 550 V) [A]	642	743	743	866	866	962
Continuous (at 575 V) [A]	613	711	711	828	828	920
Continuous (at 690 V) [A]	613	711	711	828	828	920
Maximum cable cross-section1)						
Motor [mm^2 (AWG)]	8x150 (8x300 mcm)					
Mains, F1 [mm^2 (AWG)]	8x240 (8x500 mcm)					
Mains, F3 [mm^2 (AWG)]	8x456 (8x900 mcm)					
Load share [mm^2 (AWG)]	4x120 (4x250 mcm)					
Brake [mm^2 (AWG)]	4x185 (4x350 mcm)					
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1318 (2242/2910)					
Weight, rectifier module [kg (lb)]	102 (225)					
Weight, inverter module [kg (lb)]	102 (225)				136 (300)	
Heat sink overtemperature trip [°C (°F)]	95 (203)		105 (221)		95 (203)	
Power card ambient trip [°C (°F)]	85 (185)					
* High overload=160% torque during 60 s, normal overload=110% torque during 60 s.						

Table 12.7 Technical Specifications, F1–F4, Mains Supply 525–690 V AC

1) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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FC 302	P900		P1M0		P1M2	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	750	850	850	1000	1000	1100
Typical shaft output at 575 V [hp]	1050	1150	1150	1350	1350	1550
Typical shaft output at 690 V [kW]	900	1000	1000	1200	1200	1400
Enclosure size	F2, F4					
Output current						
Continuous (at 550 V) [A]	988	1108	1108	1317	1317	1479
Intermittent (60 s overload) (at 550 V) [A]	1482	1219	1662	1449	1976	1627
Continuous (at 575/690 V) [A]	945	1060	1060	1260	1260	1415
Intermittent (60 s overload) (at 575/690 V) [A]	1418	1166	1590	1386	1890	1557
Continuous kVA (at 550 V) [kVA]	941	1056	1056	1255	1255	1409
Continuous kVA (at 575 V) [kVA]	941	1056	1056	1255	1255	1409
Continuous kVA (at 690 V) [kVA]	1129	1267	1267	1506	1506	1691
Maximum input current						
Continuous (at 550 V) [A]	962	1079	1079	1282	1282	1440
Continuous (at 575 V) [A]	920	1032	1032	1227	1227	1378
Continuous (at 690 V) [A]	920	1032	1032	1227	1227	1378
Maximum external mains fuses[1)] [A]	1600		2000		2500	
Maximum cable cross-section[2)]						
Motor [mm^2 (AWG)]	12x150 (12x300 mcm)					
Mains, F2 [mm^2 (AWG)]	8x240 (8x500 mcm)					
Mains, F4 [mm^2 (AWG)]	8x456 (8x900 mcm)					
Load share [mm^2 (AWG)]	4x120 (4x250 mcm)					
Brake [mm^2 (AWG)]	6x185 (6x350 mcm)					
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1260/1562 (2778/3444)				1294/1595 (2853/3516)	
Weight, rectifier module [kg (lb)]	136 (300)					
Weight, inverter module [kg (lb)]	102 (225)				136 (300)	
Heat sink overtemperature trip [°C (°F)]	95 (203)		105 (221)		95 (203)	
Power card ambient trip [°C (°F)]	85 (185)					
* High overload=160% torque during 60 s, normal overload=110% torque during 60 s.						

Table 12.8 Technical Specifications, F1–F4, Mains Supply 525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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12.2 F8–F9 and F10–F13 Enclosures

12.2.1 FC 102, 380–480 V

FC 102	P315	P355	P400	P450	P500	P560	P630	P710	P800	P1M0
Normal overload 110% for 1 minute	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Typical shaft output [kW] at 400 V	315	355	400	450	500	560	630	710	800	1000
Typical shaft output [hp] at 460 V	450	500	550/600	600	650	750	900	1000	1200	1350
Enclosure size	F8, F9				F10, F11				F12, F13	
Output current										
Continuous (at 380–440 V)	600	658	745	800	880	990	1120	1260	1460	1720
Intermittent (60 s overload at 380–440 V)	660	724	820	880	968	1089	1232	1386	1606	1892
Continuous (at 400 V)	416	456	516	554	610	686	776	873	1012	1192
Intermittent (60 s overload at 460–500 V)	457	501	568	610	671	754	854	960	1113	1311
Continuous (at 441–500 V)	540	590	678	730	780	890	1050	1160	1380	1530
Intermittent (60 s overload) (at 441–500 V)	594	649	746	803	858	979	1155	1276	1518	1683
Continuous (at 460 V)	430	470	540	582	621	709	837	924	1100	1219
Continuous (at 500 V)	473	517	594	640	684	780	920	1017	1209	1341
Maximum input current										
Continuous (3x380–440 V) [A]	590	647	733	787	857	964	1090	1227	1422	1675
Continuous (3x441–480 V) [A]	531	580	667	718	759	867	1022	1129	1344	1490
Maximum external mains fuses[1)][A]	700				900			1500		
Maximum cable cross-section[2)]										
Motor [mm² (AWG)]	8x150 (8x300 mcm)								12x150 (12x300 mcm)	
Mains [mm² (AWG)]	8x250 (8x500 mcm)									
Regeneration terminals [mm² (AWG)]	4x120 (4x250 mcm)									
Brake [mm² (AWG)]	2x185 (2x350 mcm)				4x185 (4x350 mcm)					
Other information										
Weight enclosure IP21/IP54 [kg (lb)]	263 (580)	270 (595)	272 (600)	313 (690)	1004 (2214)				1246 (2748)	
Heat sink overtemperature trip [°C (°F)]	110 (230)				95 (203)					
Power card ambient trip [°C (°F)]	85 (185)									

Table 12.9 Technical Specifications, F8–F13, Mains Supply 380–480 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

12.2.2 FC 102, 525–690 V

FC 102	P450	P500	P560	P630	P710	P800	P900	P1M0	P1M2	P1M4
Normal overload 110% for 1 minute	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Typical shaft output [hp] at 525–550 V	355	400	450	500	560	670	750	850	1000	1100
Typical shaft output [kW] at 690	450	500	560	630	710	800	900	1000	1200	1400
Typical shaft output [hp] at 575	450	500	600	650	750	950	1050	1150	1350	1550
Enclosure size	F8, F9				F10, F11			F12, F13		
Output current										
Continuous (6x525–550 V) [A]	470	523	596	630	763	889	988	1108	1317	1479
Intermittent (6x550 V) [A]	515	575	656	693	839	978	1087	1219	1449	1627
Continuous (6x551–690 V) [A]	450	500	570	630	730	850	945	1060	1260	1415
Intermittent (6x551–690 V) [A]	495	550	627	693	803	935	1040	1166	1386	1557
Continuous kVA (550 V) [kVA]	448	498	568	600	727	847	941	1056	1255	1409
Continuous kVA (575 V) [kVA]	448	498	568	627	727	847	941	1056	1255	1409
Continuous kVA (690 V) [kVA]	538	598	681	753	872	1016	1129	1267	1506	1691
Maximum input current										
Continuous (6x550 V) [A]	453	504	574	607	743	866	962	1079	1282	1440
Continuous (6x575 V) [A]	434	482	549	607	711	828	920	1032	1227	1378
Continuous (6x690 V) [A]	434	482	549	607	711	828	920	1032	1227	1378
Maximum external mains fuses[1)] [A]	630				900			1600	2000	2500
Maximum cable cross-section[2)]										
Motor [mm² (AWG)]	8x150 (8x300 mcm)							12x150 (12x300 mcm)		
Mains [mm² (AWG)]	8x250 (8x500 mcm)									
Regeneration terminals [mm² (AWG)]	4x120 (4x250 mcm)									
Brake [mm² (AWG)]	4x185 (4x350 mcm)									
Other information										
Weight enclosure IP21/IP54 [kg (lb)]	440/656 (880/1443)			880/1096 (1936/2471)				1022/1238 (2248/2724)		
Heat sink overtemperature trip [°C (°F)]	110 (230)				95 (203)	105 (221)	95 (203)	95 (203)	105 (221)	95 (203)
Power card ambient trip [°C (°F)]	85 (185)									

Table 12.10 Technical Specifications, F8–F13, Mains Supply 525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

12.2.3 FC 202, 380–480 V

FC 202	P315		P355		P400		P450	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 400 V [kW]	250	315	315	355	355	400	400	450
Typical shaft output at 460 V [hp]	350	450	450	500	500	600	550	600
Enclosure size	F8, F9							
Output current								
Continuous (at 400 V) [A]	480	600	600	658	658	745	695	800
Intermittent, 60 s overload (at 400 V) [A]	720	660	900	724	987	820	1043	880
Continuous (at 460/480 V) [A]	443	540	540	590	590	678	678	730
Intermittent, 60 s overload (at 460/480 V) [A]	665	594	810	649	885	746	1017	803
Continuous kVA (at 400 V AC) [kVA]	333	416	416	456	456	516	482	554
Continuous kVA (at 460 V AC) [kVA]	353	430	430	470	470	540	540	582
Maximum input current								
Continuous (400 V) [A]	472	590	590	647	647	733	684	787
Continuous (460/480 V) [A]	436	531	531	580	580	667	667	718
Maximum external main fuses1) [A]								
Maximum cable cross-section2)								
Motor [mm^2 (AWG)]	4x240 (4x500 mcm)							
Mains [mm^2 (AWG)]	4x90 (4x3/0)				4x240 (4x500 mcm)			
Brake [mm^2 (AWG)]	2x185 (2x350 mcm)							
Other information								
Weight, enclosure IP21/IP54 [kg (lb)]	447/669 (986/1475)							
Heat sink overtemperature trip [°C (°F)]	110 (230)							
Power card ambient trip [°C (°F)]	85 (185)							
*High overload=150% current for 60 s, normal overload=110% current for 60 s								

Table 12.11 Technical Specifications, F8–F13, Mains Supply 380–480 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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FC 202	P500		P560		P630		P710		P800		P1M0	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 400 V [kW]	450	500	500	560	560	630	630	710	710	800	800	1000
Typical shaft output at 460 V [hp]	600	650	650	750	750	900	900	1000	1000	1200	1200	1350
Enclosure size	F10, F11								F12, F13			
Output current												
Continuous (at 400 V) [A]	800	880	880	990	990	1120	1120	1260	1260	1460	1460	1720
Intermittent, 60 s overload (at 400 V) [A]	1200	968	1320	1089	1485	1232	1680	1386	1890	1606	2190	1892
Continuous (at 460/480 V) [A]	730	780	780	890	890	1050	1050	1160	1160	1380	1380	1530
Intermittent, 60 s overload (at 460/480 V) [A]	1095	858	1170	979	1335	1155	1575	1276	1740	1518	2070	1683
Continuous kVA (at 400 V AC) [kVA]	554	610	610	686	686	776	776	873	873	1012	1012	1192
Continuous kVA (at 460 V AC) [kVA]	582	621	621	709	709	837	837	924	924	1100	1100	1219
Maximum input current												
Continuous (400 V) [A]	779	857	857	964	964	1090	1090	1227	1227	1422	1422	1675
Continuous (460/480 V) [A]	711	759	759	867	867	1022	1022	1129	1129	1344	1344	1490
Maximum external main fuses[1)] [A]	900								1500			
Maximum cable cross-section[2)]												
Motor [mm^2 (AWG)]	8x150 (8x300 mcm)								12x150 (12x300 mcm)			
Mains [mm^2 (AWG)]	6x120 (6x250 mcm)											
Brake [mm^2 (AWG)]	4x185 (4x350 mcm)								6x185 (6x350 mcm)			
Other information												
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1319 (2242/2908)								1260/1561 (2778/3441)			
Weight, rectifier module [kg (lb)]	102 (225)								136 (300)			
Weight, inverter module [kg (lb)]	102 (225)						136 (300)		102 (225)			
Heat sink overtemperature trip [°C (°F)]	95 (203)											
Power card ambient trip [°C (°F)]	85 (185)											
*High overload=150% current for 60 s, normal overload=110% current for 60 s												

Table 12.12 Technical Specifications, F8–F13, Mains Supply 380–480 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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12.2.4 FC 202, 525–690 V

FC 202	P450		P500		P560		P630	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	315	355	315	400	400	450	450	500
Typical shaft output at 575 V [hp]	400	450	400	500	500	600	600	650
Typical shaft output at 690 V [kW]	355	450	400	500	500	560	560	630
Enclosure size	F8, F9							
Output current								
Continuous (at 550 V) [A]	395	470	429	523	523	596	596	630
Intermittent (60 s overload) (at 550 V) [A]	593	517	644	575	785	656	894	693
Continuous (at 575/690 V) [A]	380	450	410	500	500	570	570	630
Intermittent (60 s overload) (at 575/690 V) [kVA]	570	495	615	550	750	627	855	693
Continuous kVA (at 550 V) [kVA]	376	448	409	498	498	568	568	600
Continuous kVA (at 575 V) [kVA]	378	448	408	498	598	568	568	627
Continuous kVA (at 690 V) [kVA]	454	538	490	598	598	681	681	753
Maximum input current								
Continuous (at 550 V) [A]	381	453	413	504	504	574	574	607
Continuous (at 575 V) [A]	366	434	395	482	482	549	549	607
Continuous (at 690 V) [A]	366	434	395	482	482	549	549	607
Maximum external mains fuses[1)] [A]	630							
Maximum cable cross-section[2)]								
Mains [mm^2 (AWG)]	4x85 (4x3/0)							
Motor [mm^2 (AWG)]	4x250 (4x500 mcm)							
Brake [mm^2 (AWG)]	2x185 (2x350 mcm)							
Other information								
Weight, enclosure IP21/IP54 [kg (lb)]	447/669 (985/1475)							
Heat sink overtemperature trip [°C (°F)]	110 (230)							
Power card ambient trip [°C (°F)]	85 (185)							
*High overload=150% current for 60 s, normal overload=110% current for 60 s.								

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Table 12.13 Technical Specifications, F8–F13, Mains Supply 525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

FC 202	P710		P800		P900	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	500	560	560	670	670	750
Typical shaft output at 575 V [hp]	650	750	750	950	950	1050
Typical shaft output at 690 V [kW]	630	710	710	800	800	900
Enclosure size	F10, F11					
Output current						
Continuous (at 550 V) [A]	659	763	763	889	889	988
Intermittent (60 s overload) (at 550 V) [A]	989	839	1145	978	1334	1087
Continuous (at 575/690 V) [A]	630	730	730	850	850	945
Intermittent (60 s overload) (at 575/690 V) [kVA]	945	803	1095	935	1275	1040
Continuous kVA (at 550 V) [kVA]	628	727	727	847	847	941
Continuous kVA (at 575 V) [kVA]	627	727	727	847	847	941
Continuous kVA (at 690 V) [kVA]	753	872	872	1016	1016	1129
Maximum input current						
Continuous (at 550 V) [A]	642	743	743	866	866	962
Continuous (at 575 V) [A]	613	711	711	828	828	920
Continuous (at 690 V) [A]	613	711	711	828	828	920
Maximum external mains fuses[1)] [A]	900					
Maximum cable cross-section[2)]						
Mains [mm^2 (AWG)]	8x150 (8x300 mcm)					
Motor [mm^2 (AWG)]	6x120 (6x250 mcm)					
Brake [mm^2 (AWG)]	4x185 (4x350 mcm)					
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1319 (2242/2908)					
Weight, rectifier module [kg (lb)]	102 (225)					
Weight, inverter module [kg (lb)]	102 (225)				136 (300)	
Heat sink overtemperature trip [°C (°F)]	95 (203)		105 (221)		95 (203)	
Power card ambient trip [°C (°F)]	85 (185)					
*High overload=150% current for 60 s, normal overload=110% current for 60 s.						

Table 12.14 Technical Specifications, F8–F13, Mains Supply 525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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FC 202	P1M0		P1M2		P1M4	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	750	850	850	1000	1000	1100
Typical shaft output at 575 V [hp]	1050	1150	1150	1350	1350	1550
Typical shaft output at 690 V [kW]	900	1000	1000	1200	1200	1400
Enclosure size	F12, F13					
Output current						
Continuous (at 550 V) [A]	988	1108	1108	1317	1317	1479
Intermittent (60 s overload) (at 550 V) [A]	1482	1219	1662	1449	1976	1627
Continuous (at 575/690 V) [A]	945	1060	1060	1260	1260	1415
Intermittent (60 s overload) (at 575/690 V) [kVA]	1418	1166	1590	1386	1890	1557
Continuous kVA (at 550 V) [kVA]	941	1056	1056	1255	1255	1409
Continuous kVA (at 575 V) [kVA]	941	1056	1056	1255	1255	1409
Continuous kVA (at 690 V) [kVA]	1129	1267	1267	1506	1506	1691
Maximum input current						
Continuous (at 550 V) [A]	962	1079	1079	1282	1282	1440
Continuous (at 575 V) [A]	920	1032	1032	1227	1227	1378
Continuous (at 690 V) [A]	920	1032	1032	1227	1227	1378
Maximum external mains fuses[1)] [A]	1600		2000		2500	
Maximum cable cross-section[2)]						
Mains [mm^2 (AWG)]	12x150 (12x300 mcm)					
Motor [mm^2 (AWG)]	8x400 (8x900 mcm)					
Brake [mm^2 (AWG)]	6x185 (6x350 mcm)					
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1260/1561 (2778/3441)				1294/1595 (2853/3516)	
Weight, rectifier module [kg (lb)]	136 [300]					
Weight, inverter module [kg (lb)]	102 (225)				136 (300)	
Heat sink overtemperature trip [°C (°F)]	95 (203)		105 (221)		95 (203)	
Power card ambient trip [°C (°F)]	85 (185)					
*High overload=150% current for 60 s, normal overload=110% current for 60 s.						

Table 12.15 Technical Specifications, F8–F13, Mains Supply 525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

12.2.5 FC 302, 380–500 V

FC 302	P250		P315		P355		P400	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 400 V [kW]	250	315	315	355	355	400	400	450
Typical shaft output at 460 V [hp]	350	450	450	500	500	600	550	600
Typical shaft output at 500 V [kW]	315	355	355	400	400	500	500	530
Enclosure size	F8, F9							
Output current								
Continuous (at 400 V) [A]	480	600	600	658	658	745	695	800
Intermittent (60 s overload) (at 400 V) [A]	720	660	900	724	987	820	1043	880
Continuous (at 460/500 V) [A]	443	540	540	590	590	678	678	730
Intermittent (60 s overload) (at 460/500 V) [A]	665	594	810	649	885	746	1017	803
Continuous kVA (at 400 V) [kVA]	333	416	416	456	456	516	482	554
Continuous kVA (at 460 V) [kVA]	353	430	430	470	470	540	540	582
Continuous kVA (at 500 V) [kVA]	384	468	468	511	511	587	587	632
Maximum input current								
Continuous (at 400 V) [A]	472	590	590	647	647	733	684	787
Continuous (at 460/500 V) [A]	436	531	531	580	580	667	667	718
Maximum external mains fuses1) [A]	700							
Maximum cable cross-section2)								
Mains [mm^2 (AWG)]	4x90 (4x3/0)		4x90 (4x3/0)		4x240 (4x500 mcm)		4x240 (4x500 mcm)	
Motor [mm^2 (AWG)]	4x240 (4x500 mcm)		4x240 (4x500 mcm)		4x240 (4x500 mcm)		4x240 (4x500 mcm)	
Brake [mm^2 (AWG)]	2x185 (2x350 mcm)		2x185 (2x350 mcm)		2x185 (2x350 mcm)		2x185 (2x350 mcm)	
Other information								
Weight, enclosure IP21/IP54 [kg (lb)]	447/669 (985/1475)							
Heat sink overtemperature trip [°C (°F)]	110 (230)							
Control card ambient trip [°C (°F)]	85 (185)							
* High overload=160% torque during 60 s, normal overload=110% torque during 60 s.								

