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VLT® Advanced Active Filter AAF006 D and E Frame Service Manual

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Contents

1 Introduction 1-1

1.1 VLT Active Filter Product Overview 1-1

1.2 For Your Safety 1-1

1.2.1 Warnings 1-1

1.3 Electrostatic Discharge (ESD) 1-1

1.4 Frame Size Definitions 1-2

1.5 Rating Tables 1-3

1.6 Fuses 1-4

1.7 Current Transducers 1-4

1.7.1 Current Transducers 1-4

1.8 General Torque Tightening Values 1-5

1.9 Tools Required 1-5

1.10 Exploded Views 1-6

1.10.1 Exploded Views E-Frame 1-6

2 Operator Interface and Active Filter Control 2-1

2.1 Introduction 2-1

2.2 User Interface 2-1

2.2.1 LCP Layout 2-1

2.2.2 Setting LCP Display Values 2-2

2.2.3 Display Menu Keys 2-2

2.2.4 Navigation Keys 2-3

2.2.5 Operation Keys 2-3

2.2.6 Tips and Tricks 2-4

2.3 Status Messages 2-4

2.3.1 Status Message Definitions 2-4

2.4 Service Functions 2-5

2.5 Filter Inputs and Outputs 2-5

2.5.1 Current Transformers 2-5

2.5.2 Filter CT Input 2-5

2.5.2.1 External CT Input 2-5

2.5.3 Control Wiring Input/Output 2-7

2.5.4 Serial Communication Wiring 2-7

2.5.5 Relay Options 2-8

2.6 Control Terminals 2-8

2.7 Control Terminal Functions 2-9

2.8 Grounding Shielded Control Cables 2-11

3 Internal Active Filter Operation 3-1

3.1 General 3-1

3.2.2 Control Card 3-1

3.2.3 Active Filter Card 3-2

3.2.4 Control to Power Interface 3-2

3.2.5 Filter Power Section 3-3

3.3 Additional Circuitry 3-3

3.3.1 AC Contactor 3-3

3.3.2 Soft Charge Circuit 3-3

3.3.3 Additional Thermal Protection 3-4

3.3.4 Current Transducers 3-4

3.3.5 Cooling Fans 3-4

3.3.6 Fan Speed Control 3-4

3.3.7 Low Harmonic Drive 3-5

4 Troubleshooting 4-1

4.1 Troubleshooting Tips 4-1

4.2 Fault Symptom Troubleshooting 4-1

4.3 Visual Inspection 4-2

4.4 Fault Symptoms 4-3

4.4.1 No Display 4-3

4.4.2 Intermittent Display 4-3

4.5 Warning/Alarm Messages 4-4

4.5.1 Warning/Alarm Code List 4-4

4.6 After Repair Tests 4-12

5 Active Filter and the Power Grid 5-1

5.1 Grid Variations 5-1

5.1.1 Grid Configurations 5-1

5.1.2 Grid Impedance 5-1

5.1.3 Voltage Pre-distortions 5-1

5.2 Basic Troubleshooting Background 5-1

5.2.1 Line Phase Loss and Unbalanced Phase Trips 5-1

5.2.2 Voltage Dips and Flickers 5-1

5.2.3 Compatibility with Other Equipment on the Same Line Power 5-2

5.2.4 Line Power Resonances 5-2

5.2.5 Control Logic Problems 5-2

5.2.6 Programming Problems 5-3

5.3 Internal Active Filter Problems 5-3
5.3.1 Overtemperature Faults 5-3
5.3.2 Current Feedback Problems 5-3
5.3.3 Noise On CT Input 5-4
5.3.4 Effect of EMI 5-4

6 Test Procedures 6-1
6.1 Introduction 6-1
6.1.1 Tools Required for Testing 6-2
6.1.2 Signal Test Board 6-2
6.2 Static Test Procedures 6-2
6.2.1 Inverter Section Tests 6-2
6.2.1.1 Inverter Test Part I 6-2
6.2.1.2 Inverter Test Part II 6-2
6.2.1.3 Inverter Test Part III 6-3
6.2.1.4 Inverter Test Part IV 6-3
6.2.2 Gate Resistor Test 6-3
6.2.3 Intermediate Section Tests 6-3
6.2.4 Heatsink Temperature Sensor Test 6-4
6.2.5 Fan Continuity Tests 6-4
6.2.5.1 Fan Fuse Test 6-4
6.2.5.2 Ohm Test of Transformer 6-4
6.2.5.3 Ohm Test of Fans 6-4
6.2.6 AC Line power Contactor and Soft Charge Contactor Tests 6-5
6.3 Dynamic Test Procedures 6-5
6.3.1 No Display Test 6-5
6.3.2 Input Voltage Test 6-5
6.3.3 Control Card Basic Voltage Test 6-6
6.3.4 Switch Mode Power Supply (SMPS) Test 6-6
6.3.5 Current Sensors Test CT1, CT2, CT3 6-7
6.3.6 Input Terminal Signal Tests 6-7
6.3.7 Line Power Resonance Test 6-8
6.3.8 Control Card Digital Inputs/Outputs Test 6-8
6.4 After Repair Tests 6-8

7 D-Frame Sizes Disassembly and Assembly Instructions 7-1
7.1 Electrostatic Discharge (ESD) 7-1
7.2 Passive Section (Top) Instructions 7-2
7.2.1 Control Card and Control Card Mounting Plate 7-3

7.2.2 Control Assembly Support Bracket 7-3
7.2.3 Active Filter Card 7-3
7.2.4 Power Card 7-4
7.2.5 Power Card Mounting Plate 7-5
7.2.6 AC Capacitors 7-6
7.2.7 AC Capacitor Current Sensor (CT4, CT5, CT6) 7-7
7.2.8 AC Contactors 7-7
7.2.9 MOVs 7-8
7.2.10 Discharge Card 7-8
7.2.11 Soft Charge Resistor 7-8
7.3 Active Side (Bottom) Instructions 7-9
7.3.1 Input Terminal Mounting Plate 7-9
7.3.2 Gate Drive Card 7-11
7.3.3 Contactor Transformer 7-11
7.3.4 Common Mode (CM) RFI Filter Card 7-11
7.3.5 Differential Mode (DM) RFI Filter Card 7-12
7.3.6 Capacitor Bank Assembly 7-12
7.3.7 IGBT Modules 7-13
7.3.8 IGBT Current Sensors CT1, CT2, and CT3 7-14
7.3.9 Damping Resistors 7-14
7.3.10 Fan Transformer 7-14
7.3.11 Fan 7-14

8 E-Frame Sizes Disassembly and Assembly Instructions 8-1
8.1 Electrostatic Discharge (ESD) 8-1
8.2 Passive Section (Top) Instructions 8-2
8.2.1 Control Card and Control Card Mounting Plate 8-3
8.2.2 Control Assembly Support Bracket 8-3
8.2.3 Active Filter Card 8-3
8.2.4 Power Card 8-4
8.2.5 Power Card Mounting Plate 8-5
8.2.6 AC Capacitors 8-6
8.2.7 AC Capacitor Current Sensor (CT4, CT5, CT6) 8-7
8.2.8 AC Contactors 8-9
8.2.9 Common Mode (CM) RFI Filter Card 8-10
8.2.10 Differential Mode (DM) RFI Filter Card 8-10
8.2.11 MOVs 8-10
8.2.12 Discharge Card 8-10

8.2.13 Soft Charge Resistor 8-10
8.3 Active Section (Bottom) Instructions 8-10
8.3.1 Input Terminal Mounting Plate 8-10
8.3.2 Gate Drive Card Mounting Plate 8-12
8.3.3 Gate Drive Card 8-12
8.3.4 Upper Capacitor Bank Assembly 8-13
8.3.5 Lower Capacitor Bank Assembly 8-14
8.3.6 IGBT Modules 8-15
8.3.7 IGBT Current Sensors CT1, CT2, and CT3 8-17
8.3.8 Fan Transformer 8-18
8.3.9 Fan 8-18
8.3.10 Damping Resistors 8-18
9 Special Test Equipment 9-1
9.1 Test Equipment 9-1
9.1.1 Signal Test Board (p/n 176F8437) 9-1
9.1.2 Signal Test Board Pin Outs: Description and Voltage Levels 9-1

1 Introduction

The purpose of this manual is to provide detailed technical information and instructions to enable a qualified technician to identify faults and perform repairs on VLT® Advanced Active Filters in D- and E-frame sizes. It covers both the stand alone active filter (AAF) and the filter portion of the VLT® Low Harmonic Drive (LHD).