Table 12.16 Technical Specifications, F8–F13, Mains Supply 380–500 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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FC 302	P450		P500		P560		P630		P710		P800	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 400 V [kW]	450	500	500	560	560	630	630	710	710	800	800	1000
Typical shaft output at 460 V [hp]	600	650	650	750	750	900	900	1000	1000	1200	1200	1350
Typical shaft output at 500 V [kW]	530	560	560	630	630	710	710	800	800	1000	1000	1100
Enclosure size	F10, F11								F12, F13			
Output current												
Continuous (at 400 V) [A]	800	880	880	990	990	1120	1120	1260	1260	1460	1460	1720
Intermittent (60 s overload) (at 400 V) [A]	1200	968	1320	1089	1485	1232	1680	1386	1890	1606	2190	1892
Continuous (at 460/500 V) [A]	730	780	780	890	890	1050	1050	1160	1160	1380	1380	1530
Intermittent (60 s overload) (at 460/500 V) [A]	1095	858	1170	979	1335	1155	1575	1276	1740	1518	2070	1683
Continuous kVA (at 400 V) [kVA]	554	610	610	686	686	776	776	873	873	1012	1012	1192
Continuous kVA (at 460 V) [kVA]	582	621	621	709	709	837	837	924	924	1100	1100	1219
Continuous kVA (at 500 V) [kVA]	632	675	675	771	771	909	909	1005	1005	1195	1195	1325
Maximum input current												
Continuous (at 400 V) [A]	779	857	857	964	964	1090	1090	1227	1227	1422	1422	1675
Continuous (at 460/500 V) [A]	711	759	759	867	867	1022	1022	1129	1129	1344	1344	1490
Maximum external mains fuses[1)] [A]	900								1500			
Maximum cable cross-section[2)]												
Mains [mm² (AWG)]	6x120 (6x250 mcm)											
Motor [mm² (AWG)]	8x150 (8x300 mcm)								12x150 (12x300 mcm)			
Brake [mm² (AWG)]	4x185 (4x350 mcm)								6x185 (6x350 mcm)			
Other information												
Weight, enclosure IP21/IP54 [kg]	1017/1319 (2242/2908)								1261/1562 (2780/3444)			
Weight, rectifier module [kg (lb)]	102 (225)								136 (300)			
Weight, inverter module [kg (lb)]	102 (225)						136 (300)		102 (225)			
Heat sink overtemperature trip [°C (°F)]	95 (203)											
Power card ambient trip [°C (°F)]	85 (185)											
* High overload=160% torque during 60 s, normal overload=110% torque during 60 s.												

Table 12.17 Technical Specifications, F8–F13, Mains Supply 380–500 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

12.2.6 FC 302, 525–690 V

FC 302	P355		P400		P500		P560	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	315	355	315	400	400	450	450	500
Typical shaft output at 575 V [hp]	400	450	400	500	500	600	600	650
Typical shaft output at 690 V [kW]	355	450	400	500	500	560	560	630
Enclosure size	F8, F9							
Output current								
Continuous (at 550 V) [A]	395	470	429	523	523	596	596	630
Intermittent (60 s overload) (at 550 V) [A]	593	517	644	575	785	656	894	693
Continuous (at 575/690 V) [A]	380	450	410	500	500	570	570	630
Intermittent (60 s overload) (at 575/690 V) [A]	570	495	615	550	750	627	855	693
Continuous kVA (at 550 V) [kVA]	376	448	409	498	498	568	568	600
Continuous kVA (at 575 V) [kVA]	378	448	408	498	498	568	568	627
Continuous kVA (at 690 V) [kVA]	454	538	490	598	598	681	681	753
Maximum input current								
Continuous (at 550 V) [A]	381	453	413	504	504	574	574	607
Continuous (at 575 V) [A]	366	434	395	482	482	549	549	607
Continuous (at 690 V) [A]	366	434	395	482	482	549	549	607
Maximum external mains fuses[1)] [A]	630							
Maximum cable cross-section[2)]								
Mains [mm^2 (AWG)]	4x85 (4x3/0)							
Motor [mm^2 (AWG)]	4x250 (4x500 mcm)							
Brake [mm^2 (AWG)]	2x185 (2x350 mcm)		2x185 (2x350 mcm)		2x185 (2x350 mcm)		2x185 (2x350 mcm)	
Other information								
Weight, enclosure IP21/IP54 [kg (lb)]	447/669 (985/1475)							
Heat sink overtemperature trip [°C (°F)]	110 (230)							
Power card ambient trip [°C (°F)]	85 (185)							
* High overload=160% torque during 60 s, normal overload=110% torque during 60 s.								

Table 12.18 Technical Specifications, F8–F13, Mains Supply 525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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FC 302	P630		P710		P800	
High/normal load	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	500	560	560	670	670	750
Typical shaft output at 575 V [hp]	650	750	750	950	950	1050
Typical shaft output at 690 V [kW]	630	710	710	800	800	900
Enclosure size	F10, F11					
Output current						
Continuous (at 550 V) [A]	659	763	763	889	889	988
Intermittent (60 s overload) (at 550 V) [A]	989	839	1145	978	1334	1087
Continuous (at 575/690 V) [A]	630	730	730	850	850	945
Intermittent (60 s overload) (at 575/690 V) [A]	945	803	1095	935	1275	1040
Continuous kVA (at 550 V) [kVA]	628	727	727	847	847	941
Continuous kVA (at 575 V) [kVA]	627	727	727	847	847	941
Continuous kVA (at 690 V) [kVA]	753	872	872	1016	1016	1129
Maximum input current						
Continuous (at 550 V) [A]	642	743	743	866	866	962
Continuous (at 575 V) [A]	613	711	711	828	828	920
Continuous (at 690 V) [A]	613	711	711	828	828	920
Maximum external mains fuses[1)] [A]	900					
Maximum cable cross-section[2)]						
Mains [mm^2 (AWG)]	6x120 (6x250 mcm)					
Motor [mm^2 (AWG)]	8x150 (8x300 mcm)					
Brake [mm^2 (AWG)]	4x185 (4x350 mcm)					
Other information						
Weight, enclosure IP21/IP54 [kg (lb)]	1017/1319 (2242/2908)					
Weight, rectifier module [kg (lb)]	102 (225)					
Weight, inverter module [kg (lb)]	102 (225)				136 (300)	
Power heatsink overtemperature trip [°C (°F)]	95 (203)		105 (221)		95 (203)	
Power card ambient trip [°C (°F)]	85 (185)					
* High overload=160% torque during 60 s, normal overload=110% torque during 60 s						

Table 12.19 Technical Specifications, F8–F13, Mains Supply 525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

FC 302	P900		P1M0		P1M2	
High/normal load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical shaft output at 550 V [kW]	750	850	850	1000	1000	1100
Typical shaft output at 575 V [hp]	1050	1150	1150	1350	1350	1550
Typical shaft output at 690 V [kW]	900	1000	1000	1200	1200	1400
Enclosure size	F12, F13					
Output current						
Continuous (at 550 V) [A]	988	1108	1108	1317	1317	1479
Intermittent (60 s overload) (at 550 V) [A]	1482	1219	1662	1449	1976	1627
Continuous (at 575/690 V) [A]	945	1060	1060	1260	1260	1415
Intermittent (60 s overload) (at 575/690 V) [A]	1418	1166	1590	1386	1890	1557
Continuous kVA (at 550 V) [kVA]	941	1056	1056	1255	1255	1409
Continuous kVA (at 575 V) [kVA]	941	1056	1056	1255	1255	1409
Continuous kVA (at 690 V) [kVA]	1129	1267	1267	1506	1506	1691
Maximum input current						
Continuous (at 550 V) [A]	962	1079	1079	1282	1282	1440
Continuous (at 575 V) [A]	920	1032	1032	1227	1227	1378
Continuous (at 690 V) [A]	920	1032	1032	1227	1227	1378
Maximum external mains fuses[1)] [A]	1600		2000		2500	
Maximum cable cross-section[2)]						
Mains, F12 [mm² (AWG)]	8x240 (8x500 mcm)					
Mains, F13 [mm² (AWG)]	8x400 (8x900 mcm)					
Motor [mm² (AWG)]	12x150 (12x300 mcm)					
Brake [mm² (AWG)]	6x185 (6x350 mcm)					
Other information						
Weight, enclosure IP21/IP 54 [kg (lb)]	1261/1562 (2780/3444)				1295/1596 (2855/3519)	
Weight, rectifier module [kg (lb)]	136 (300)					
Weight, inverter module [kg (lb)]	102 (225)				136 (300)	
Power heat sink overtemperature trip [°C (°F)]	95 (203)		105 (221)		95 (203)	
Power card ambient trip [°C (°F)]	85 (185)					
* High overload=160% torque during 60 s, normal overload=110% torque during 60 s.						

Table 12.20 Technical Specifications, F8–F13, Mains Supply 525–690 V AC

1) For type of fuse, consult the operating intructions.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

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12.3 Ratings Tables

12.3.1 Warning and Alarm Trip Points

The frequency converter is protected against short circuits with current measurement in each of the 3 motor phases (250–1400 kW (350–1550 hp)). A short circuit between 2 output phases causes an overcurrent in the frequency converter. The frequency converter turns off the IGBTs individually when the short-circuit current exceeds the permitted value (*alarm 16, Trip Lock*).

380–480 V AC	**FC 102/FC 202**	**P500**	**P560**	**P630**	**P710**	**P800**	**P1M0**
380–500 V AC	FC 302	P450	P500	P560	P630	P710	P800
Overcurrent warning	[A_{rms}]	1777	1777	2338	2580	2666	3507
Overcurrent alarm1) (1.5 s delay)	[A_{rms}]	1777	1777	2338	2580	2666	3507
Ground fault alarm	[A_{rms}]	400	440	495	560	630	730
Short circuit alarm	[A_{rms}]	2260	2260	2974	3281	3390	4460
Heat sink overtemperature	[°C]	95 (203)					
Heat sink under temperature warning	[°C (°F)]	0 (32)					
Power card ambient overtem-perature	[°C (°F)]	75 (167)					
Power card ambient under temperature	[°C (°F)]	-20 (-4)					
Mains phase warning (30 s delay)	DC Bus Ripple Vpkpk	30					
Mains phase alarm (60 s delay)	DC Bus Ripple Vpkpk	30					

Table 12.21 Warning and Alarm Trip Points, 380–500 V AC

1) Based on crest factor of 1.414.

525–690 V AC	**FC 102/FC 202**	**P710**	**P800**	**P900**	**P1M0**	**P1PM2**	**P1M4**
525–690 V AC	**FC 302**	**P630**	**P710**	**P800**	**P900**	**P1M0**	**P1M2**
Overcurrent warning	[A_{rms}]	1648	1974	2338	2472	2961	3507
Overcurrent alarm1) (1.5 s delay)	[A_{rms}]	1648	1974	2338	2472	2961	3507
Ground fault alarm	[A_{rms}]	330	382	445	494	554	659
Short circuit alarm	[A_{rms}]	2096	2511	2974	3144	3766	4460
Heat sink overtemperature	[°C (°F)]	95	105	95	95	105	95
Heat sink under temperature warning	[°C (°F)]	0 (32)					
Power card ambient overtemperature	[°C (°F)]	75 (167)					
Power card ambient under temperature	[°C (°F)]	-20 (-4)					
Mains phase warning (30 s delay)	DC Bus Ripple Vpkpk	50					
Mains phase alarm (60 s delay)	DC Bus Ripple Vpkpk	50					

Table 12.22 Warning and Alarm Trip Points, 525–690 V AC

1) Based on crest factor of 1.414.

12.3.2 DC Voltage Levels

	380–480 V units	380–500 V units	525–690 V units
Inrush circuit enabled [V DC]	370	370	550
Inrush circuit disabled [V DC]	395	395	570
Inverter undervoltage disabled [V DC]	373	373	553
Undervoltage warning [V DC]	410	410	585
Inverter undervoltage re-enabled (warning reset) [V DC]	413	413	602
Overvoltage warning (without brake) [V DC]	778	817	1084
Dynamic brake turned on [V DC]	778	810	1099
Inverter overvoltage re-enabled (warning reset) [V DC]	786	821	1099
Overvoltage warning (with brake) [V DC]	810	828	1109
Overvoltage trip [V DC]	820	855	1130