This manual provides the reader with a general view of the filter's main assemblies and a description of the internal processing. With this information, technicians should have an understanding of AAF operation for troubleshooting and repair.

This manual provides instructions for the active filter models and voltage ranges described in *Table 1.1*.

1.1 VLT Active Filter Product Overview

VLT® Active Filter AAF006 is a device for harmonics and reactive current mitigation. The unit is designed for installation in various applications or combined with a Adjustable frequency drive as a packaged low harmonic drive solution. The AAF measures the current signal via external transducers and counteracts the unwanted elements of the measured current. The unwanted elements are programmable via the LCP. The active filter can compensate all harmonics until 40th harmonics at the same time in an overall compensation mode or until the 25th harmonics individual selected down to specified value set via the LCP. The unit is also capable of correcting reactive currents to harmonize the current and voltage phases, creating a displacement power factor close to 1. The AAF also balances the current loads equally on all three phases.

1.2 For Your Safety

1.2.1 Warnings

⚠CAUTION

Active filters contain dangerous voltages when connected to line power. The connected current transducers may also hold dangerous voltages when connected. Only a competent technician should carry out service.

⚠WARNING

For dynamic test procedures, line power is required and all devices and power supplies connected to line power are energized at rated voltage. Use extreme caution when conducting tests in a powered unit. Contact with powered components could result in electrical shock and personal injury.

1. DO NOT touch electrical parts of the filter or external current transducers when connected to line power. After removing power from line power, wait 20 minutes for D-frame and 40 for E-frame units before touching any electrical parts.
2. When any repair or inspection is made, line power must be disconnected.
3. The STOP key on the control panel does not disconnect line power.
4. When servicing external current transformers (CTs), remove power completely from the connection point on both line power and secondary side of the CTs.
5. Use a shorting connector on the secondary side of customer-supplied external current transformers (CTs) whenever current is present on the line power (primary side) and the AFC card is NOT wired to the external CT terminals.

1.3 Electrostatic Discharge (ESD)

CAUTION

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

Many electronic components within the unit are sensitive to static electricity. Voltages so low that they cannot be easily detected can reduce the longevity and performance of the AAF, or completely destroy sensitive electronic components.

1.4 Frame Size Definitions

380–480 V AC			
Active Filter current	Associated LHD power range	Frame designation	Weight of unit
	HO/NO (hp [kW])	Filter	lbs [kg]
A190		D13	524.7 [238]
A250		E1	945.8 [429]
A310		E1	945.8 [429]
A400		E1	998.7 [453]
A120	175/225 [132/160]	D14	676.8 [307]
A120	225/275 [160/200]	D14	676.8 [307]
A120	275/350 [200/250]	D14	676.8 [307]
A210	350/425 [250/315]	E9	1490 [676]
A210	425/500 [315/355]	E9	1490 [676]
A210	500/550 [355/400]	E9	1490 [676]
A210	550/600 [400/450]	E9	1490 [676]
A330	450/500–630/700	F18	4409 [2000]

Table 1.1 Active Filter Ratings

Frame designation	Depth (in [mm])	Width (in [mm])	Height (in [mm])
D13	14.96 [380]	23.62 [600]	68.5 [1740]
D14	14.96 [380]	40.16 [1020]	68.5 [1740]
E1	19.69 [500]	23.62 [600]	78.74 [2000]
E9	19.69 [500]	47.24 [1200]	78.74 [2000]
F18	23.62 [600]	110.24 [2800]	86.61 [2200]

Table 1.2 Dimensions

Filters are available in IP21 and IP54.

1.5 Rating Tables

Ratings below are for the active filter. Drive related specifications can be found in the respective Low Harmonic Drive Instruction Manual.

Harmonic compensation values for the LHD filters are approximate. Variations due to tuning for frame sizes and associated drives may occur.

Model number			AAF006 A120 LHD filter only	AAF006 A190	AAF006 A210 LHD filter only	AAF00 6A250	AAF006 A310	AAF006 A330	AAF006 A400
Frame			D		E			F	E
Total	Current	[A]	120	190	210	250	310	330	400
Peak	Current	[A]	300	475	625	775	775	825	1000
Overload	60 s every 10 min	[%]	No overload	110	No overload	110	110	No overload	110
LHD built-in CT rating		[A]	500	NA	1000	NA	NA	1500	NA
Overcurrent indication		[% s]							
Overcurrent trip level		[A pk]	554	554	1030	1030	1030	1818	1818
DC overcurrent		[A]	285	285	465	465	465	750	750
LCL Capacitor current trip		[A]	22	22	34	34	34	58	58
Damping resistor temperature		(° F [°C])	239 [115]	239 [115]	239 [115]	239 [115]	239 [115]	239 [115]	239 [115]

Table 1.3 Product Related Specifications

The filter will automatically limit output to avoid overcurrent tripping.

Typical average switching frequency	3.0–4.5 kHz
Excessive switching frequency trip limit	6.0 kHz
Voltages	
DC voltage maximum reference	790 V DC
Inrush circuit enabled	370 V DC
Inrush circuit disabled	395 V DC
Undervoltage disable	402 V DC
Undervoltage warning	423 V DC
Undervoltage re-enable (reset)	442 V DC
Start permissive	821 V DC
Overvoltage warning	850 V DC
Overvoltage trip	855 V DC
Temperatures	
Heatsink over-temperature enable (automatic derating begins.)	185° F [85° C]
Heatsink over-temperature trip	221° F [105° C]
Heatsink under-temperature warning	32° F [0° C]
Damping resistor heatsink over-temperature enable (automatic derating begins.)	221° F [105° C]
Damping resistor heatsink over-temperature trip	239° F [115° C]
Power card over-temperature	154.4° F [68° C]
Power card under-temperature	-4° F [-20° C]
Ground fault alarm	50%

Table 1.4 Trip Points

1.6 Fuses

Table 1.5 provides the types and ratings and function of various fuses for the AAF.

Identification	Type	Current rating	Function	If blown check for short in
FU4	KLK	15 A	Fan Fuse	Heatsink or Door Fan
FU5	KLK	4 A	DC Bus plus to Power Card for SMPS	SMPS on Power Card
FU6	FNQ-R3	3 A	Primary of contactor transformer	Transformer
FU8	G	See Note	Line Power Input Fuse (Optional)	Power Component
FU9	G	See Note	Line Power Input Fuse (Optional)	Power Component
FU10	G	See Note	Line Power Input Fuse (Optional)	Power Component
FU11	KLK	15 A	Line Power Supply to Power Card for Fans & Soft Charge Circuit	Fan Transformer
FU12	KLK	15 A	Line Power Supply to Power Card for Fans & Soft Charge Circuit	Fan Transformer
FU13	KLK	15 A	Line Power Supply to Power Card for Fans & Soft Charge Circuit	Fan Transformer
FU14	FQN-R	1 A	Soft Charge Resistor	DC Capacitor Bank, IGBT Module
FU15	FQN-R	1 A	Soft Charge Resistor	DC Capacitor Bank, IGBT Module

Table 1.5 Fuse Ratings and Functions

NOTE!

Size Dependent. AAF190 = 250 A, AAF310 = 400 A, AAF400 = 500 A

1.7 Current Transducers

1.7.1 Current Transducers

Current transducers are used to monitor current in various locations in the filter. Three current transducers on the output-phases bus bars induce counter harmonics onto line power. There are also three current transformers on the line power bus bars outside of the active filter. The information from these three transformers, via the active filter card, is what the filter compensates for on the line power. (For the LHD drive, these transformers are on the line power input bus bars of the Adjustable frequency drive for measuring the harmonics caused by the Adjustable frequency drive.) Three other current transducers in the LCL filter section are used for overload protection for the AC capacitors and damping resistors.

Identification	Type	Function
CT1	Hall Effect	Output of inverter IGBT current sensor
CT2	Hall Effect	Output of inverter IGBT current sensor
CT3	Hall Effect	Output of inverter IGBT current sensor
CT4	Hall Effect	AC capacitor current sensor
CT5	Hall Effect	AC capacitor current sensor
CT6	Hall Effect	AC capacitor current sensor
CT7	Current Transformer	External current transformer
CT8	Current Transformer	External current transformer
CT9	Current Transformer	External current transformer

Table 1.6 Current Transducers

1.8 General Torque Tightening Values

For fastening hardware described in this manual, the torque values in the table below are used. These values are not intended for fastening IGBTs. See the instructions included with those replacement parts for correct values.

Shaft Size	Driver Size Torx/Hex [mm]	Torque [in-lbs]	Torque [Nm]
M4	T-20/7	10	1.0
M5	T-25/8	20	2.3
M6	T-30/10	35	4.0
M8	T-40/13	85	9.6
M10	T-50/17	170	19.2
M12	18/19	170	19

Table 1.7 Torque Values

1.9 Tools Required

Instruction Manual for the FC Series Active Filters

Metric socket set	7–19 mm
Socket extensions	100 mm–150 mm (4 in and 6 in)
Torx driver set	T-10 - T-50
Torque wrench	0.675–19 Nm (6–170 in-lbs)
Needle nose pliers	
Magnetic sockets	
Ratchet	
Screwdrivers	Standard and cross-thread

Table 1.8

Additional Tools Recommended for Testing

Digital volt/ohmmeter (must be rated for 1200 V DC for 690 V units)
Analog voltmeter
Oscilloscope
Megohmmeter
Clamp-on style amp meter
Signal test board (p/n 176F8437) and extension board (p/n 130B3147)
Split-bus power supply (p/n 130B3146)
Power quality analyses Fluke 435 (p/n 130BB3173), Dranetz 4300, 4400, or similar

Table 1.9

1.10 Exploded Views

1.10.1 Exploded Views E-Frame

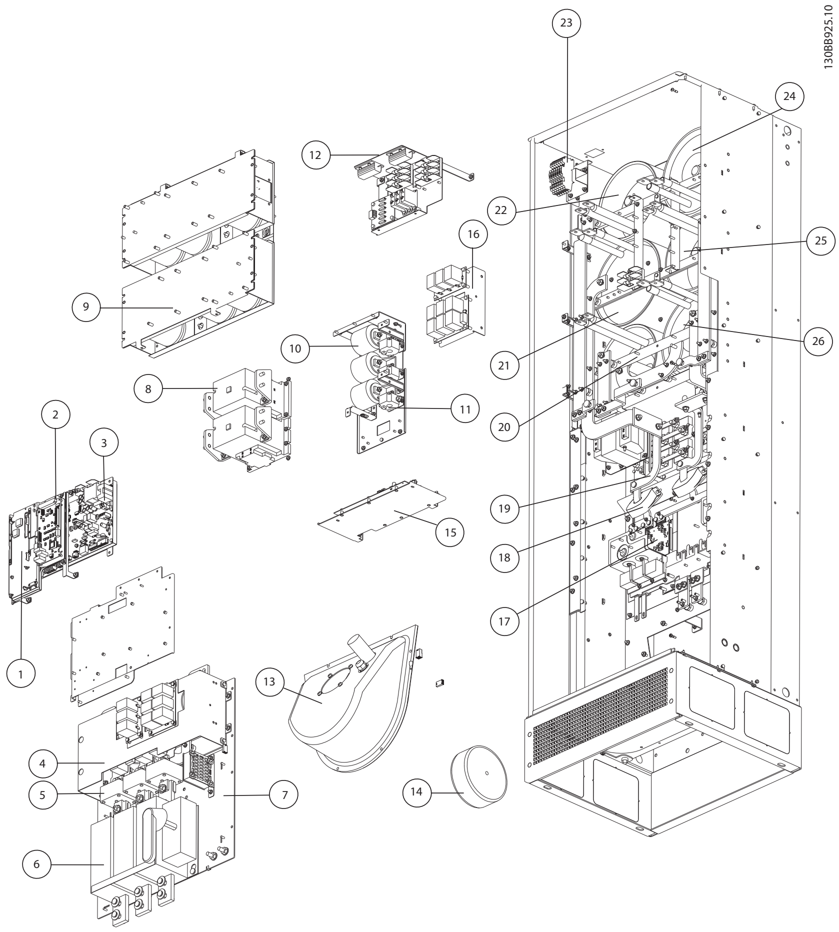


Figure 1.1

1	Control card (not shown)	14	Fan transformer
2	Active filter card	15	Gate drive card
3	Power card	16	RFI circuit block
4	Input RFI (option)	17	IGBT module
5	Line power input fuse (option)	18	IGBT current sensor
6	Line power disconnect (option)	19	Damping resistors
7	Input terminal mounting plate	20	Cross bus bar
8	Line power contactor	21	DC link inductor
9	Lower capacitor bank assembly	22	DC link inductor
10	LCL capacitors	23	CT connection terminals
11	LCL capacitor current sensor	24	DC link inductor
12	Soft charge resistors, MOV, discharge card, and fuse assembly	25	DC link inductor
13	Fan	26	Bus bar retaining nut

Table 1.10

2 Operator Interface and Active Filter Control

2.1 Introduction

The advanced active filter (AAF) monitors external and internal harmonic current conditions. When an alarm is issued and the filter trips, it cannot be assumed that the fault lies within the active filter itself. Most alarms that the AAF displays are generated by conditions outside of the active filter. This service manual provides techniques and test procedures to isolate a fault condition whether within or outside of the active filter.

Active filters have protection circuitry that reduces the filter output current. If the reduced output is insufficient, or in critical situations, a fault is registered and the unit will trip - suspend operation - to avoid damage. When a fault occurs, a fault message is displayed to assist in troubleshooting and service. The normal operating status of the filter is displayed in real-time on the LCP display. Virtually every filter operation results in an indication on the LCP display. Fault logs are maintained within the active filter for fault history.

The filter also shows warnings on the LCP display to indicate that the unit has reached a given limit. In most cases, the AAF automatically adjusts to assure operation is not disrupted. Warnings usually indicate that the filter is running at its maximum capability. Familiarity with the information provided on the display is important. Diagnostic data can be accessed through the LCP.

2.2 User Interface

The local control panel (LCP) is the combined display and keypad on the front of the unit. The LCP is the user interface to the active filter.

The LCP has several user functions.

- Start and stop the filter when in local control
- Display operational data, status, warnings and cautions
- Programming active filter functions
- Manually reset the active filter after a fault when auto-reset is inactive

2.2.1 LCP Layout

The LCP display is divided into three functional groups (see *Figure 2.1*).

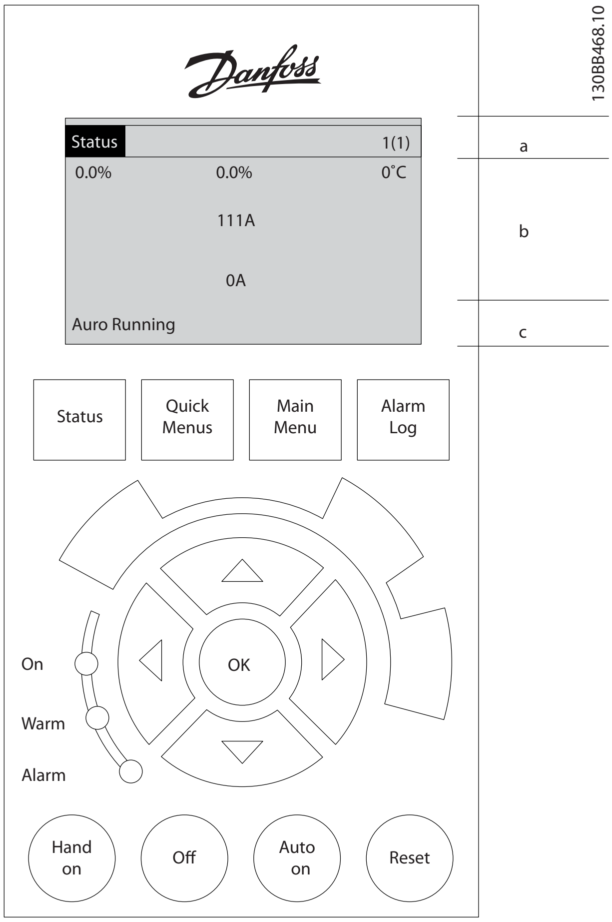


Figure 2.1 LCP Display

a. Display mode line shows which display mode is active and indicates which set up is active and how many set ups are programmed 1(1). Pressing [Status] changes modes.

b. Lines 1 - 3 display user selected operation data (see *2.2.2 Setting LCP Display Values*).

c. Status line displays filter-generated status messages (see *2.3.1 Status Messages*).