Table 12.23 DC Voltage Levels

13 Block Diagrams

13.1 Block Diagrams for F1–F4 Enclosures

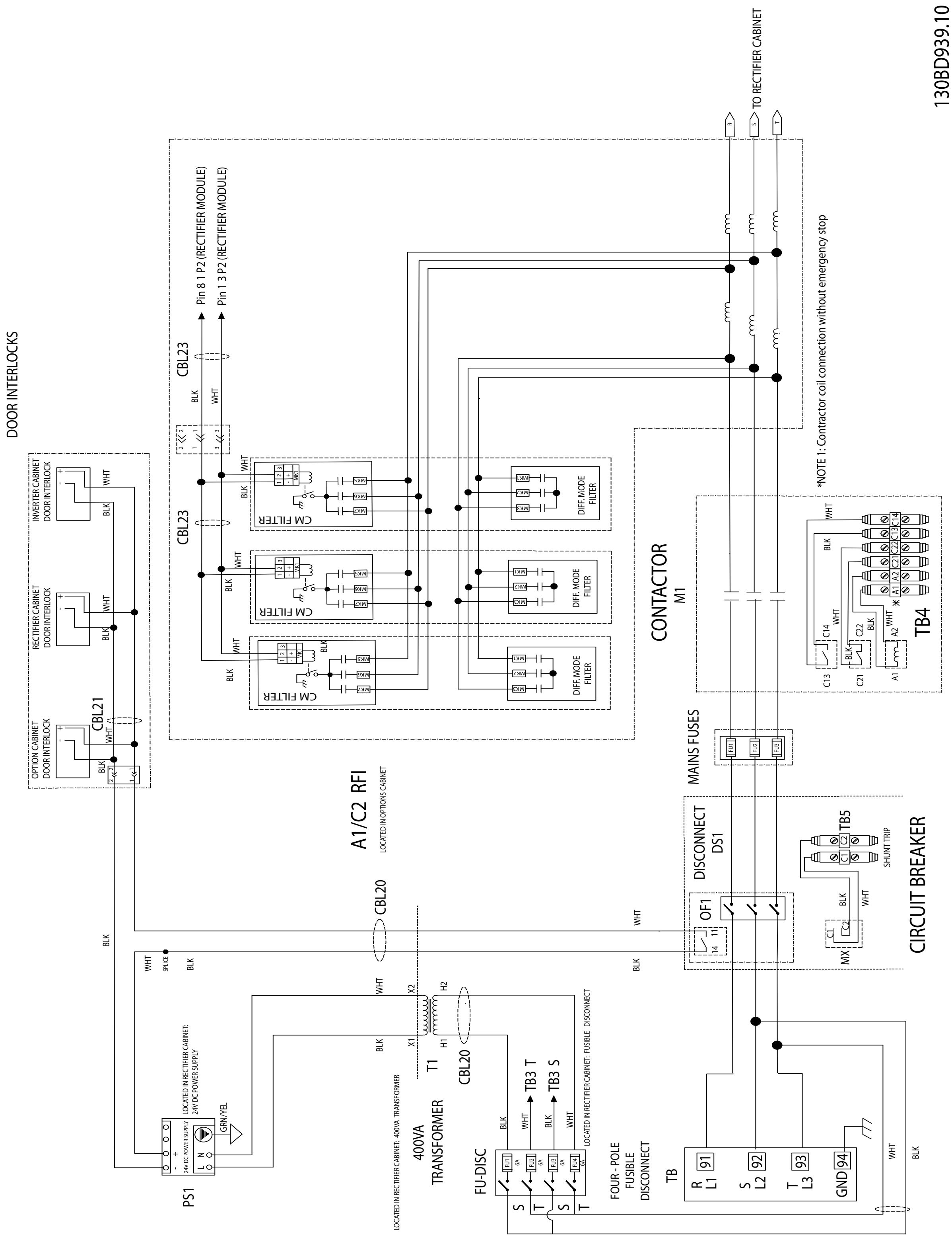


Illustration 13.1 Block Diagram, F1–F4 Options Cabinet

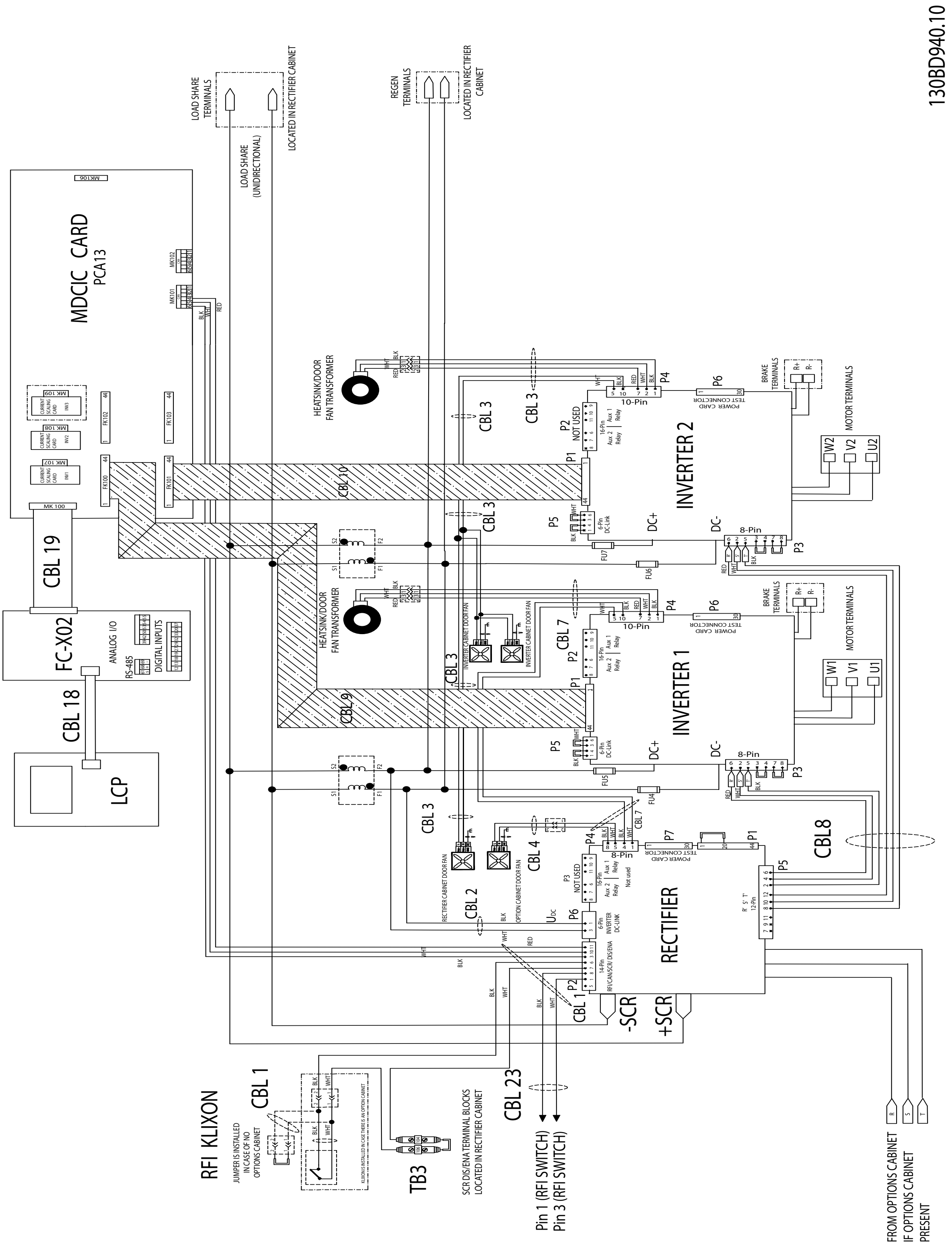


Illustration 13.2 Block Diagram, F1/F3 Top Level

13

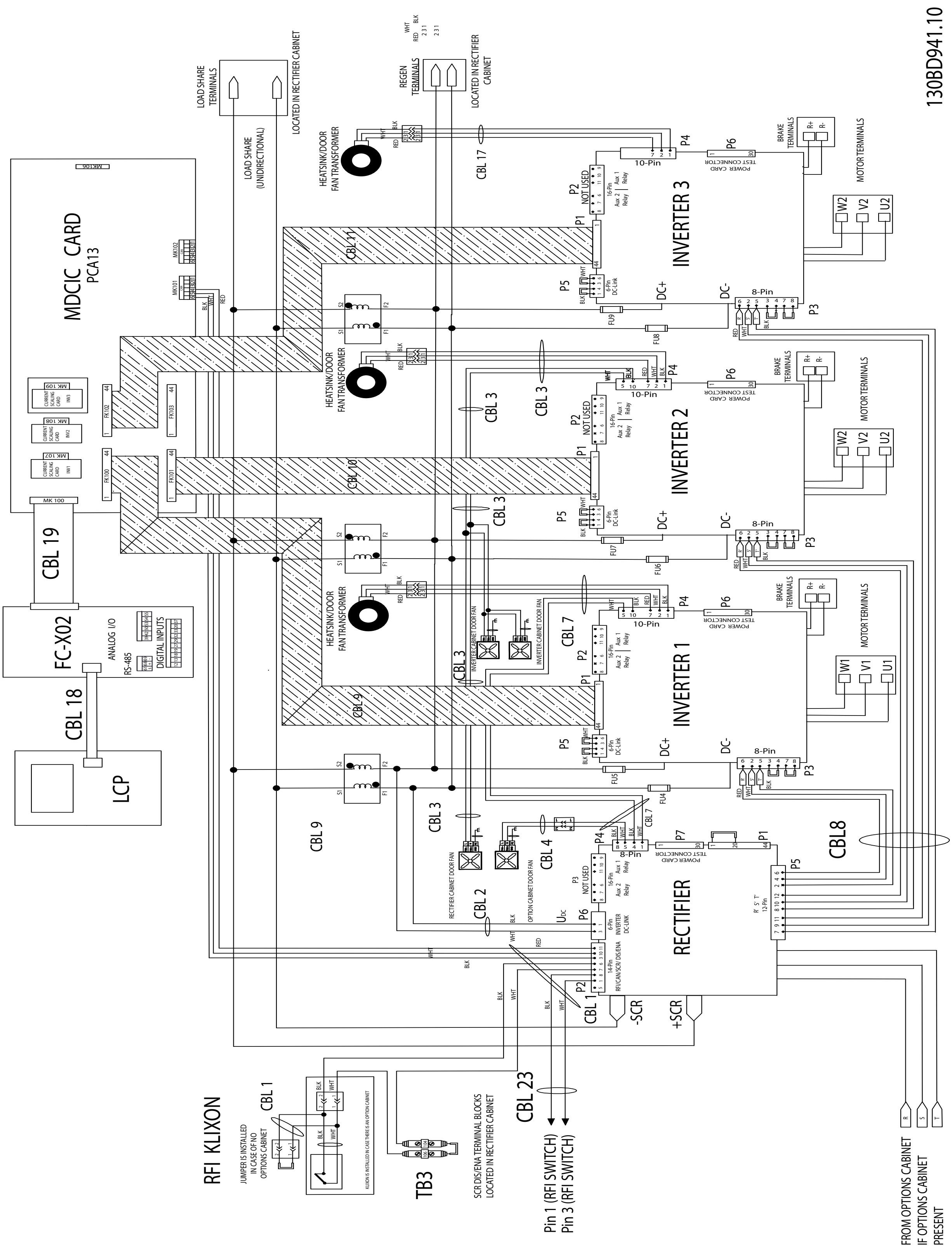


Illustration 13.3 Block Diagram, F2/F4 Top Level

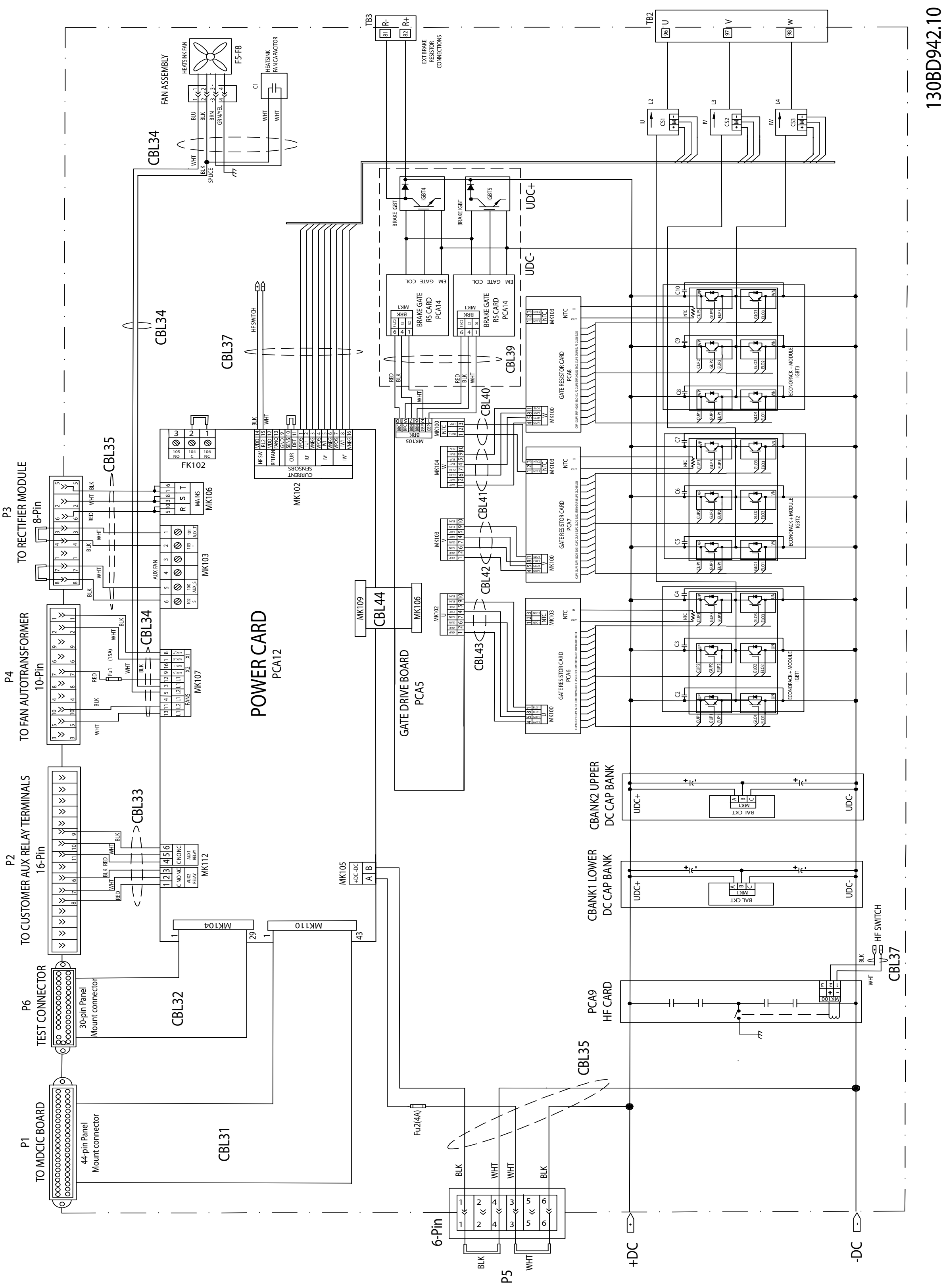


Illustration 13.4 Block Diagram, F1–F4 Inverter Module

13

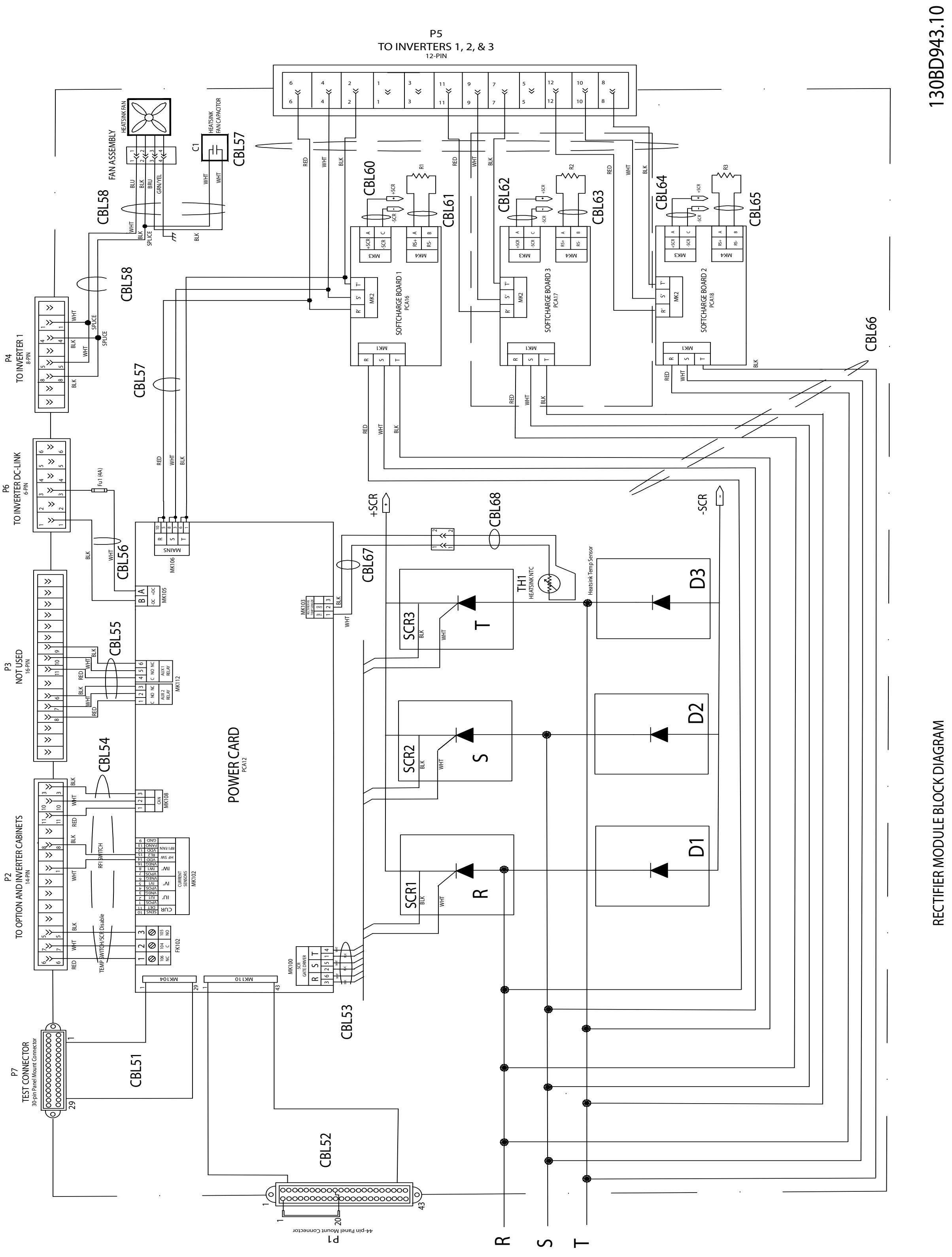


Illustration 13.5 Block Diagram, F1–F4 Rectifier Module

13

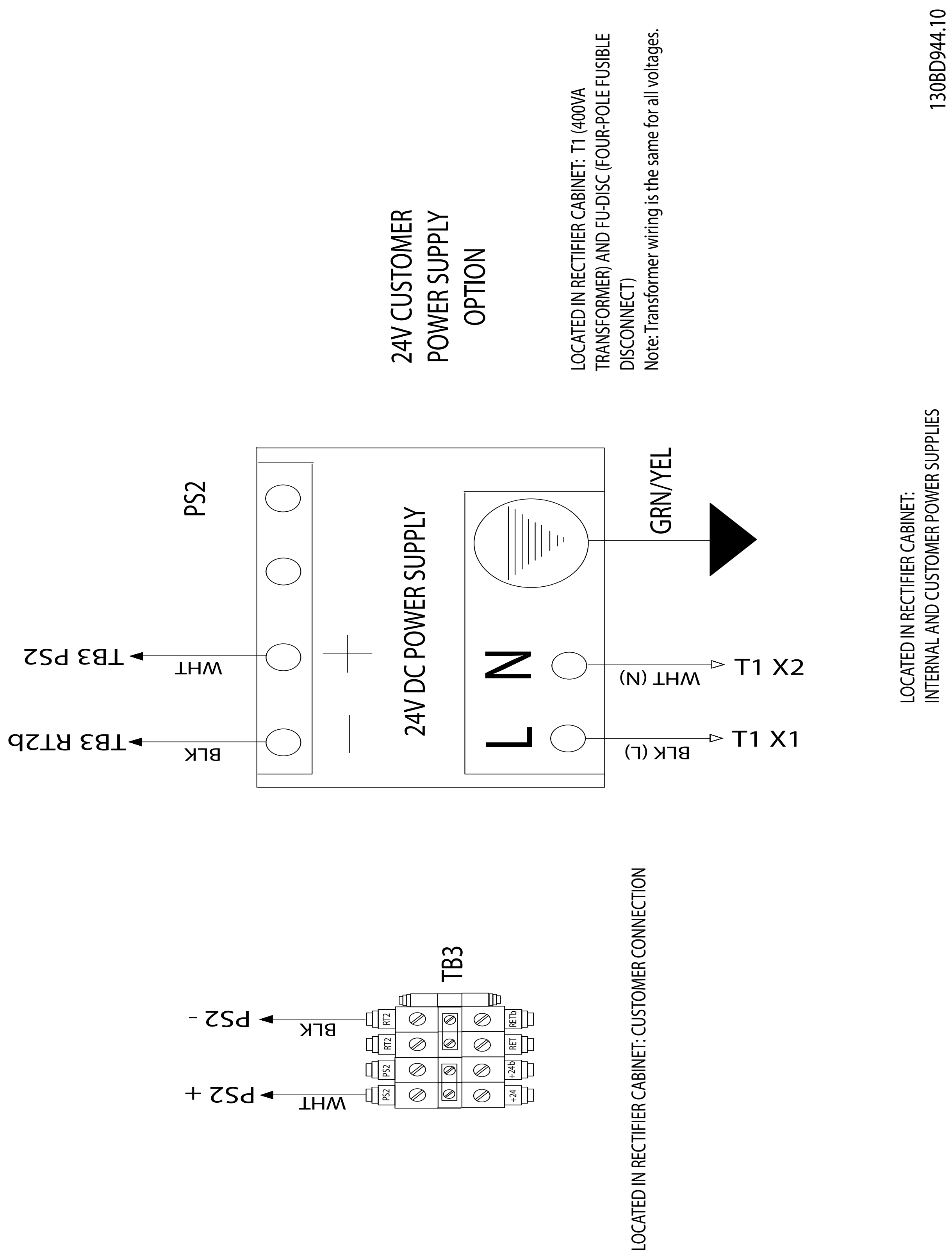


Illustration 13.6 Block Diagram, F1–F4 Customer 24 V Supply Option

13

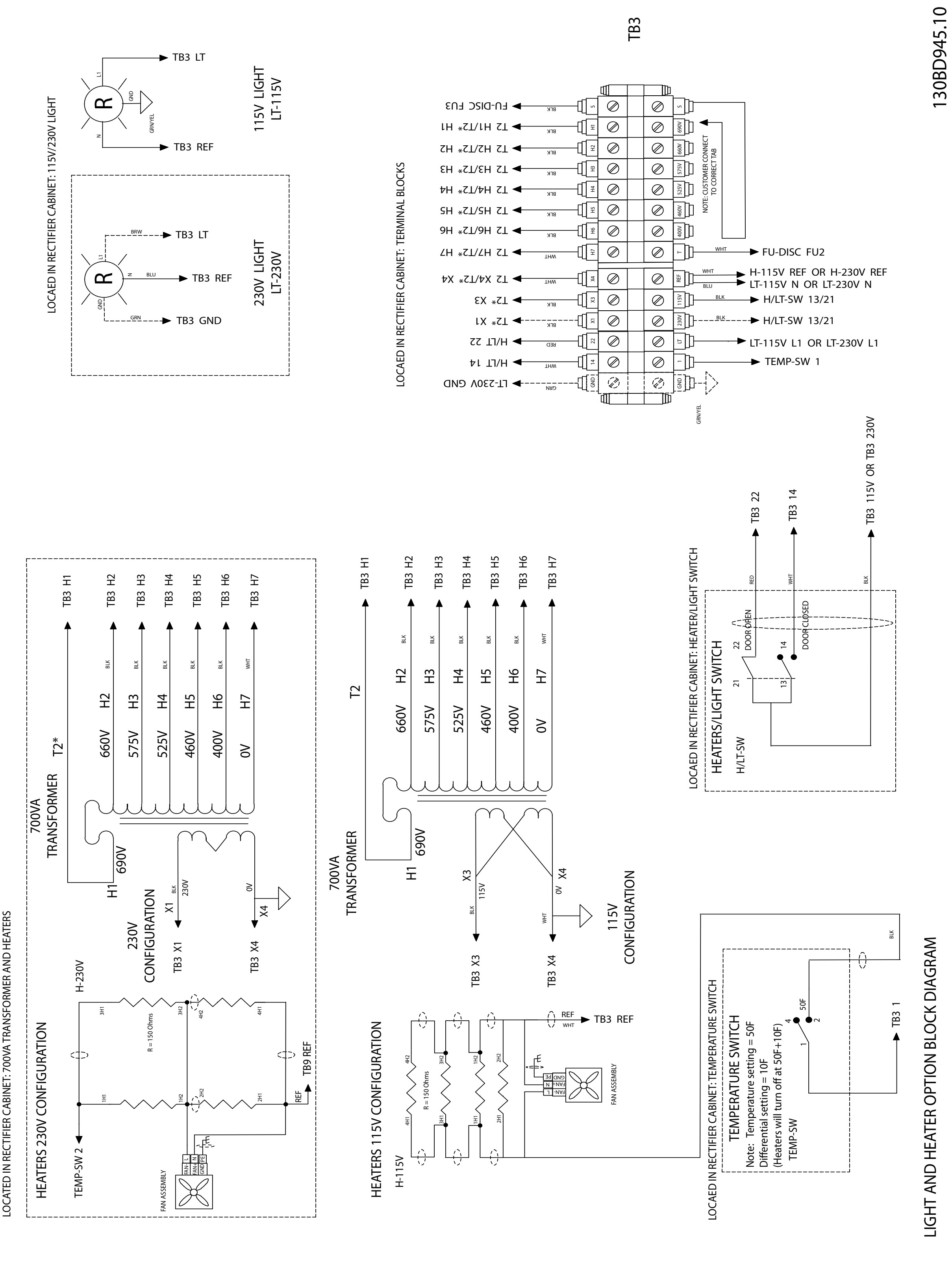
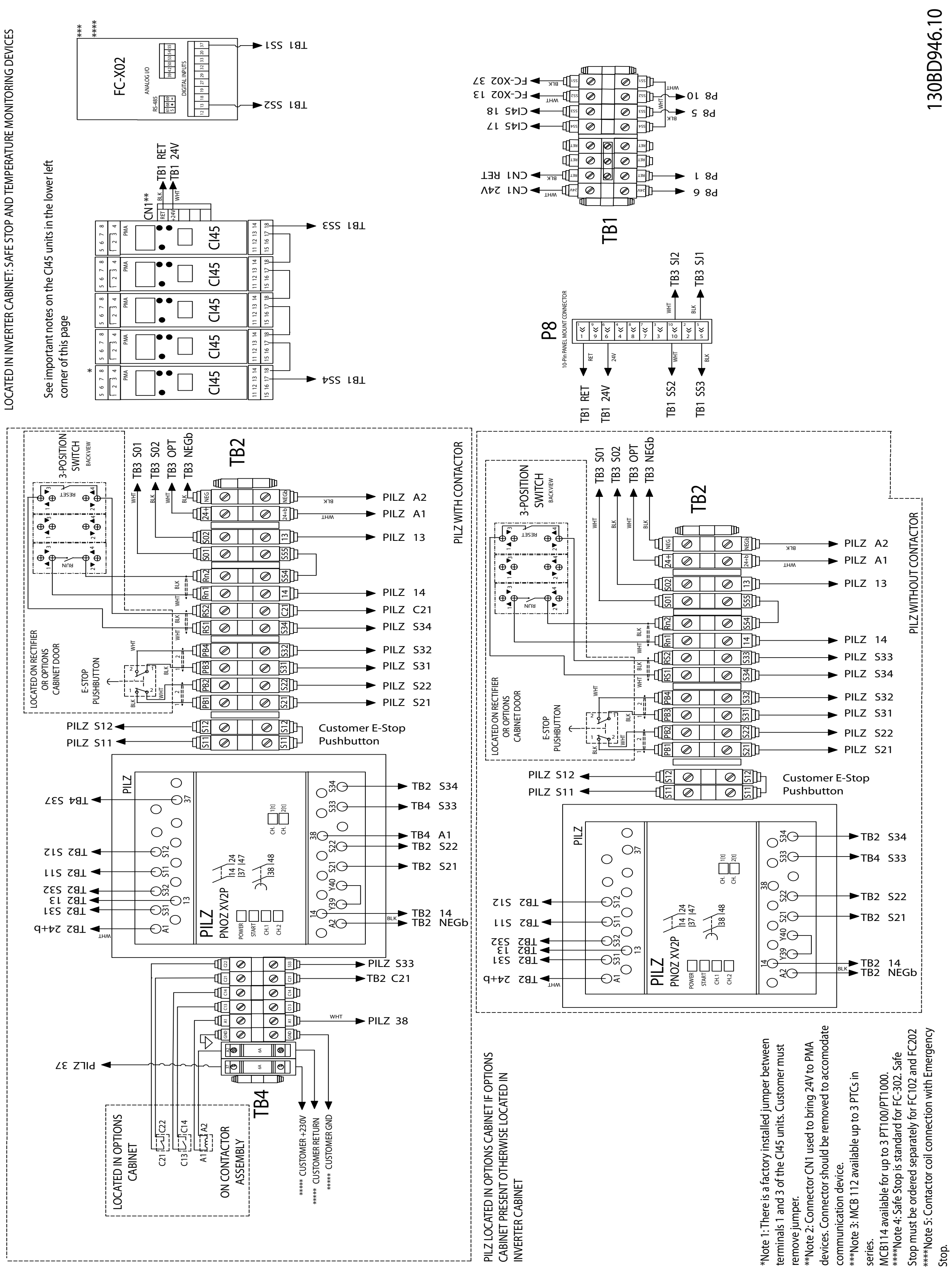


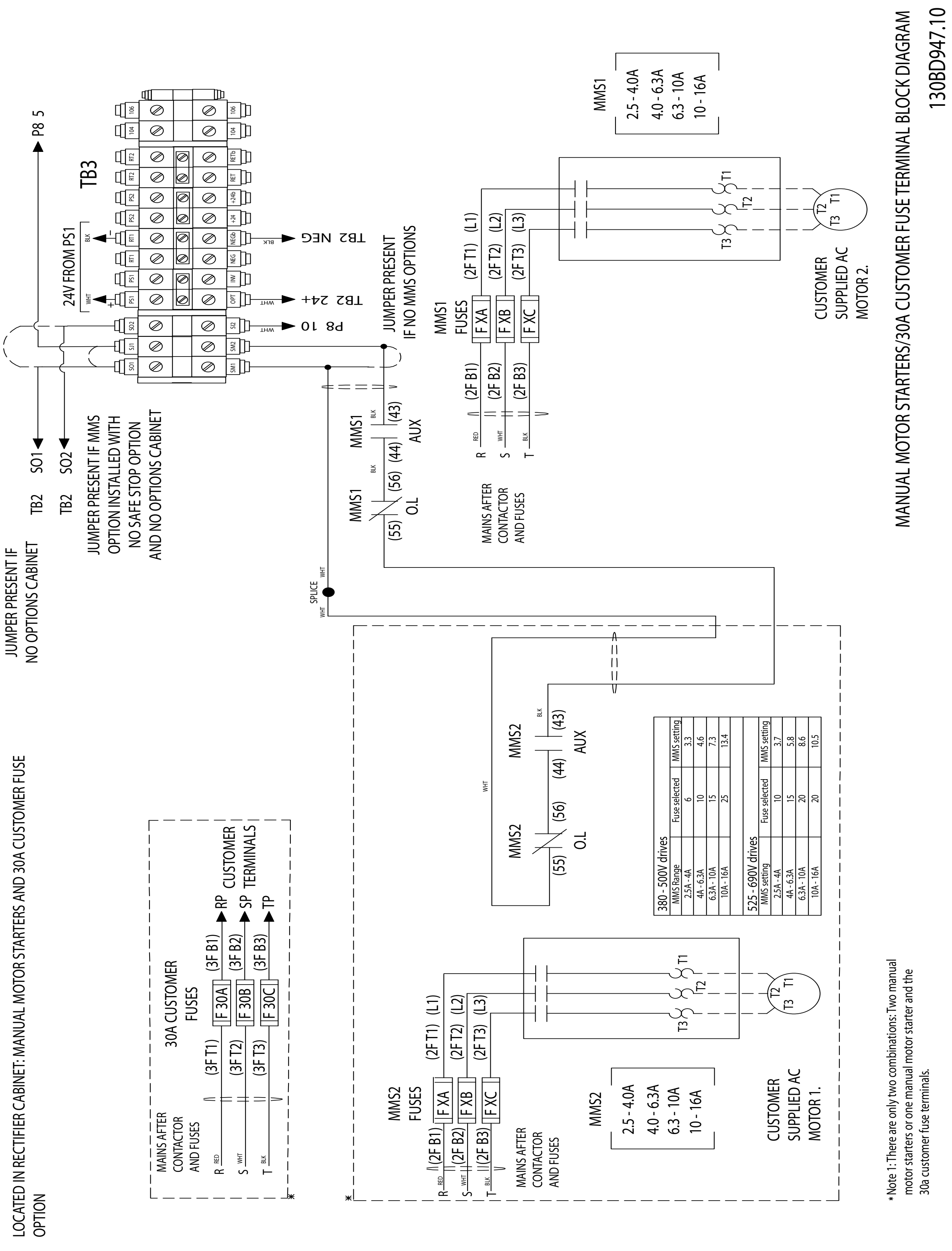
Illustration 13.7 Block Diagram, F1–F4 Cabinet Heater and Service Lights Option



*Note 1: There is a factory installed jumper between terminals 1 and 3 of the CI45 units. Customer must remove jumper.
**Note 2: Connector CN1 used to bring 24V to PMA devices. Connector should be removed to accomodate communication device.
***Note 3: MCB 112 available up to 3 PTCs in series.
MCB114 available for up to 3 PT100/PT1000.
****Note 4: Safe Stop is standard for FC-302. Safe Stop must be ordered separately for FC102 and FC202
****Note 5: Contactor coil connection with Emergency Stop.

Illustration 13.8 Block Diagram, F1–F4 Pilz Relay/Thermal Monitor Option

13

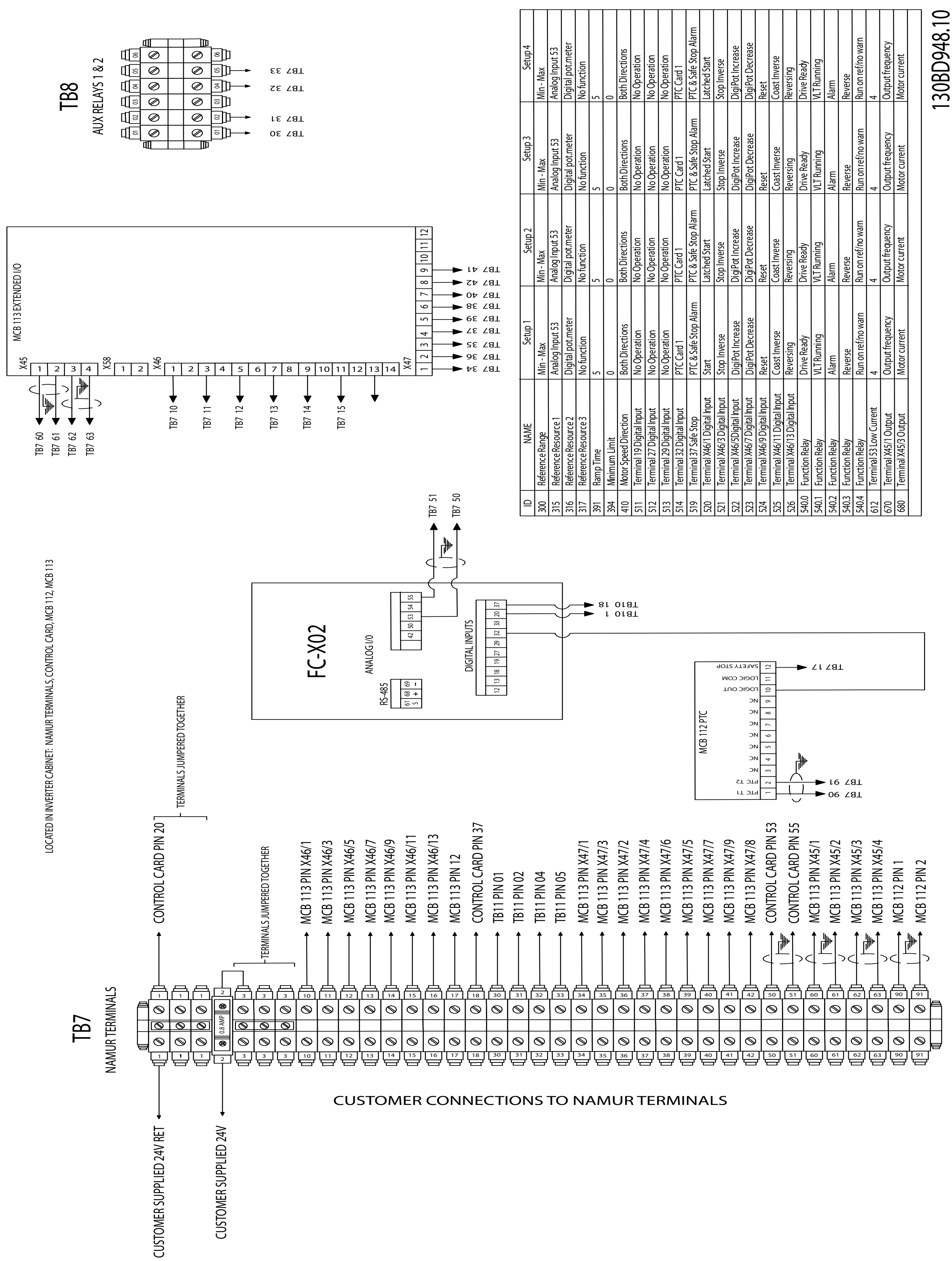


380 - 500V drives		
MMS Range	Fuse selected	MMS setting
2.5A - 4A	6	3.3
4A - 6.3A	10	4.6
6.3A - 10A	15	7.3
10A - 16A	25	13.4

525 - 690V drives		
MMS setting	Fuse selected	MMS setting
2.5A - 4A	10	3.7
4A - 6.3A	15	5.8
6.3A - 10A	20	8.6
10A - 16A	20	10.5

*Note 1: There are only two combinations: Two manual motor starters or one manual motor starter and the 30a customer fuse terminals.

Illustration 13.9 Block Diagram, F1–F4 Manual Motor Starter/30 A Customer Fuse Terminal



ID	NAME	Setup 1	Setup 2	Setup 3	Setup 4