2

2.2.2 Setting LCP Display Values

The display area is activated when the active filter receives power from AC line voltage, a DC bus terminal, or an external 24 V supply

The information displayed on the LCP can be customized for user application

- Each display readout has a parameter associated with it
- Options are selected in the main menu *0-** Operation/Display*
- Display 2 has an alternate larger display option
- The active filter status at the bottom line of the display is generated automatically and is not selectable. See *2.3 Status Messages* for definitions and details.

Display	Parameter number	Default setting
1.1	0-20	Power factor
1.2	0-21	THD of current (%)
1.3	0-22	Line power current (A)
2	0-23	Output current (A)
3	0-24	Line power frequency (Hz)

Table 2.1

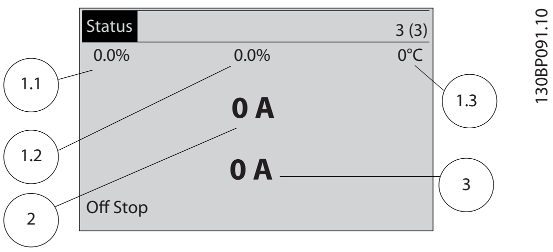


Figure 2.2 Default Display Values

2.2.3 Display Menu Keys

Menu keys are used for menu access for parameter setup, toggling through status display modes during normal operation, and viewing fault log data.

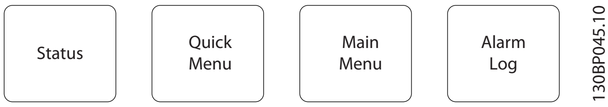


Figure 2.3

Key	Function
Status	Press to show operational information. • In Auto mode, press and hold to toggle between status readout displays • Press repeatedly to scroll through each status display. • Press and hold [Status] plus [▲] or [▼] to adjust the display brightness • The symbol in the upper right corner of the display shows whichsetup is active. This is not programmable.
Quick Menu	Allows access to programming parameters for initial set-up instructions and many detailed application instructions. • Press to access *Q2 Quick Set-up* for sequenced instructions to program the basic setup • Follow the sequence of parameters as presented for the function set-up
Main Menu	Allows access to all programming parameters. • Press twice to access top level index. • Press once to return to the last location accessed. • Press and hold to enter a parameter number for direct access to that parameter.
Alarm Log	Displays a list of current warnings, the last 10 alarms, and the maintenance log. • For details about the active filter before it entered the alarm mode, select the alarm number using the navigation keys and press [OK].

Table 2.2

2.2.4 Navigation Keys

Navigation keys are used for programming functions and moving the display cursor. Three status indicator lights are also located in this area.

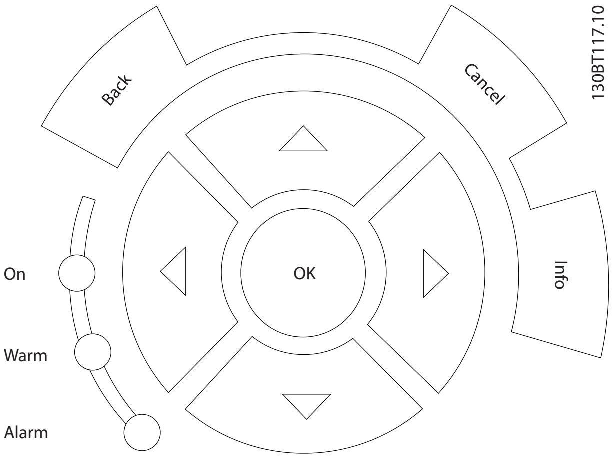


Figure 2.4

Key	Function
Back	Reverts to the previous step or list in the menu structure.
Cancel	Cancels the last change or command as long as the display mode has not changed.
Info	Press for a definition of the function being displayed.
Navigation Keys	Use the four navigation arrows to move between items in the menu.
OK	Use to access parameter groups or to enable a choice.

Table 2.3

Light	Indicator	Function
Green	ON	The ON light activates when the active filter receives power from AC line voltagee, a DC bus terminal, or an external 24 V supply.
Yellow	WARN	When warning conditions are met, the yellow WARN light comes on and text appears in the display area identifying the problem.
Red	ALARM	A fault condition causes the red alarm light to flash and an alarm text is displayed.

Table 2.4

2.2.5 Operation Keys

Operation keys are found at the bottom of the control panel.

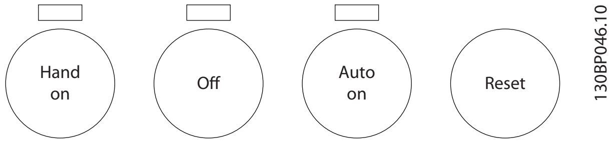


Figure 2.5

Key	Function
Hand On	Press to start the active filter in local control. • The filter measures distortion and closes the main contactors to start filtering when needed • The other operation keys are still active in hand on mode • An external stop signal by control input or serial communication overrides the local hand on • A remote signal has higher priority than hand on
Off	Stops the filtering function but does not remove power to the active filter.
Auto On	Puts the system in remote operational mode. • Responds to an external start command by control terminals or serial communication
Reset	Resets the active filter manually after a fault has been cleared.

Table 2.5

2.2.6 Tips and Tricks

- The AAF default parameter settings ensure that few setup changes are necessary. For the majority of applications, the Quick Menu *Q2 Quick Set-up* provides access to all the typical parameters required.
- Perform Auto CT for all stand-alone filters to set correct current sensor setup. Auto CT setup is only possible when CTs are installed at Point of Common Coupling (PCC) - towards the transformer. (CT setup of LHD units is preset from the factory.)
- Under Quick Menu *Q5 Changes Made*, any parameter changed from factory settings is displayed.
- Press and hold [Main Menu] for three seconds to access any parameter
- For service purposes, it is recommended to back up parameter settings to the LCP, see *0-50 LCP Copy* for further information.

2.3 Status Messages

Status messages appear in the bottom of the display.
The left part of the status line indicates the active operation model of the filter.
The right part of the status line gives the operation status, e.g., Run, Stop, Trip.

Operation Mode

Off The device does not react to any control signal until [Auto On] or [Hand On] on the LCP are pressed.

Auto On The filter is controlled via the control terminals and/or the serial communication.

Hand On The operator is able to adjust the local reference manually. Stop commands, alarm reset, and setup selection signals can be applied to the control terminals.

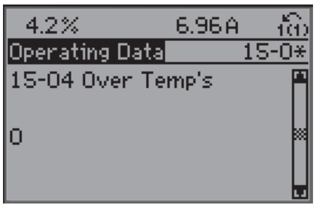
2.3.1 Status Message Definitions

Operation Status	
Auto CT ready	The automatic current transformer detection is ready for operation. Press [Hand On] to begin the process.
Auto CT running	Automatic current transformer detection is running.
Auto CT finished	Automatic current transformer detection is finished. Press [OK] to accept the settings found or cancel to discard. Location, polarity, or ratio errors may be caused when running with large grid/load changes. If errors occur, set the polarity, location and ratio manually.
PowerUnit Off	Available only with an optional device installed (for example, a 24 V supply). The line power supply to the unit is removed, but the control card is still supplied with 24 V.
Protection md	The filter has detected a critical status (e.g., an overcurrent or overvoltage). To avoid tripping of the unit (alarm), protection mode is activated. This includes reducing compensation and average switching frequency. If possible, protection mode ends after approximately 10 s.
Running	The filter is active and compensating.
Sleeping	The energy saving function is enabled. This means that the filter line power contactors are open and no harmonic compensation is performed. The filter will restart automatically when the wake up condition is met.
Standby	In Auto On mode, the filter is active and is waiting for a remote start signal via digital input or serial communication.
Stop	[Off] was pressed on the LCP or Stop was activated as a function for a digital input terminal. The corresponding terminal is not active.
Trip	An alarm has occurred. When the cause of the alarm is cleared, the filter may be reset via a remote signal through a control terminal or serial communication or by pressing [Reset] on the LCP.
Trip lock	A serious alarm has occurred. When the cause of the alarm is cleared, line power must be cycled on and off before resetting the filter. This puts the filter in trip mode and can be reset as described.

Table 2.6

2.4 Service Functions

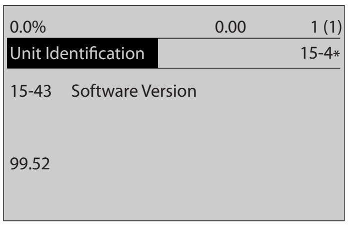
Service information can be displayed on lines 3 and 4. Included in the data are total operating hours, power-ups and trips, and fault logs that store status values present at the 20 most recent trips. The service information is accessed by displaying items in parameter group 15-**.



130BX173.10

Figure 2.6

Parameter group 15 also displays software versions for various components, hardware identification numbers, and other useful information and to determine revision status.



130BP095.10

Figure 2.7

2.5 Filter Inputs and Outputs

2.5.1 Current Transformers

The active filter monitors internal current harmonics and receives input from external current transformers. A current transformer (CT) measures electrical current. The CT has a primary circuit and a secondary circuit. The secondary circuit duplicates the primary exactly but with a reduced current load. The AAF receives signals from the external CT secondary circuit and actively generates an output wave pattern to compensate for current irregularities. Internally, the AAF monitors harmonics of the IGBT output along with the LCL capacitor banks.

2.5.2 Filter CT Input

The active filter operates by receiving signals from the current transformers (CTs). The signals are processed and the filter reacts accordingly to programmed instructions. Invalid signals cause the filter malfunctions or for the filter to trip. Input signals are wired to the CT terminal. Incorrect CT settings or improper wiring are the primary reasons for the filter not starting or causing the unit to trip or malfunction. Setting CTs is described in *2.5.2.1 External CT Input*.

The active filter receives current signal input from three different measure points.

- External/line power CT input
- Internal CT input from IGBT current injection
- Internal CT input from LCL capacitors (AC capacitors)

All three inputs are 3-phase. These are processed individually and the filter reacts according to programmed instructions.

NOTE!

Incorrect CT settings or improper wiring are the primary reasons for causing the filter to trip or not starting.

2.5.2.1 External CT Input

For LHD units, CTs are built-in. LHD CTs are located in the drive section at the input plate and have the following values: D-frame = 500 A, E-frame = 1000 A, F-frame = 1500 A. Signals are input at terminal MK101 on the AFC board.

CAUTION

Line Power (Primary Side) Current

Use a shorting connector on the secondary side of customer-supplied external current transformers (CT) whenever current is present on line power (primary side) and the AFC card is NOT wired to the external CT terminals. When performing service on an active filter, use a shorting connector on the secondary side of external CTs for extra safety. Failure to short out the secondary side of current transformers when current is present on the primary side and the AFC card is NOT connected could damage the current transformer.

The active filter uses external CT signals to measure the current distortion that the filter is to compensate. External CT wires are connected to the CT terminal block. The CT terminal block is wired to the AFC board through internal wiring. The active filter supports external current transformers with either a 1A and 5A secondary.

- For 1A CT input, the 8-pin connector must be wired to terminal MK108.
- For 5A CT input, connection must be wired to terminal MK101.

Primary rating (A)							
1 A	250	300	400	500	600	750	1000
5 A	1250	1500	2000	2500	3000	3500	4000

Table 2.7

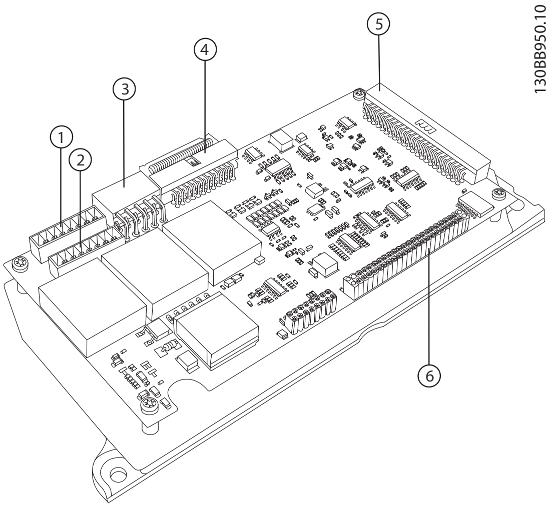


Figure 2.8 Active Filter Card

1	MK101 (5 A external connector)	4	MK107
2	MK108 (1 A external connector)	5	MK100
3	MK103	6	FK100

Table 2.8

External CT settings are programmed in parameter group 300-2*. The automatic CT detection is only possible with CT installed on the PCC side.

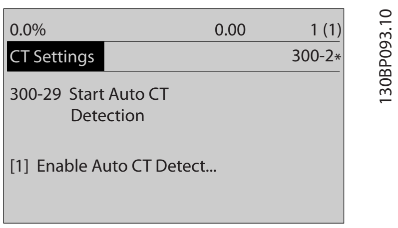


Figure 2.9 Auto CT Detection

Perform an automatic CT detection for all stand alone filters in *300-29 Start Auto CT Detection*

The following conditions must be met:

- Active filter bigger than 10% of CT RMS rate
- CTs installed on the PCC side. (Auto CT not possible for load side CT installation.)
- Only one CT per phase. (Auto CT not possible for summation CTs.)
- CTs are part of standard range.

Unsuccessful Auto CT Detection can indicate an incorrect CT installation. Check the CT installation and program the CTs by hand.

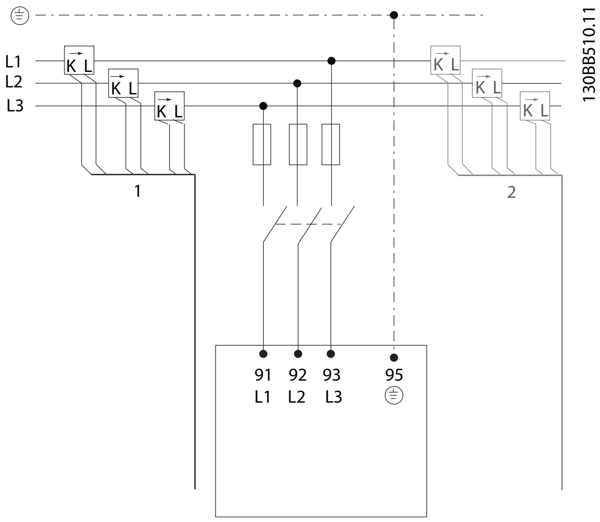


Figure 2.10 External CT Wiring

The filter supports all standard CTs with 1 A or 5 A secondary rating. CTs should have an accuracy of 0.5% or better to reassure sufficient accuracy.

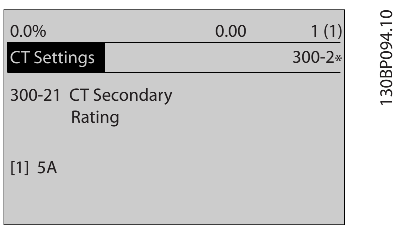


Figure 2.11 CT Secondary Rating

2.5.3 Control Wiring Input/Output

The active filter allows external control signals for either input control to the filter or to receive feedback from the filter. Control wiring to the active filter, depending on type, can connect to the following.

- FC control board
- AFC
- CT input terminal
- Power card

The active filter supports the following.