300	Reference Range	Min - Max	Min - Max	Min - Max	Min - Max
315	Reference Resource 1	Analog Input 53	Analog Input 53	Analog Input 53	Analog Input 53
316	Reference Resource 2	Digital pot.meter	Digital pot.meter	Digital pot.meter	Digital pot.meter
317	Reference Resource 3	No function	No function	No function	No function
391	Ramp Time	5	5	5	5
394	Minimum Limit	0	0	0	0
410	Motor Speed Direction	Both Directions	Both Directions	Both Directions	Both Directions
511	Terminal 19 Digital Input	No Operation	No Operation	No Operation	No Operation
512	Terminal 27 Digital Input	No Operation	No Operation	No Operation	No Operation
513	Terminal 29 Digital Input	No Operation	No Operation	No Operation	No Operation
514	Terminal 32 Digital Input	PTC Card 1	PTC Card 1	PTC Card 1	PTC Card 1
519	Terminal 37 Safe Stop	PTC & Safe Stop Alarm	PTC & Safe Stop Alarm	PTC & Safe Stop Alarm	PTC & Safe Stop Alarm
520	Terminal X46/1 Digital Input	Start	Latched Start	Latched Start	Latched Start
521	Terminal X46/3 Digital Input	Stop Inverse	Stop Inverse	Stop Inverse	Stop Inverse
522	Terminal X46/5Digital Input	DigiPot Increase	DigiPot Increase	DigiPot Increase	DigiPot Increase
523	Terminal X46/7 Digital Input	DigiPot Decrease	DigiPot Decrease	DigiPot Decrease	DigiPot Decrease
524	Terminal X46/9 Digital Input	Reset	Reset	Reset	Reset
525	Terminal X46/11 Digital Input	Coast Inverse	Coast Inverse	Coast Inverse	Coast Inverse
526	Terminal X46/13 Digital Input	Reversing	Reversing	Reversing	Reversing
540.0	Function Relay	Drive Ready	Drive Ready	Drive Ready	Drive Ready
540.1	Function Relay	VLT Running	VLT Running	VLT Running	VLT Running
540.2	Function Relay	Alarm	Alarm	Alarm	Alarm
540.3	Function Relay	Reverse	Reverse	Reverse	Reverse
540.4	Function Relay	Run on ref/no warn	Run on ref/no warn	Run on ref/no warn	Run on ref/no warn
612	Terminal 53 Low Current	4	4	4	4
670	Terminal X45/1 Output	Output frequency	Output frequency	Output frequency	Output frequency
680	Terminal X45/3 Output	Motor current	Motor current	Motor current	Motor current