- 3 inputs (terminal 18, 19, 20)
- 2 programmable in/output (terminal 27, 29)

External control signals are all wired to the FCA terminal MK102.

Digital inputs and outputs

Digital signals are a simple binary 0 or 1 which, in effect, act as a switch. Digital signals are controlled by a 0 to 24 V DC signal. 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 filter are switched commands such as start, stop, and reset.

- Digital inputs to connection MK102 (18, 19, 20, 27 and/or 29) can be programmed for external start, stop and/or reset of the unit or to receive an external signal for filter sleep mode.
- (For the LHD units, terminals 18 and 20 are wired to the drive terminal 29 and 20 to allow the drive to start and stop the filter when drive goes into standby or off modes. The LHD filter should be in Hand On (local) mode for proper operation.
- Digital input terminal 32 and 33 are pre-wired and configured for feedback from the Line power contactor (CBL28). These are not for external use and cannot be reconfigured.
- Digital output signals on terminal 27 and 29 can be used for external THDi or THDv readout to an external controller or system. To allow for this option, pulse reference signals need to be programmed for terminals 27 and 29.
- Terminals 12 and 13 provide 24 V DC low voltage power, often used to supply power to the digital input terminals (18-33).
- The terminal 37 safe stop function can be used to stop the filter in emergency stop situations. In the normal operating mode when safe stop is not required, the regular stop function is used. Use of safe stop on terminal 37 requires that the user satisfies all provisions for safety including relevant laws, regulations and guidelines.

2.5.4 Serial Communication Wiring

Serial communication to the filter can be supported through different terminals.

- RS-485/EIA-485 terminal
- USB connector
- MK103 termination
- Optional add-on communication protocol connections

A serial communication protocol supplies commands and references to the filter, can be used to program the filter, and reads status data from the filter. The serial bus connects to the unit through the RS-485/EIA-485 serial port.

Commands and references to the filter can be accessed via the USB terminal.

Connector MK103 allows serial communication to be wired to terminals (+) 68 and (-) 69. Terminal 61 is common and may be used for terminating shields only when the control cable run between Danfoss filters or between filters and Danfoss adjustable frequency drives. Do not use the common shield between filters and other devices.

For optional add-on communication protocols, see the instruction manual for the option.

2.5.5 Relay Options

No relays are available for customer use. Additional output relays are available with the MCB105 relay card option. This card provides three relays of up to 2 A at 240 V resistive load or 0.2 A inductive.

2.6 Control Terminals

Control terminals must be programmed. Each terminal has specific functions it is capable of performing and a numbered parameter associated with it. See *Table 2.9*. 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.

Parameter settings are displayed by pressing the [Status] key on the LCP.

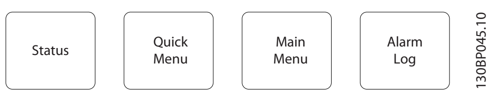


Figure 2.12

Use the arrow keys [▲], [▼], [►] and [◄] on the LCP to scroll through parameters.

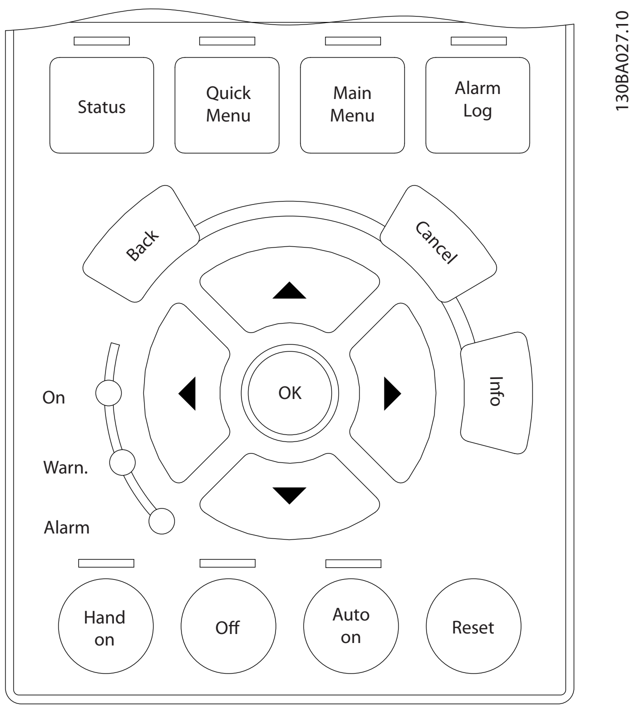


Figure 2.13

Consult AAF instruction manuals manual for details on changing parameters and the functions available for each control terminal.

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 two ways. Digital input can be selected for display by pressing [Status] as discussed previously, or a voltmeter may be used to check for voltage at the control terminal. In a few cases, the filter can trip before the signal reads on the voltmeter. See procedure details at Input Terminal Signal Test in section*6 Test Procedures*.

In summary, for proper functioning, the filter input control terminals must be:

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

2.7 Control Terminal Functions

The following describes the functions of the control terminals. Many of these terminals have multiple functions determined by parameter settings.

Connector	Terminal Number	Function
Active filter card		
MK101	1-8	Input from external current transducers, 5 amp
MK108	1-8	Input from external transducers, 1 amp
Power Card		
FK100	01, 02, 03	Aux relay 1 NC/N0, used for temperature feedback
FK101	04, 05, 06	Aux relay 2 NO, used to set line power contactor
Control card		
MK102	12, 13	24 V DC power supply to digital inputs and external transducers. The maximum output current is 200 mA. Terminal 12 used for internal relay feedback.
	18	Digital input for controlling the filter. R = 2 Kohm. Less than 5 V = logic 0 (open). Greater than 10 V = logic 1 (closed). Wired and programmed for start/stop signal from drive in the LHD.
	20	Common for digital input. Wired and programmed for start/stop signal from drive in the LHD.
	19, 27, 29	Digital inputs for controlling the filter. R = 2 Kohm. Less than 5 V = logic 0 (open). Greater than 10 V = logic 1 (closed). Terminals 27 and 29 are programmable as digital/ pulse outputs.
	32, 33	Digital input for controlling the filter. R = 2 Kohm. Less than 5 V = logic 0 (open). Greater than 10 V = logic 1 (closed). Wired and programmed for feedback from line power.
	37	0–24 V DC input for safety stop (some units). Jumper to terminal 13.
MK101	39	Common for analog and digital outputs.
	42	Analog and digital outputs for indicating values such as THD, current and power. 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.
	53, 54	Selectable for 0 to 10 V DC voltage input, R = 10 k Ω, or analog signals 0/4 to 20 mA at a maximum of 200 Ω. Used for reference or feedback signals.
	55	Common for terminals 53 and 54.
MK103	61	RS-485 common.
	68, 69	RS-485 interface and serial communication

Table 2.9 Terminal Function and Connection Overview

Term	18	19	27	29	32	33	37
Par.	5-10	5-11	5-01/5-12	5-02/5-13	5-14	5-15	5-19

Table 2.10 Control Terminals and Associated Parameter

Control terminals must be programmed. Each control terminal has specific functions it is capable of performing and associated parameter. The setting selected in the parameter enables the function of the terminal.

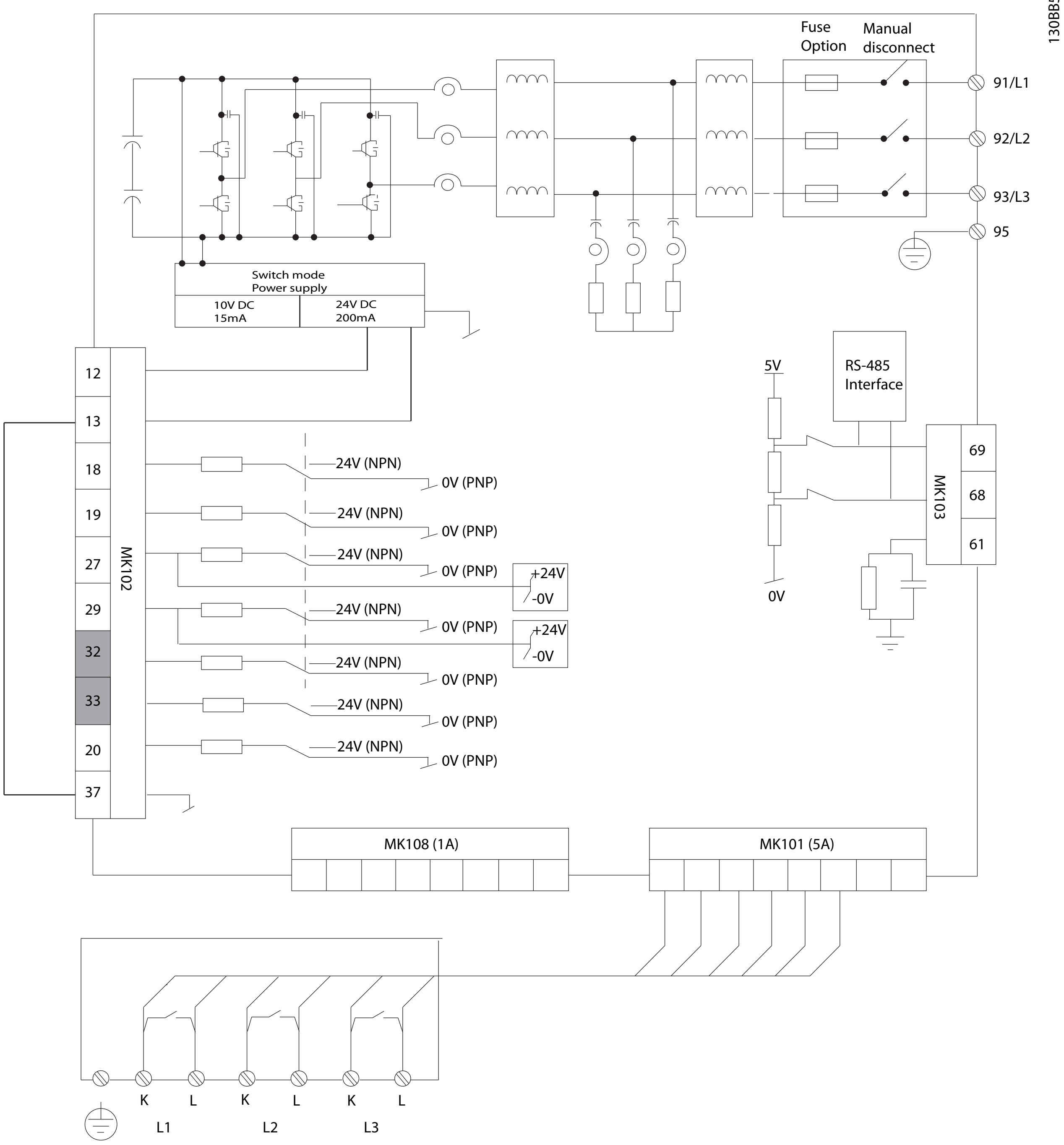


Figure 2.14 AFC Card Connections

2.8 Grounding Shielded Control Cables

Shield all control cables and connect the shield with cable clamps at both ends to the metal cabinet. *Table 2.11* shows ground cabling for optimal results.

NOTE!

CT wires must be shielded or twisted pair to reduce noise impact on measured signal.

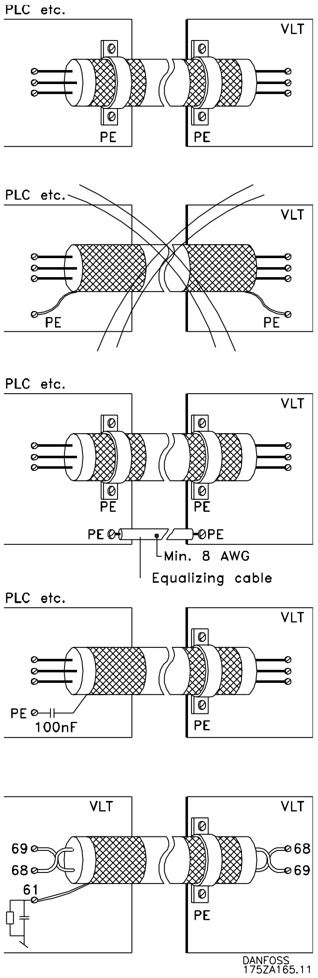
 	**Correct grounding** control cables and cables for serial communication must be fitted with cable clamps at both ends to ensure the best possible electrical connection. **Incorrect grounding** Do not use twisted cable ends (pigtails) since these increase shield impedance at high frequencies. **Ground potential protection** When the ground potential between the filter and the PLC or other interface device is different, electrical noise may occur that can disrupt the entire system. This can be resolved by fitting an equalizing cable next to the control cable. Minimum cable cross section is 8 AWG. **50/60 Hz ground loops** When using very long control cables, 50/60 Hz ground loops may occur that can disturb the entire system. This can be resolved by connecting one end of the shield with a 100 nF capacitor and keeping the lead short. **Serial communication control cables** Low frequency noise currents between filters can be eliminated by connecting one end of the shielded cable to filter terminal 61. This terminal connects to ground through an internal RC link. It is recommended to use twisted-pair cables to reduce the differential mode interference between conductors.

Table 2.11 Grounding Shielded Control Cables

3 Internal Active Filter Operation

3.1 General

This section is intended to provide an operational overview of the filter's main assemblies and circuitry. With this information, a repair technician should have a better understanding of the unit's operation and aid in the troubleshooting process.

3.2 Description of Operation

3.2.1 Introduction

The AAF consists of an inverter section (active) and an LCL filter (passive). The inverter section actively compensates for harmonic distortion on line power to maintain minimal influence on the supply transformer load. The harmonic suppression is designed to comply with customer requirements and local standards. The LCL passive filter section ensures trouble-free connection of the active inverter section to line power, along with suppressing the inverter switching frequency. In the filter section three capacitors are located between two reactors to form an LCL circuit. The LCL circuit is arranged in a common mode (CM) and differential mode (DM) configuration. Connected in series with the capacitors are three damping resistors to ensure that the filter prevents resonance. Soft charge circuitry limits the inrush current during power-up. The control card along with the active filter control (AFC) card provide the logic for controlling the active filter.

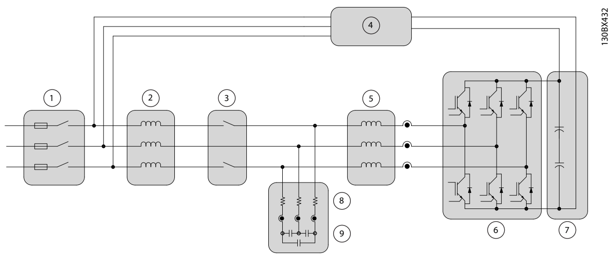


Figure 3.1 AAF Internal Circuitry

1	Line power option plate	6	Power module
2	HI (Lm) reactor	7	DC capacitors
3	Line power contactor	8	Damping resistors
4	Power card	9	AC capacitor
5	Inverter side reactor (Lc)		

Table 3.1

3.2.2 Control Card

The primary logic element of the control card is a microprocessor which supervises and controls all functions of filter operation. In addition, separate PROMs contain programmable parameters to provide the user with customized control performance. These parameters are programmed to enable the filter to meet application requirements and to allow for changing the operational characteristics of the filter. The programmed instructions are then stored in an EEPROM which provides security during power-down.

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

Another part of the control section is the local control panel (LCP). This is a removable keypad/display mounted on the front of the filter. The LCP provides the user interface with the unit. All the filter's programmable parameter settings can be uploaded into the EEPROM located in the LCP. This function is useful for maintaining a backup parameter set. It can also download programming to the filter to restore programming to a repaired unit, or to program multiple units by downloading from a programmed master LCP. The LCP is removable to prevent undesired program changes. With an optional remote mounting kit, the LCP can be mounted in a remote location of up to 10 ft [3 m] away.

Control terminals, which are programmable for specific functions, are provided for input. In addition, output terminals provide signals to control peripheral devices or for reporting the status of monitored filter functions. The control card logic is also capable of communicating, through its serial link, with outside devices such as personal computers or programmable logic controllers (PLC).