Illustration 13.10 Block Diagram, F1–F4 NAMUR Terminal Option

13

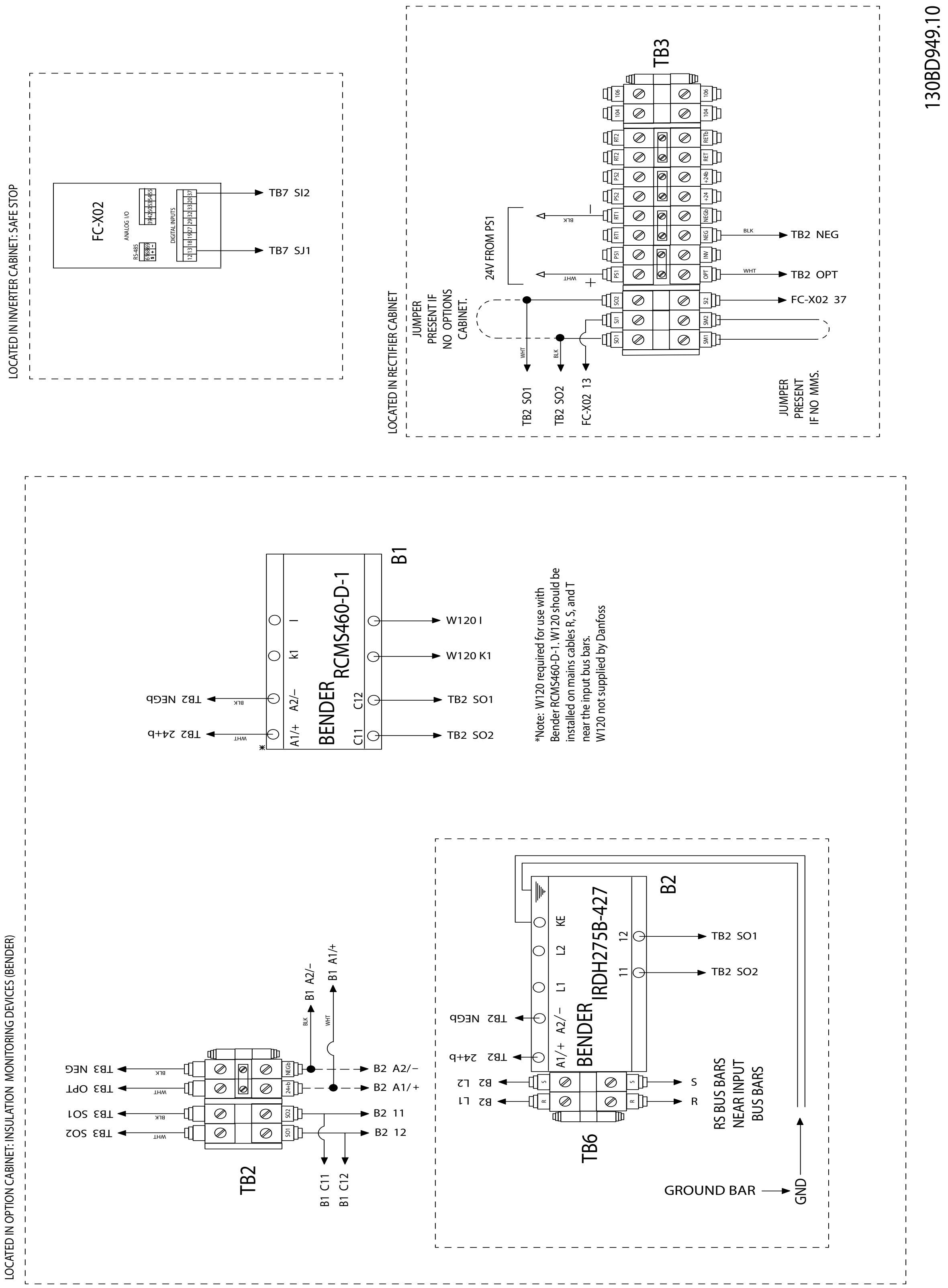


Illustration 13.11 Block Diagram, F1–F4 IRM/RCD Options

13.2 Block Diagrams for F8–F9 Enclosures

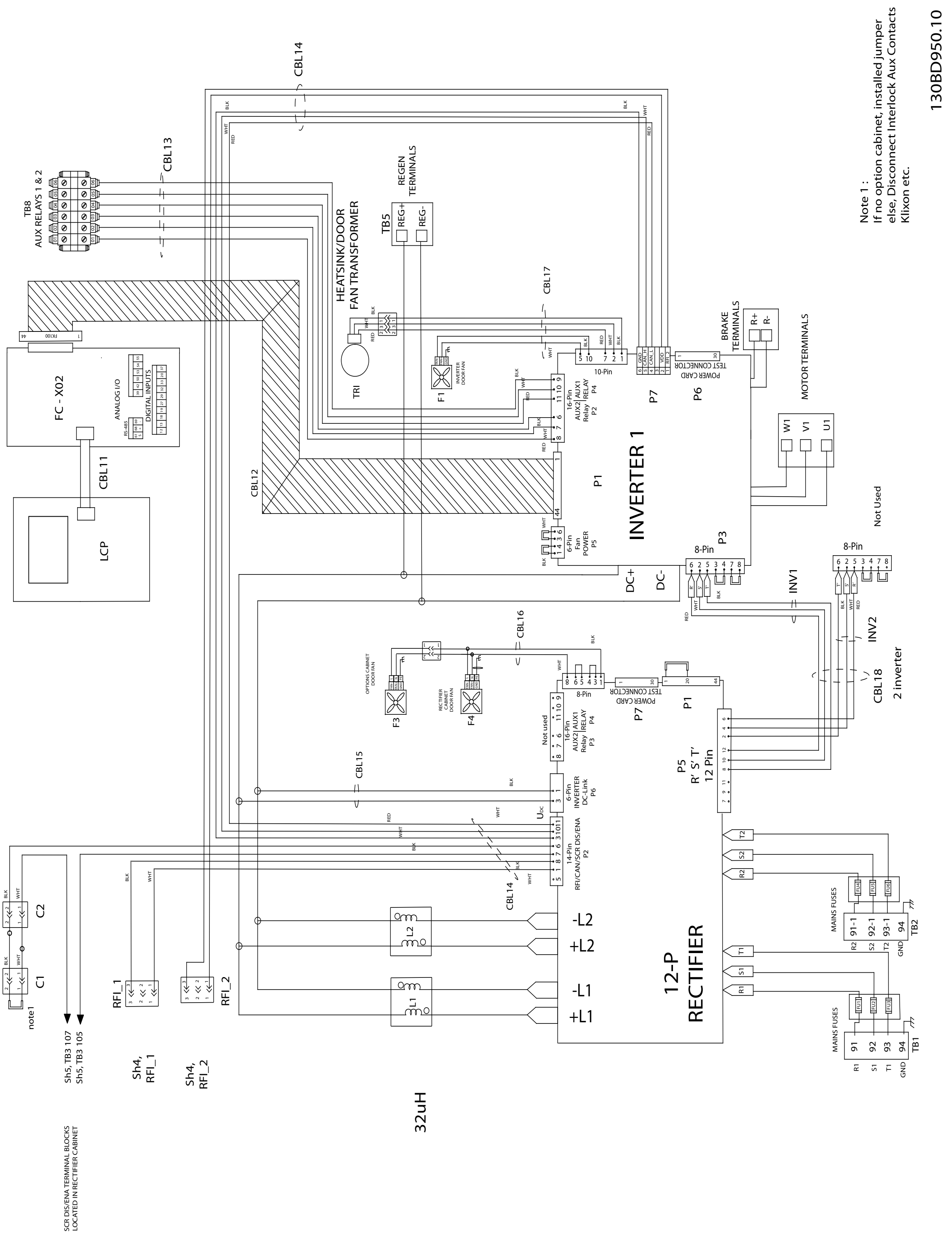


Illustration 13.12 Block Diagram, F8–F9 Top Level

13

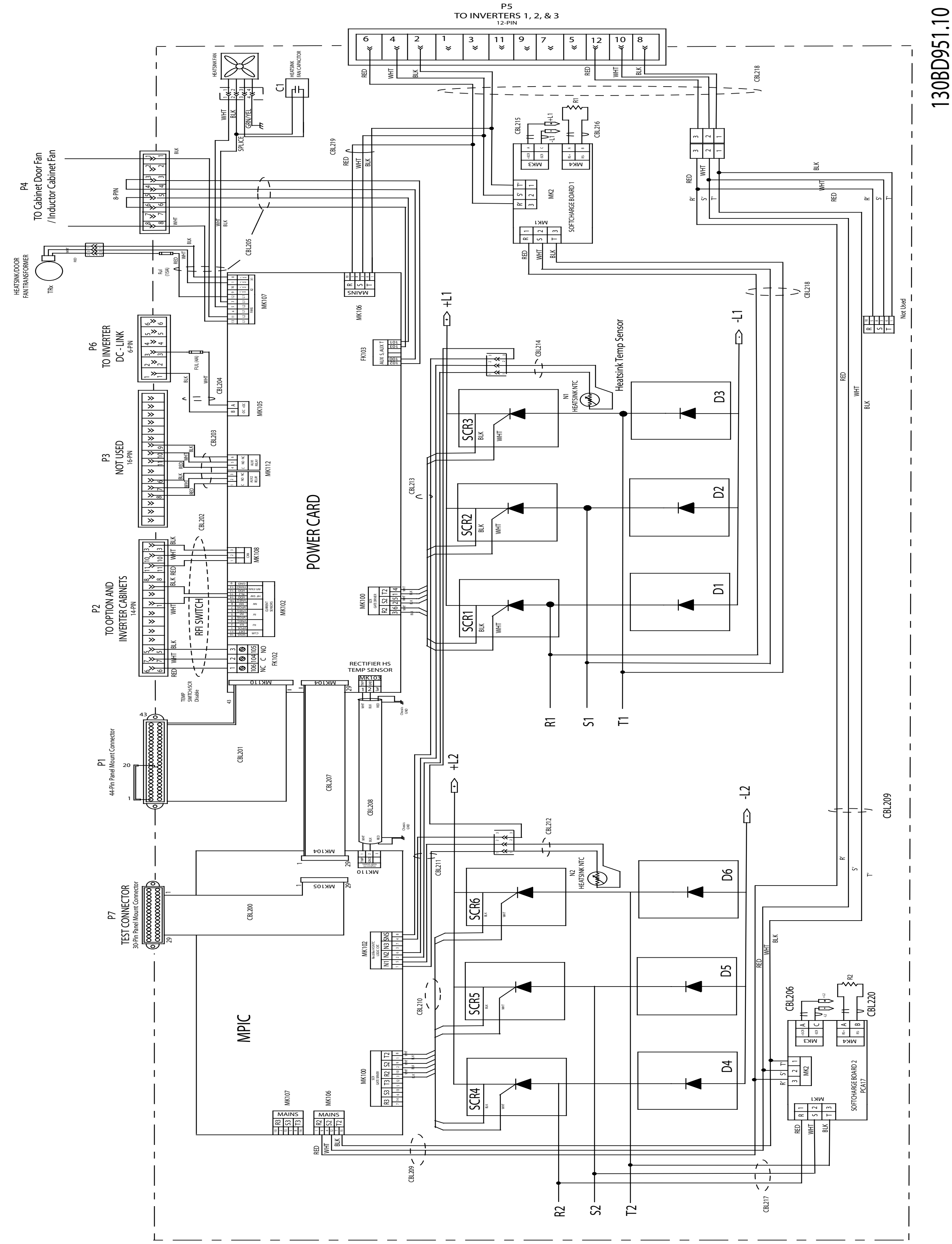


Illustration 13.13 Block Diagram, F8–F9 Rectifier Module

13

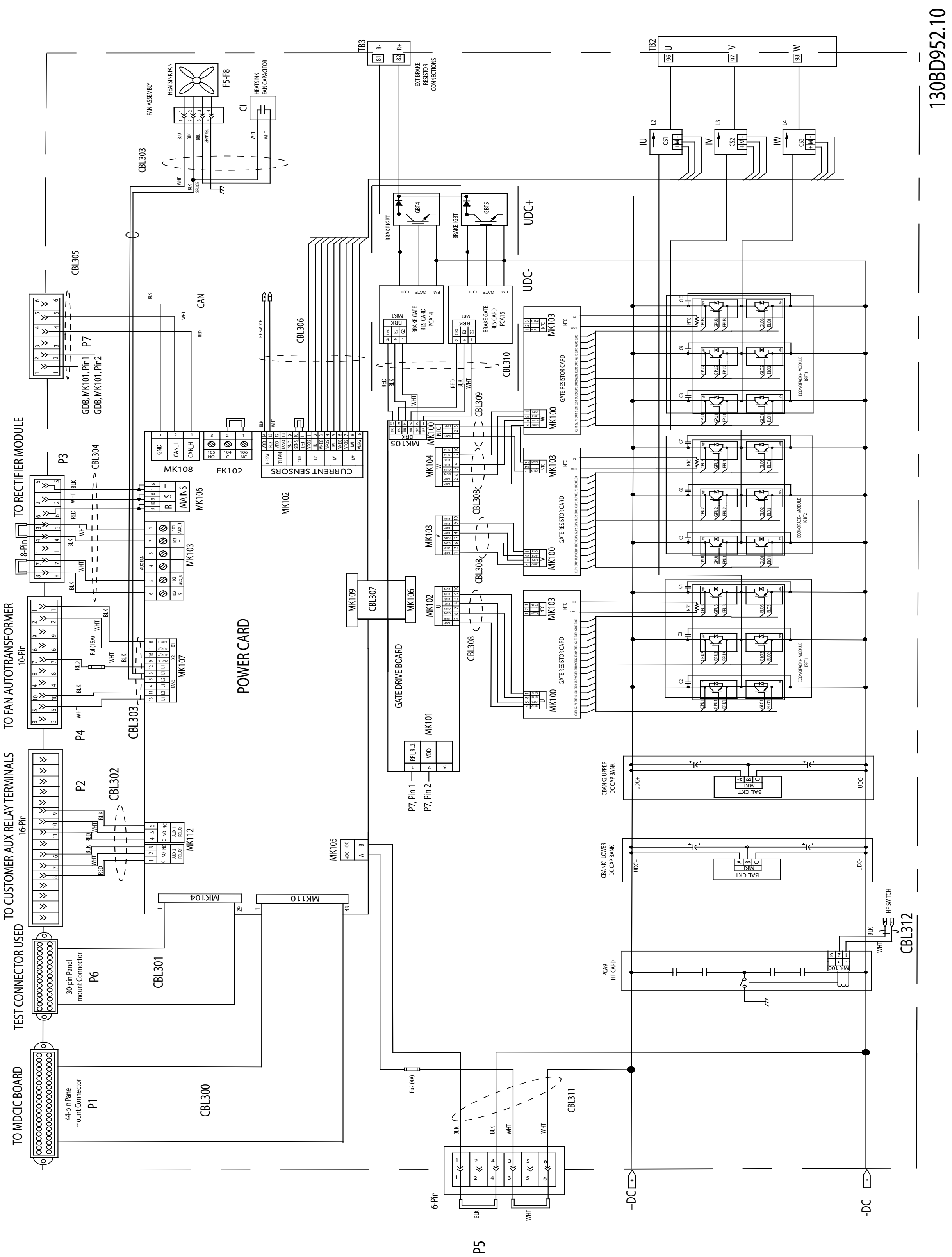


Illustration 13.14 Block Diagram, F8–F9 Inverter Module

13

13

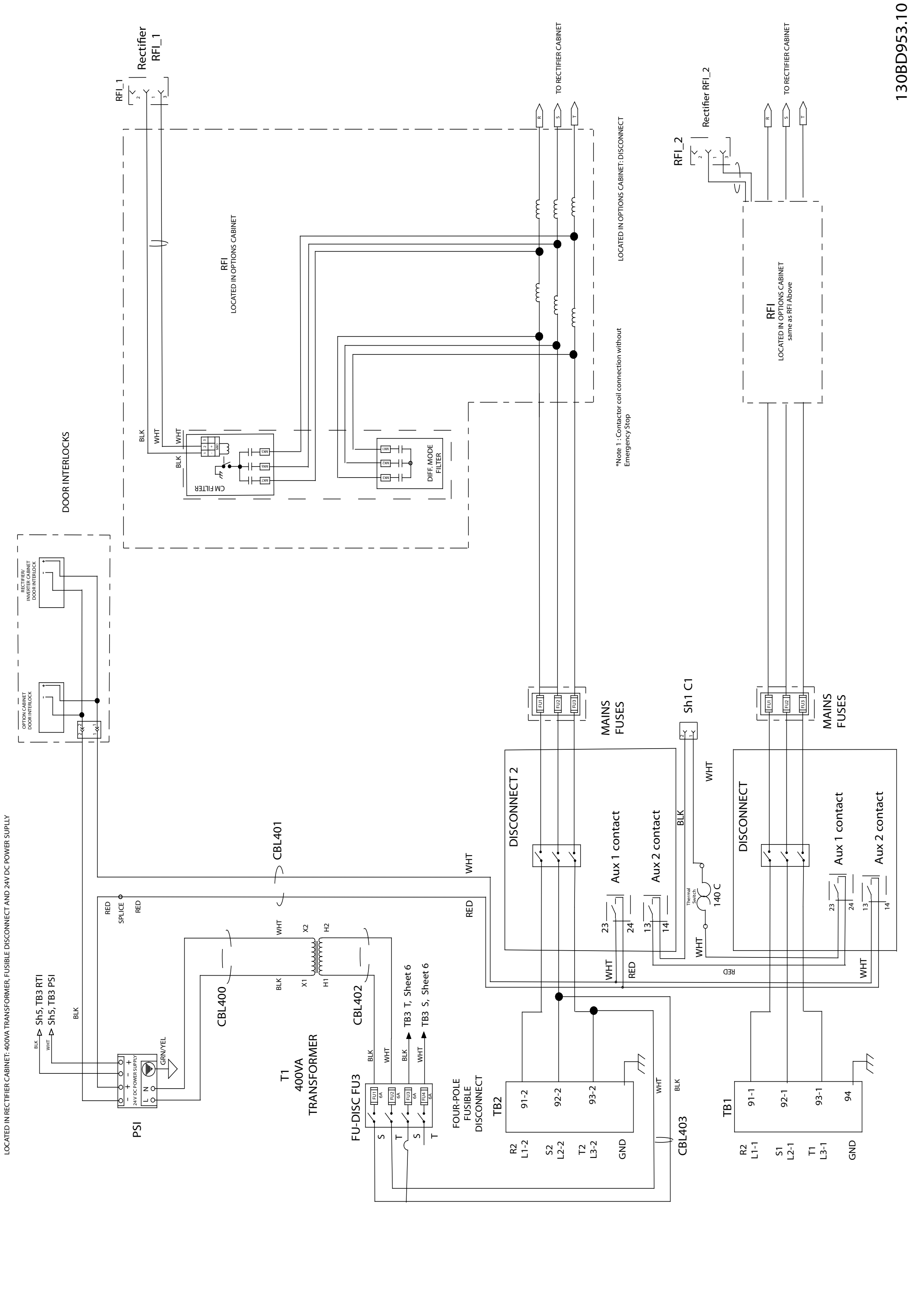


Illustration 13.15 Block Diagram, F8–F9 Options Cabinet

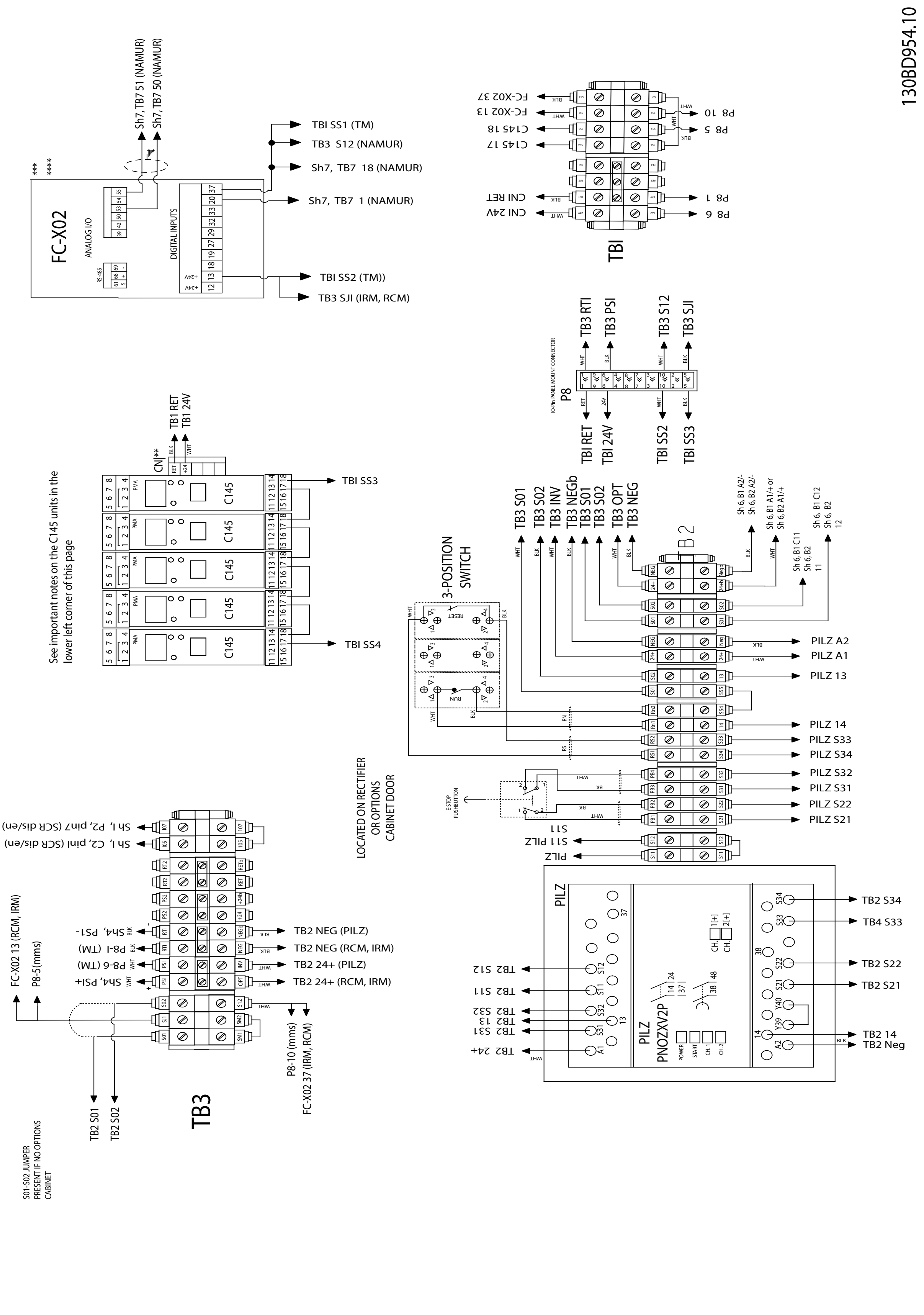


Illustration 13.16 Block Diagram, F8–F9 Pilz Relay with No Contactor/Thermal Monitor

13

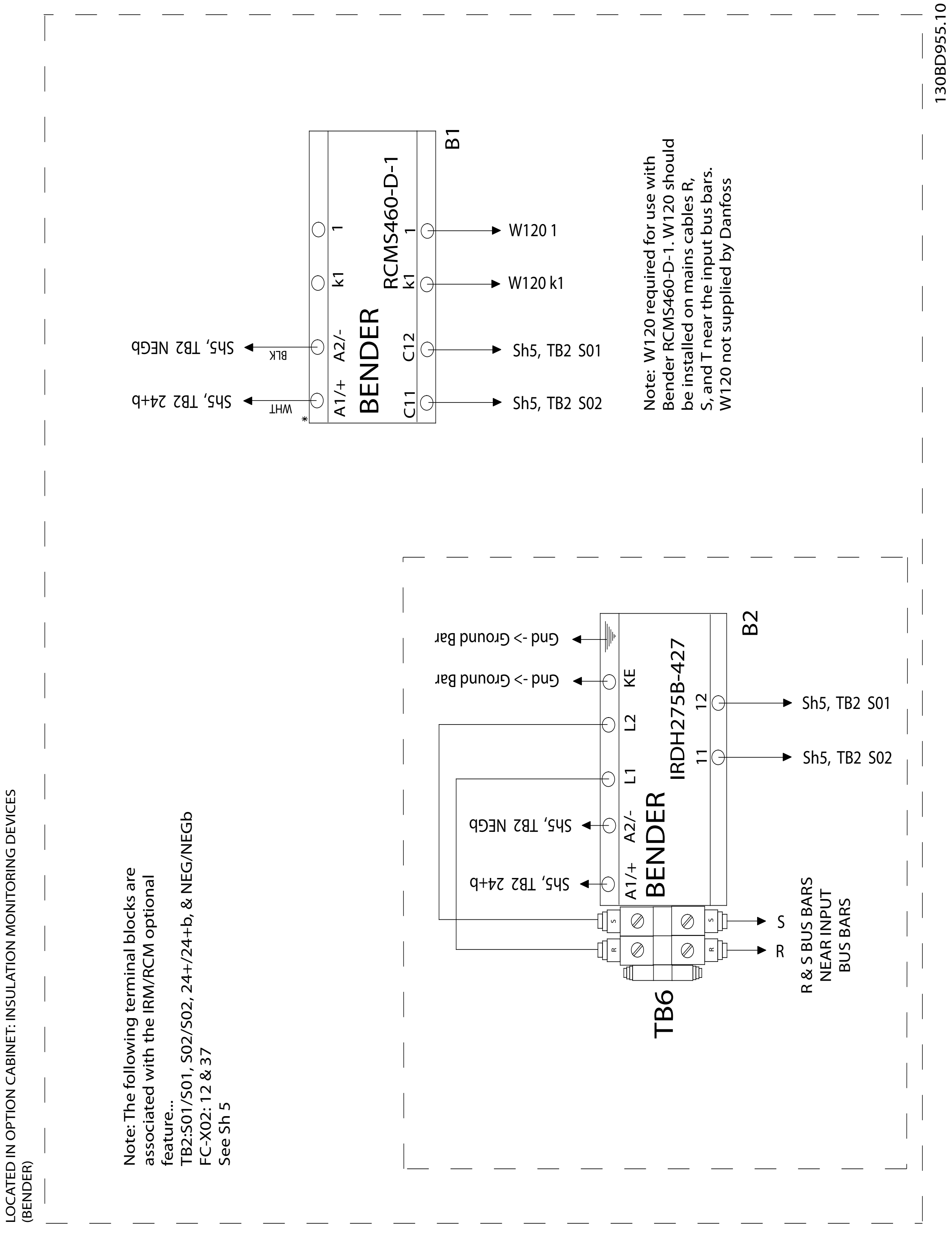


Illustration 13.17 Block Diagram, F8–F9 IRM/RCD Options

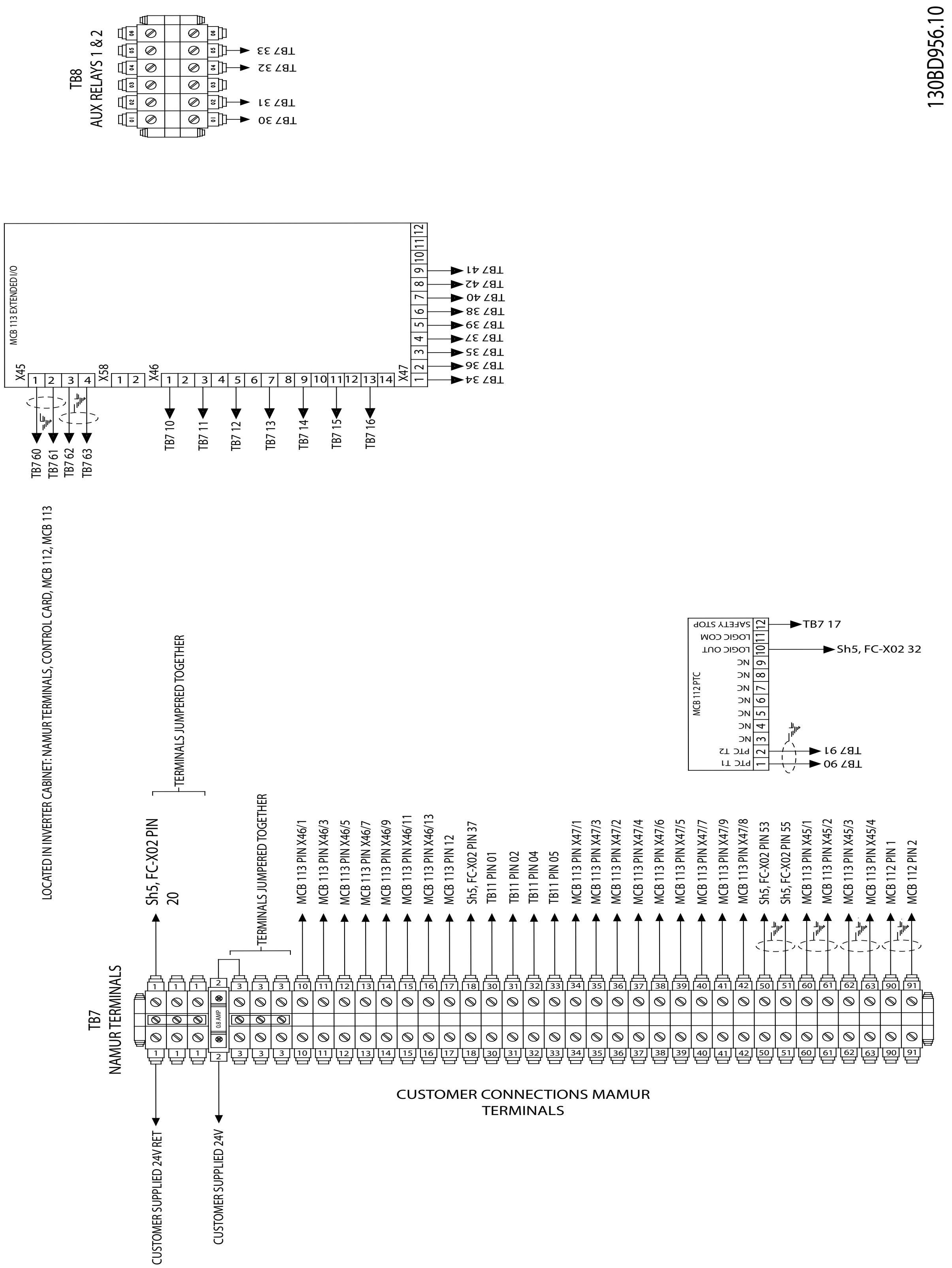


Illustration 13.18 Block Diagram, F8–F9 NAMUR Terminal Option

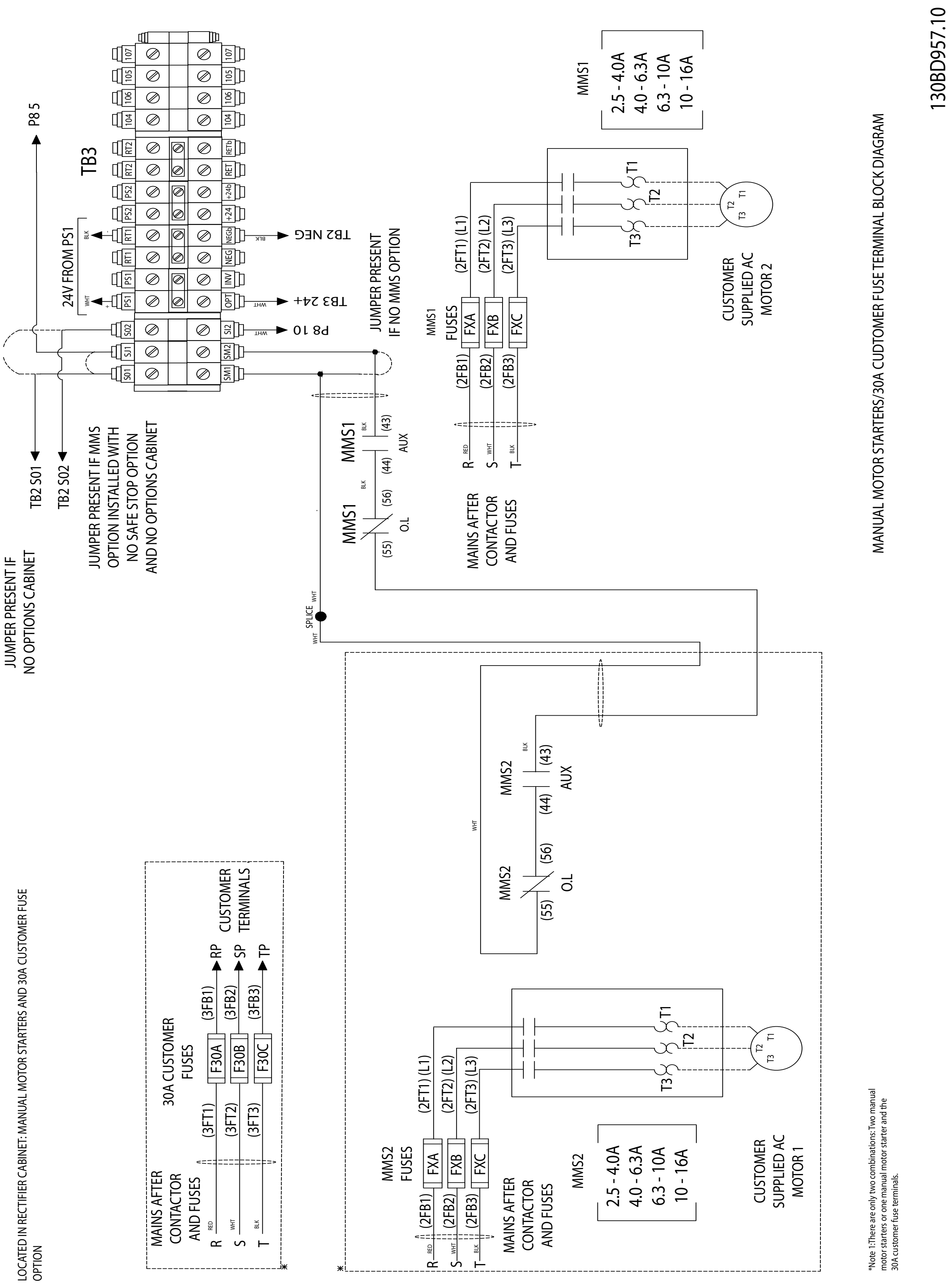


Illustration 13.19 Block Diagram, F8–F9 Manual Motor Starters/30 A Customer Fuse Terminal

13.3 Block Diagrams for F10-F13 Enclosures

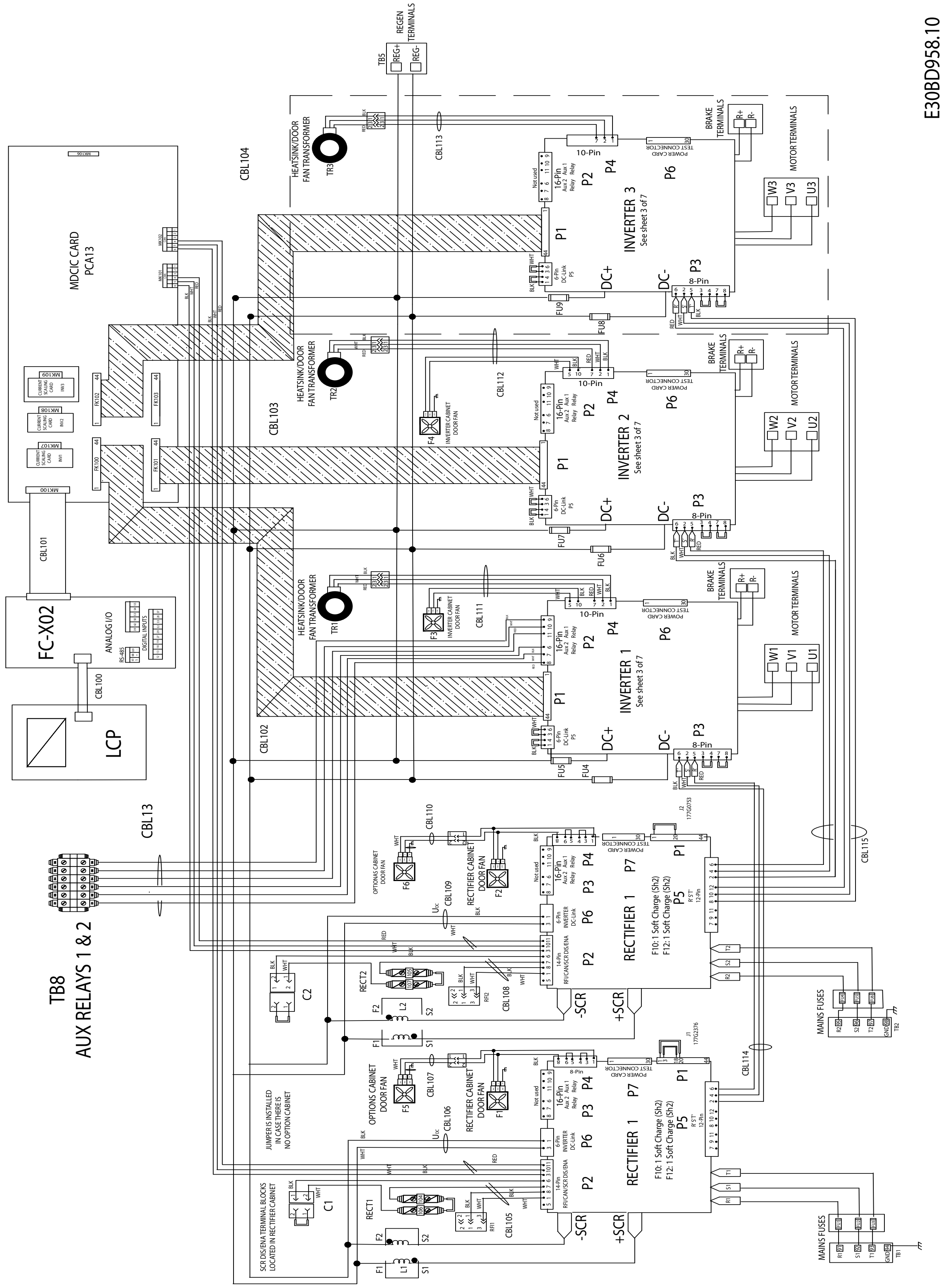


Illustration 13.20 Block Diagram, F10–F13 Top Level

13

13

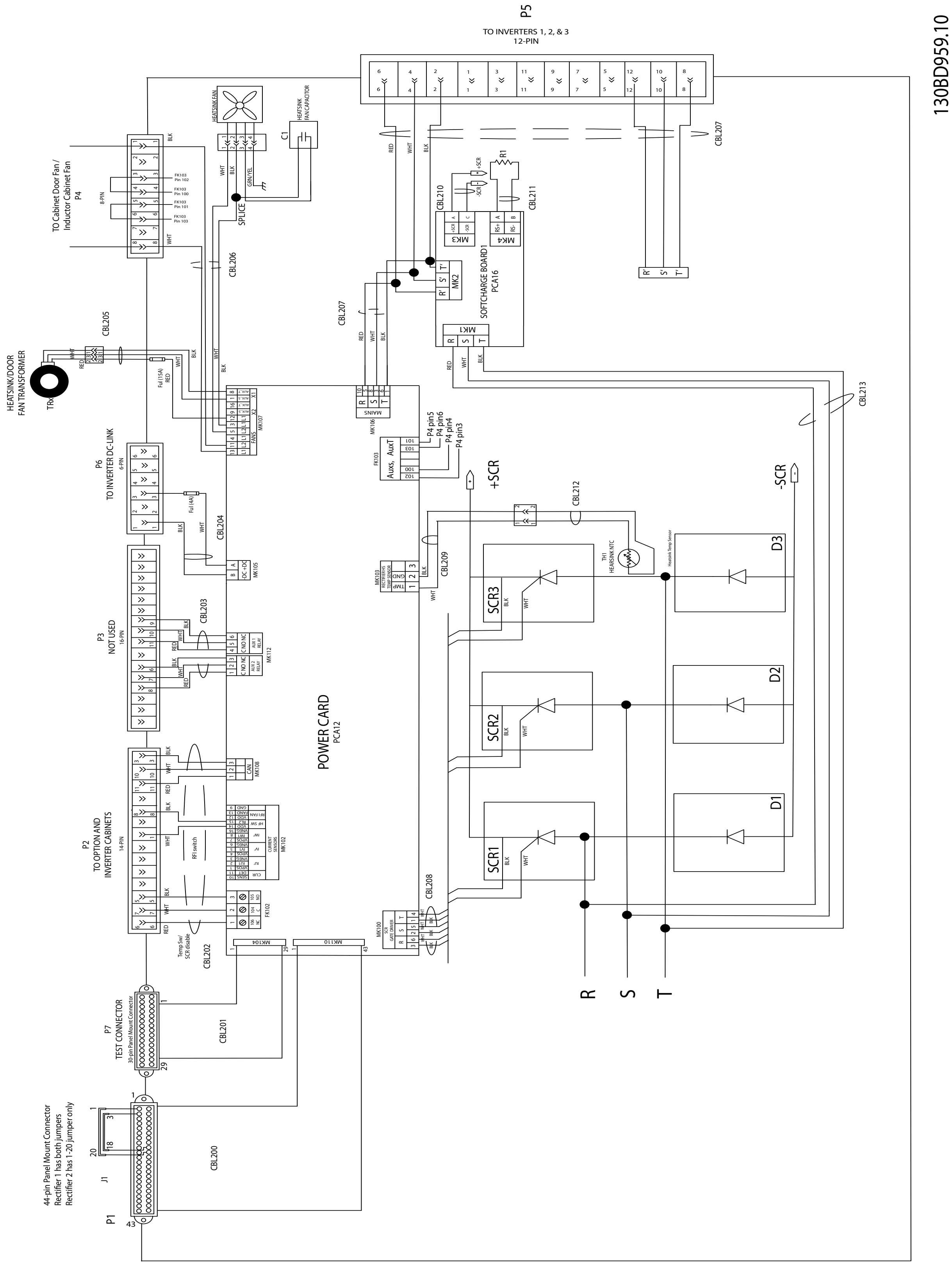


Illustration 13.21 Block Diagram, F10–F13 Rectifier with 1 Soft Charge Circuit

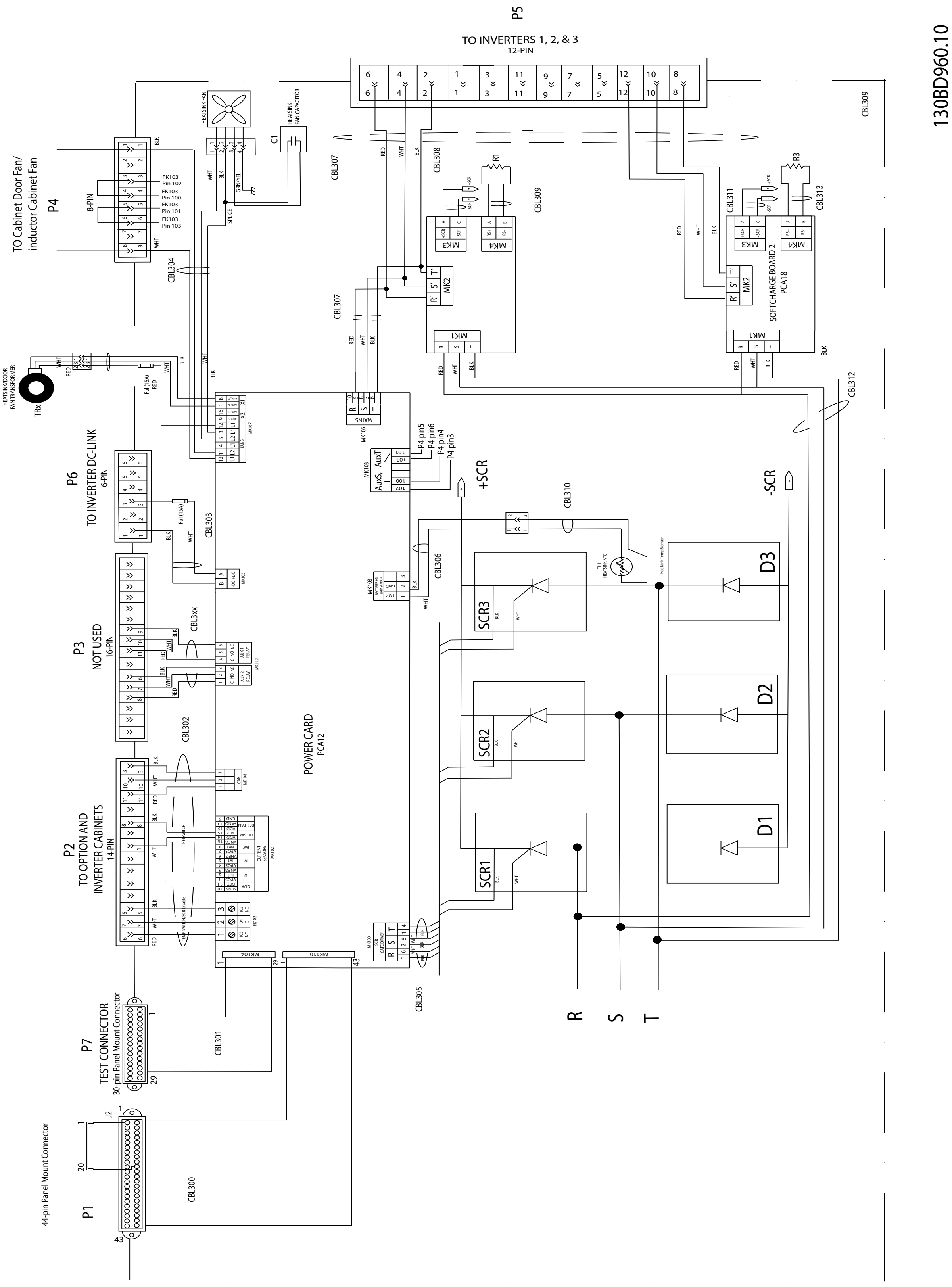


Illustration 13.22 Block Diagram, F10–F13 Rectifier with 2 Soft Charge Circuit

13

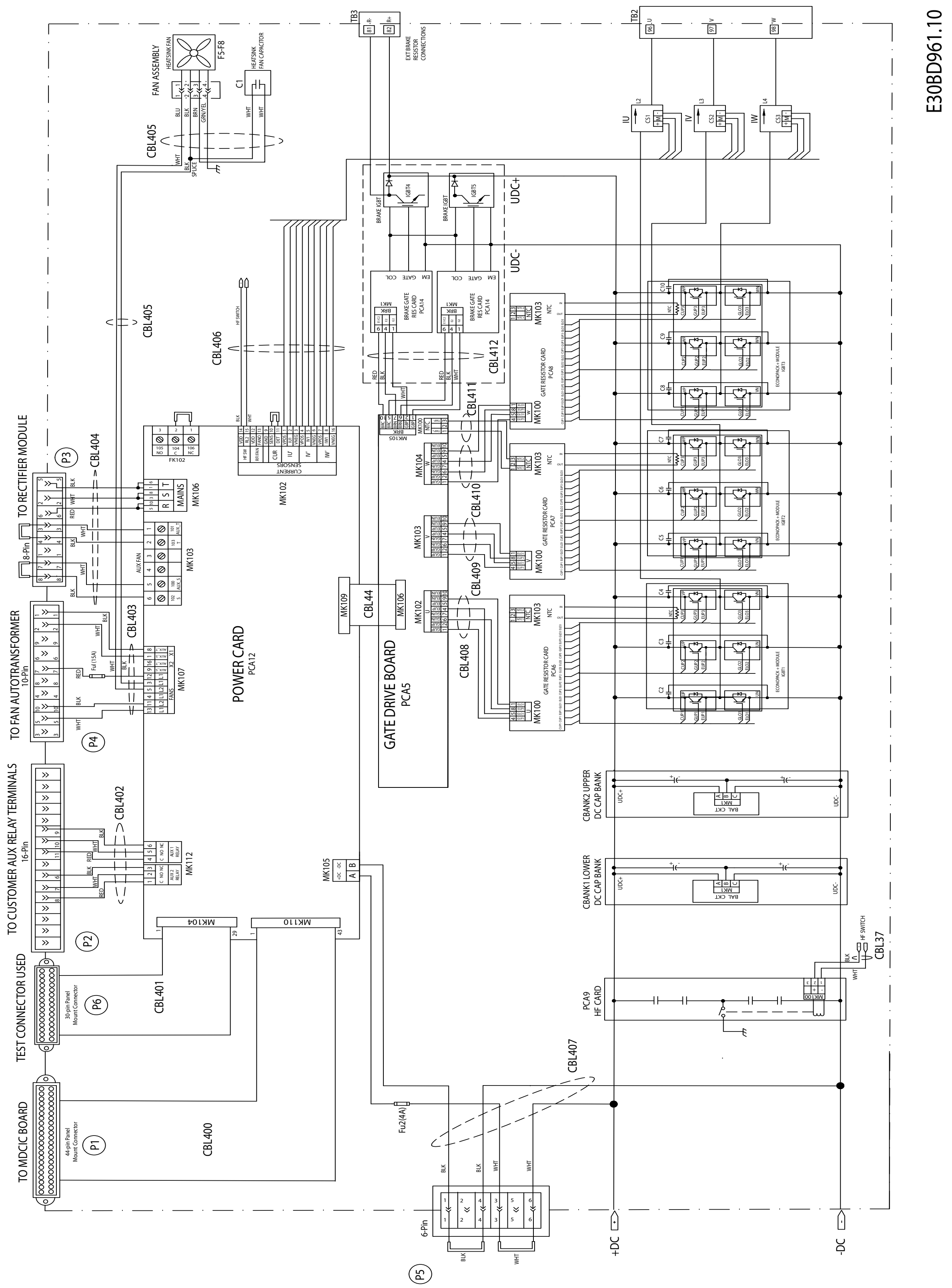


Illustration 13.23 Block Diagram, F10–F13 Inverter Module

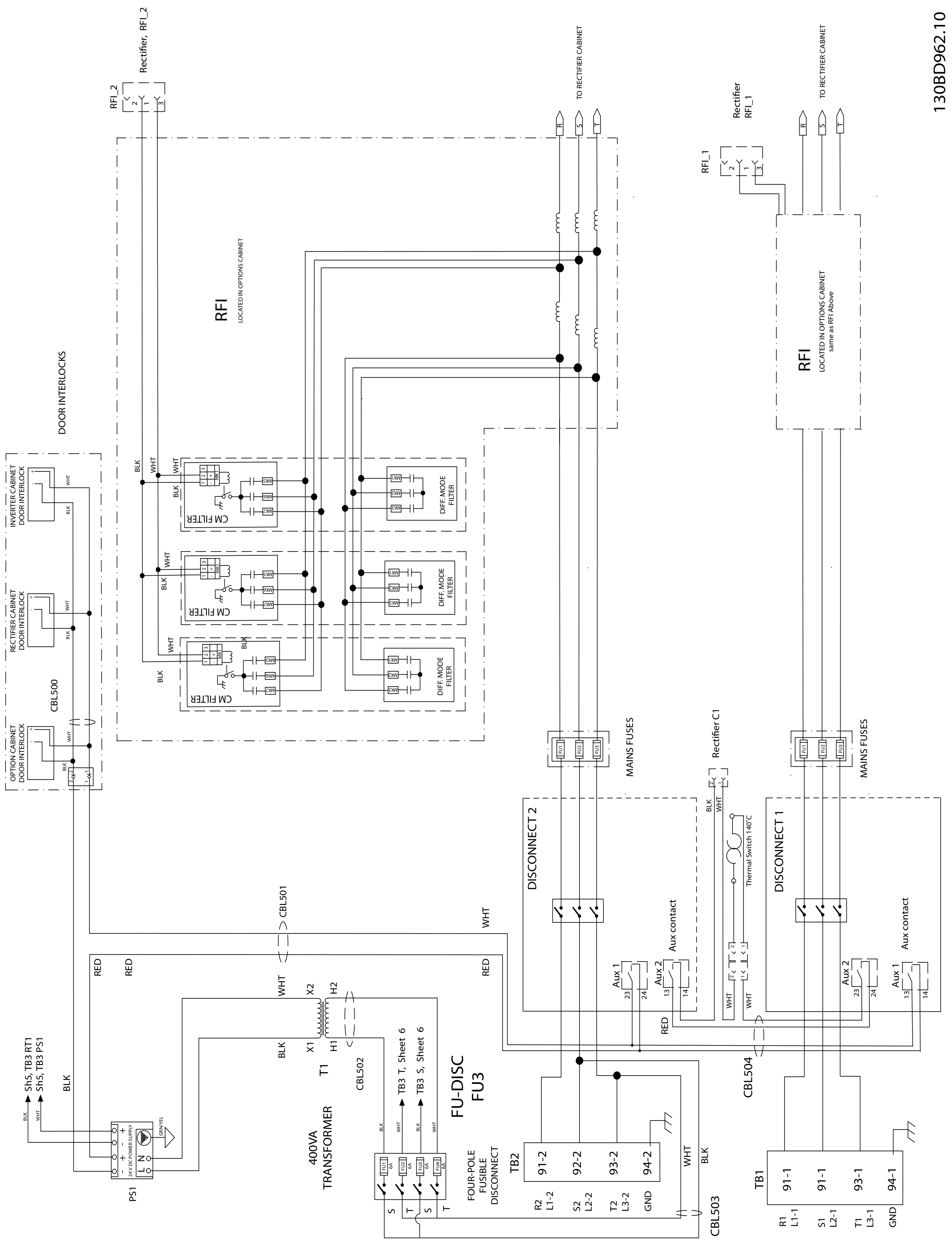


Illustration 13.24 Block Diagram, F10–F13 Options Cabinet

13

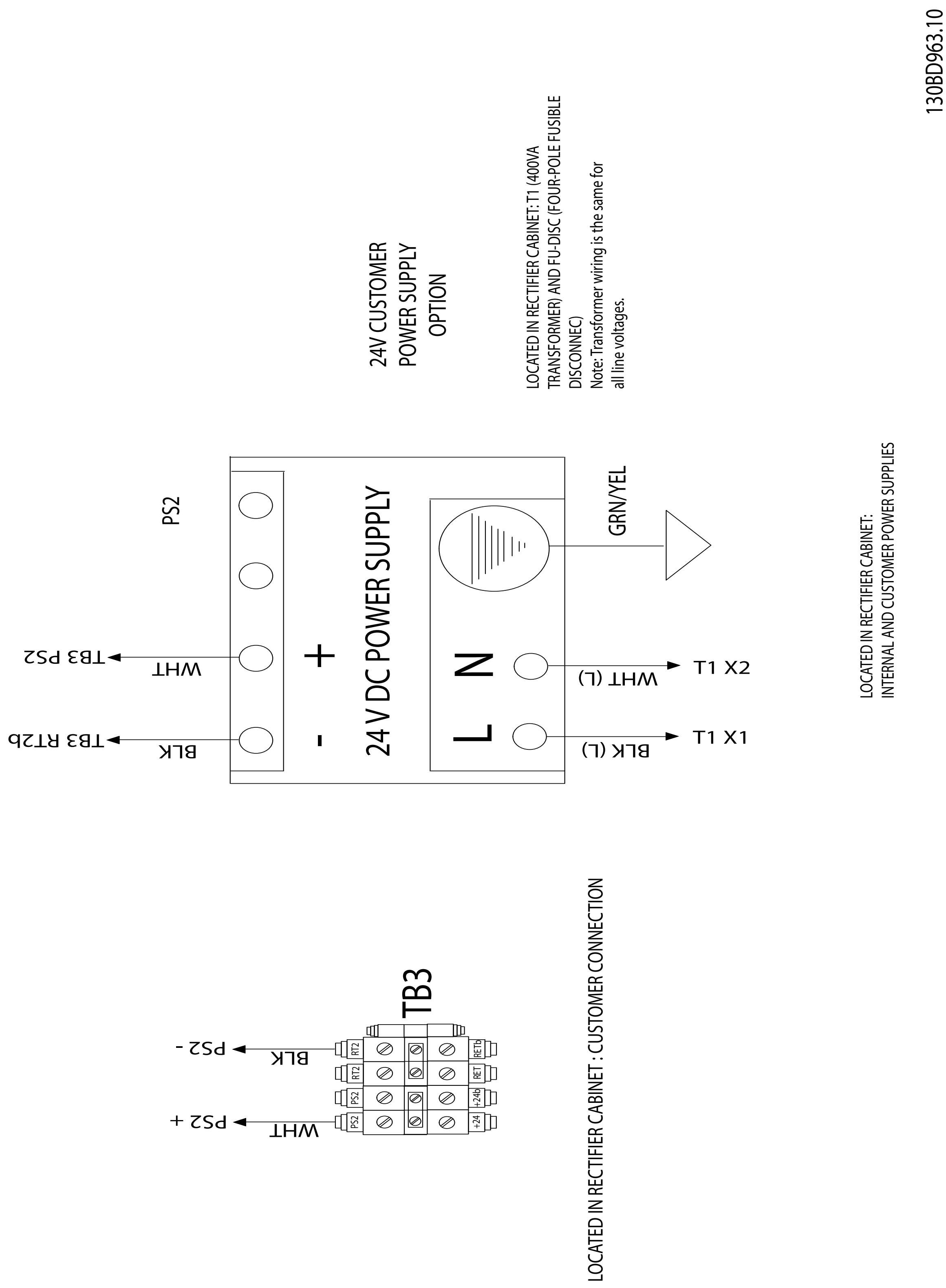


Illustration 13.25 Block Diagram, F10–F13 Customer 24 V Supply

13

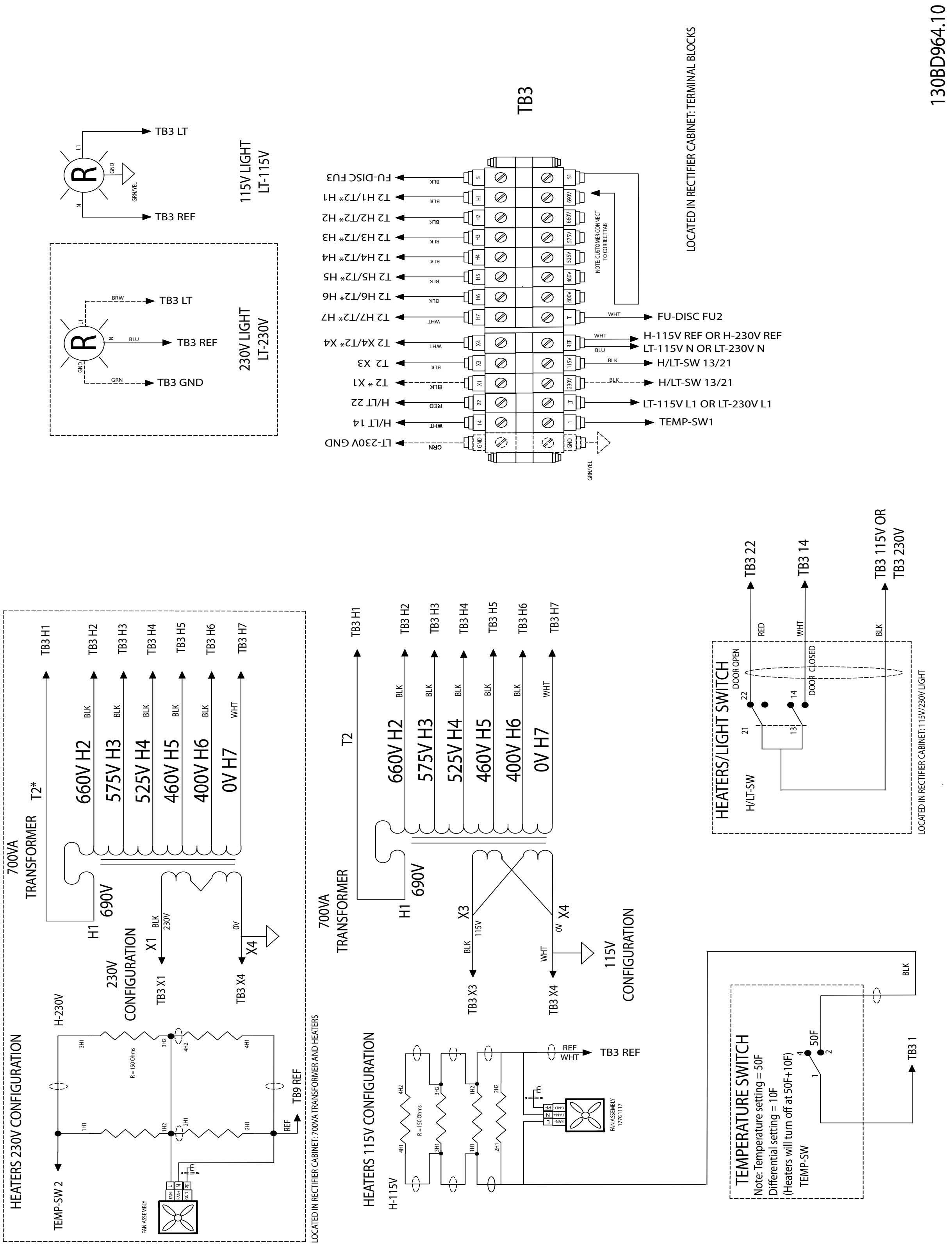
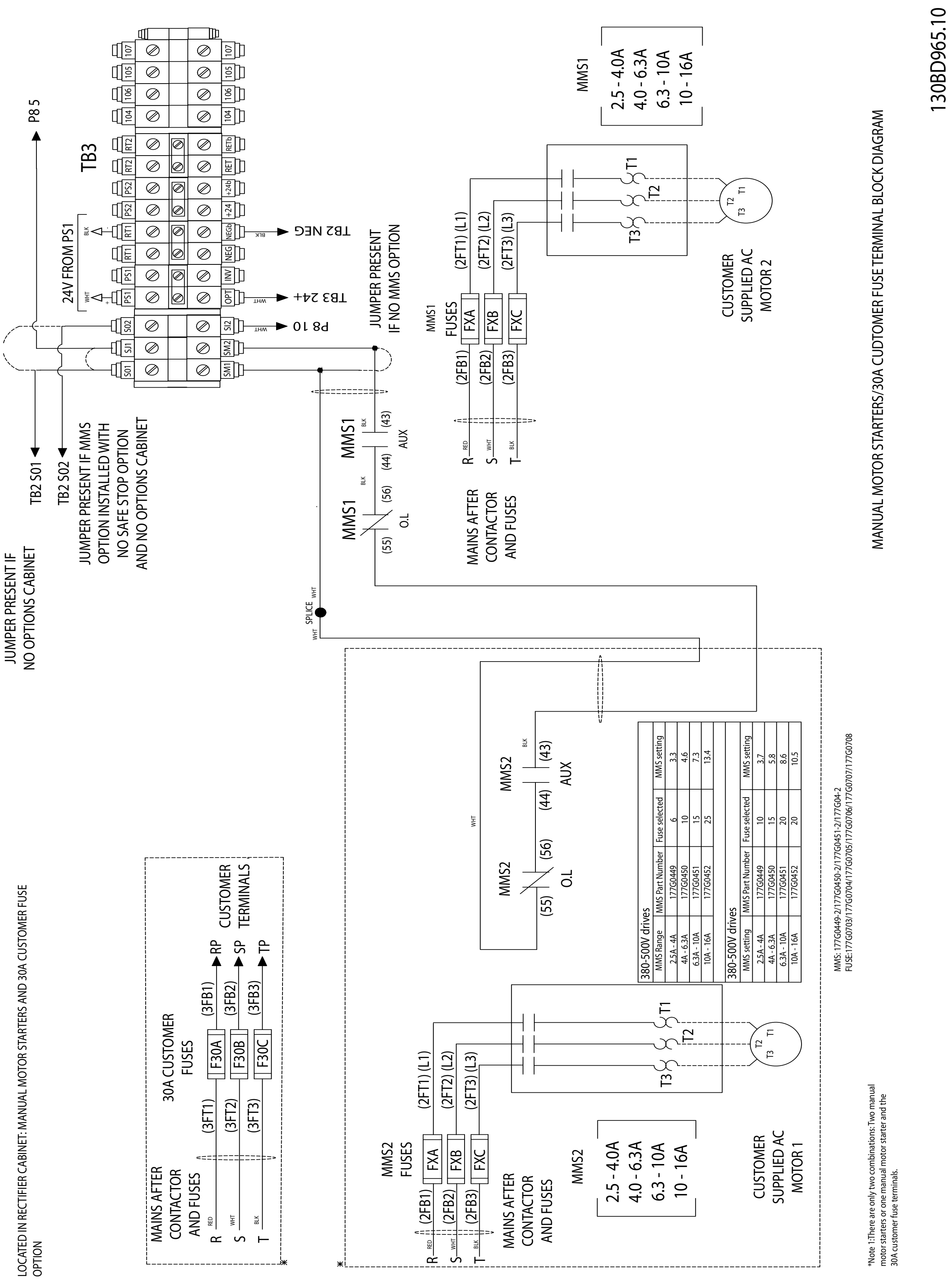


Illustration 13.26 Block Diagram, F10–F13 Cabinet Heater and Service Lights Option



380-500V drives			
MMS Range	MMS Part Number	Fuse selected	MMS setting
2.5A - 4A	177G0449	6	3.3
4A - 6.3A	177G0450	10	4.6
6.3A - 10A	177G0451	15	7.3
10A - 16A	177G0452	25	13.4

380-500V drives			
MMS setting	MMS Part Number	Fuse selected	MMS setting
2.5A - 4A	177G0449	10	3.7
4A - 6.3A	177G0450	15	5.8
6.3A - 10A	177G0451	20	8.6
10A - 16A	177G0452	20	10.5

MMS: 177G0449-2/177G0450-2/177G0451-2/177G04-2
FUSE:177G0703/177G0704/177G0705/177G0706/177G0707/177G0708

Illustration 13.27 Block Diagram, F10–F13 Manual Motor Starter/30 A Customer Fuse Terminal

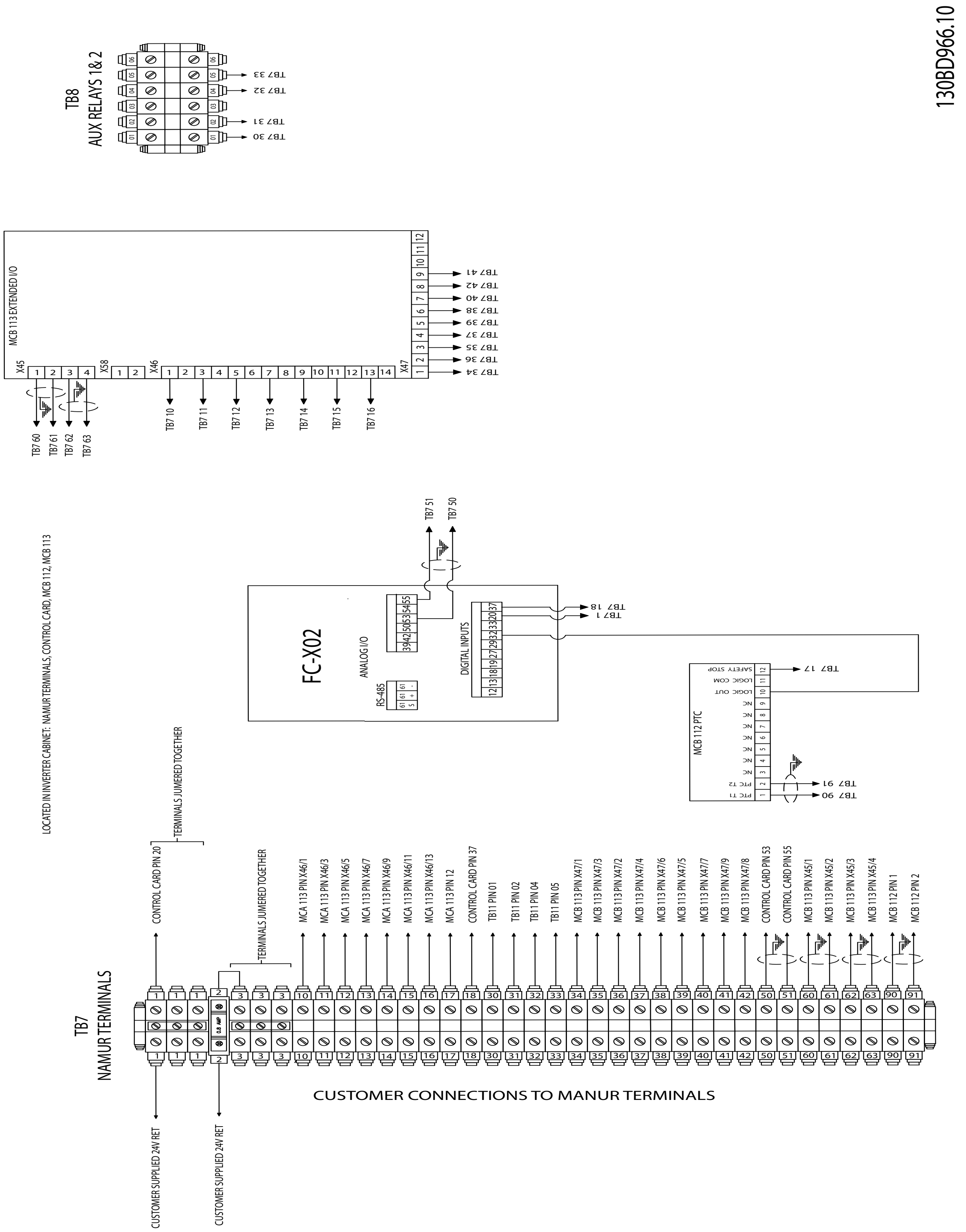


Illustration 13.28 Block Diagram, F10–F13 NAMUR Terminal

13

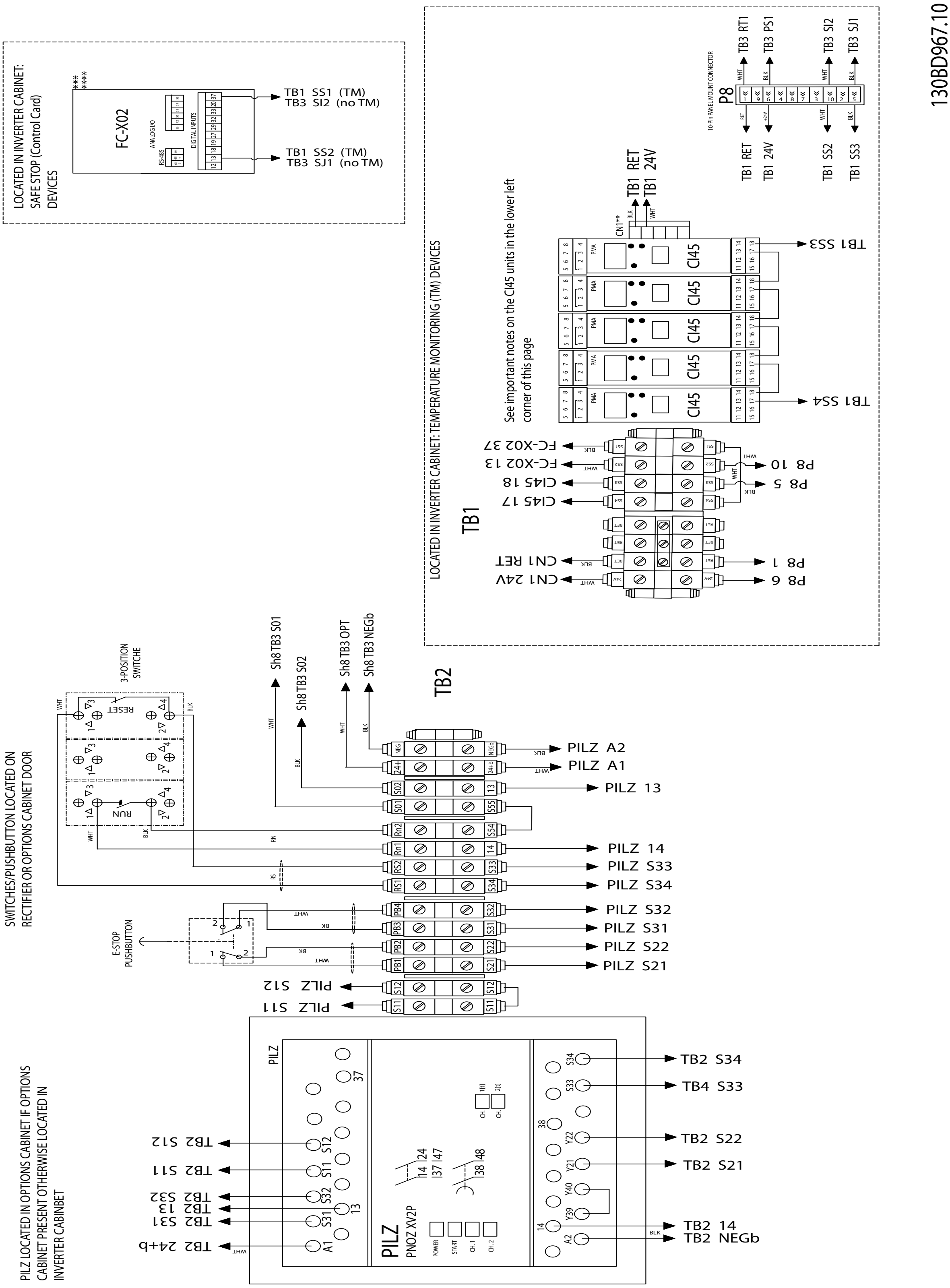


Illustration 13.29 Block Diagram, F10–F13 Pilz Relay No Contactor

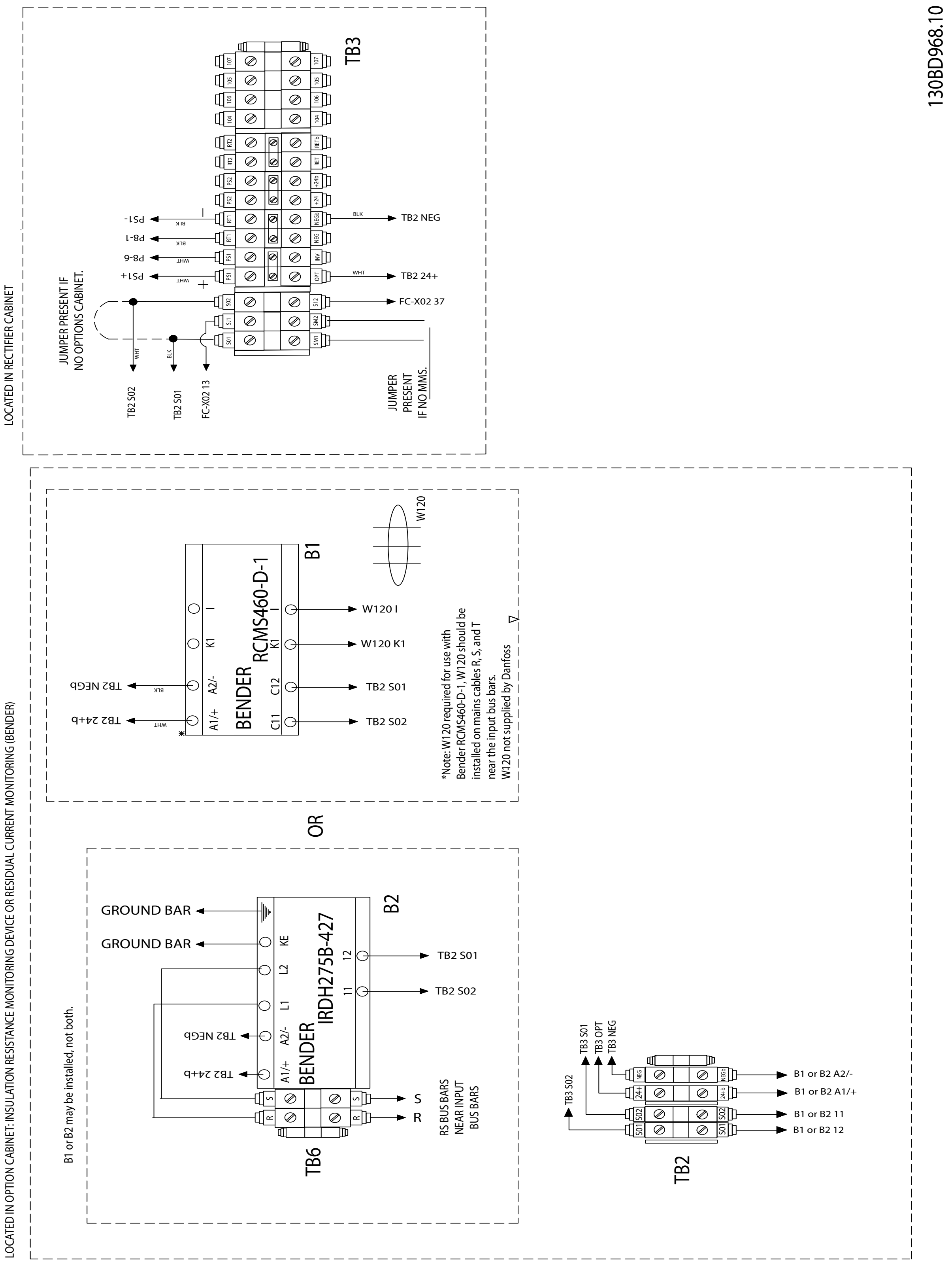


Illustration 13.30 Block Diagram, F10–F13 IRM/RCD Options

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