The control card can also provide two voltage supplies for use from the control terminals. The 24 V DC is used for switching functions such as start and stop. The 24 V DC supply also provides 200 mA of power, part of which may be used to power external devices. A 10 V DC supply on terminal 50 is rated at 17 mA is also available for use.

3.2.3 Active Filter Card

The active filter card (AFC) performs calculations based on internal currents from IGBT current transducers, external currents from customer-supplied current transformers (CTs), and voltage information from the DC bus. These calculations are used to control the output current of the active filter for harmonic suppression on line power. The AFC also interfaces with the power card. The power card provides information about the DC bus voltage and the output current from the internal IGBT current transducers in the inverter. In addition, the AFC receives input from the internal AC capacitor current transducers. The external CTs also interface with the AFC and are mounted in the customer electrical supply system. (In the LHD, the external CTs are mounted in front of the Adjustable frequency drive.)

The customer-supplied external CT secondary coil can be rated with nominal currents of 5 A or 1 A, depending on the secondary rating of the CT. Connectors on the AFC board correspond to these current ratings.

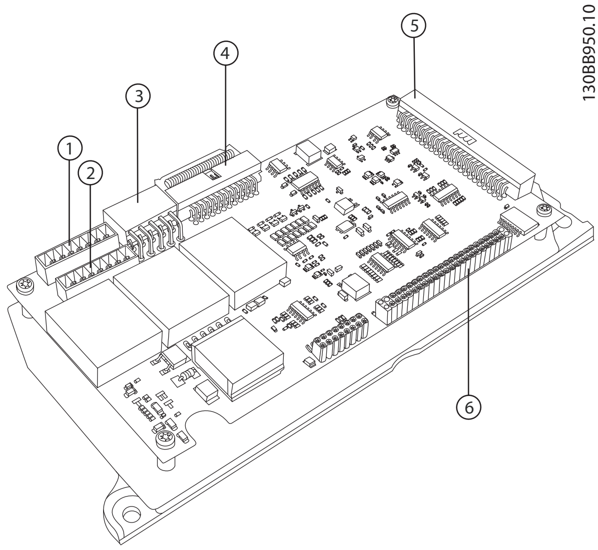


Figure 3.2 Active Filter Card

1	MK101 (5 A external connector)	4	MK107
2	MK108 (1 A external connector)	5	MK100
3	MK103	6	FK100

Table 3.2

3.2.4 Control to Power Interface

The control to power interface isolates the high voltage components of the power section from the low voltage signals of the control section. The interface section consists of the power card and the gate drive card. Much of the fault processing is handled by the control card. The power card provides conditioning of these signals along with scaling of current and voltage feedbacks. The power card contains a switch mode power supply (SMPS) which provides the unit with 24 V DC, +18 V DC, –18 V DC and 5 V DC operating voltages. The control and interface circuitry is powered by the SMPS. The SMPS is supplied by the DC bus voltage. The filter can be purchased with an optional secondary SMPS which is powered from a customer-supplied 24 V DC source. This secondary SMPS provides power to the control circuitry when line power input is disconnected and can maintain communication options when the filter is not powered from line power. Circuitry for controlling the cooling fans is also provided on the power card. The gate signals from the control card to the transistors (IGBTs) are isolated and buffered on the gate drive card.

3.2.5 Filter Power Section

Line power enters though the input terminals or the disconnect and/or the RFI option, depending on the unit's configuration. If the unit is equipped with optional fuses, these fuses limit damage caused by a short circuit in the power section.

The three line phases are fed to a Harmonics Isolation reactor (HI reactor) that distributes line power to the inverter (or the Adjustable frequency drive for the LHD). If the filter is used as a stand alone AAF unit, the HI reactor is considered a line power-side filter containing only the line power-side reactor Lm.

The line power will not be applied to the inverter until the intermediate circuit (DC bus) has been charged and the AC contactors have cut in. This happens after the soft charge circuit has charged the intermediate circuit capacitors in the inverter. By turning the filter on, the inverter connects to the line power through the inverter side reactor (Lc), the AC contactors, and the HI (Lm) reactor. At this stage, the DC voltage is boosted, the amount depending on the AC line voltage.

3.3 Additional Circuitry

3.3.1 AC Contactor

Because the line power contactor circuit ties into the soft charge circuit, understanding both is necessary to understand the working principles of the Line power contactor. The filters contain two three-phase normally-open contactors. These are used as single-phase by shortening all input terminals together and all output terminals together. This is done to reduce the size of the contactors. Since the DC link is floating, this guarantees that there is no current flow when only two phases are opened. The two virtual single-phase contactors are in front of phase R and T, respectively.

The line power contactors connect or disconnect the active filter inverter from the line power. These contactors are commanded to close after the soft charged period has passed and before operation of the filter begins. The contactor is commanded open if the filter stops for any reason, such as when an alarm condition is detected, or when the filter is commanded to stop or sleep. It is only closed when the filter is ON, thereby minimizing standby losses.

When the line power contactor is open, active filter control is maintained by the soft charge circuit. The status of the main contactors is monitored via an auxiliary contact reporting to terminals 32 and 33 on the FC control card (PCA1).

3.3.2 Soft Charge Circuit

Because the soft charge circuit ties into the main contactor circuit, understanding both is necessary to understand the working principles of the soft charge circuit.

The purpose of the soft charge circuit is to:

- Limit inrush current when DC link capacitors are charged
- Provide control power when the line power contactor is open due to faults or when the filter is in sleep mode

The soft charge circuit contains MOVs, fuses, resistors, and a control transformer. Three fuses on the grid side protect the circuit. Three delta-connected MOVs suppress transient when present on the incoming line power.

Resistors in series with the L1-L3-phases limit the inrush current during start up when the DC link capacitors are not charged. When the capacitors are charged and the filter is commanded to operate, the contactors across the resistors energize and short circuit the resistors. Voltage for the coils of these contactors is supplied by the soft charge control transformer.

The soft charge control transformer has one primary and two secondary sides. The line power contactor is powered within 110–127 V. Depending on the AC line voltage, the line power contactor is powered by one of the two soft charge control transformer secondaries. Control is from connector FK100 on the power card (PCB3).

When the filter is powered on the soft charge circuit, the DC link capacitors will be charged to approximately sqrt(2)*line to line AC line voltage. The soft charge time depends on main voltage and filter type. Standby current is 0.3 A. *Table 3.3* lists the soft charge time and RMS current.

Filter size (A)	Imax (RMS)		Soft charge time (s)	
	342 V	550 V	342 V	550 V
190	3.3 A	5.2 A	1.2	0.3
250	3.3 A	5.3 A	2	0.4
310	3.3 A	5.3 A	2	0.4
400	3.3 A	5.3 A	3.7	0.7

Table 3.3 Soft Charge Electrical Characteristics

3.3.3 Additional Thermal Protection

A software temperature-protection circuit monitors filter temperature conditions. To meet UL requirements, additional thermal protection is provided by signals to the line power contactors via the power card (PCA3) relay contactor FK101. Signals are generated by a series of thermal switches in each phase of the LM reactors and LC reactors and through single thermal switches mounted on the damping resistors (LCL) and IGBT module heatsinks. Before issuing a fault and opening the contactors, the filter will automatically try to reduce its temperature by reducing its compensation. The line power contactors are rated for 110–127 V and power is supplied from the soft charge control transformer.

3.3.4 Current Transducers

Current transducers are used to monitor current in various locations in the filter. Three current transducers on the output-phases bus bars induce counter harmonics onto line power. There are also three current transformers on the line power bus bars outside of the active filter. The information from these three transformers, via the active filter card, is what the filter compensates for on the line power. (For the LHD drive, these transformers are on the line power input bus bars of the Adjustable frequency drive for measuring the harmonics caused by the Adjustable frequency drive.) Three other current transducers in the LCL filter section are used for overload protection for the AC capacitors and damping resistors.

Identification	Type	Function
CT1	Hall Effect	Output of inverter IGBT current sensor
CT2	Hall Effect	Output of inverter IGBT current sensor
CT3	Hall Effect	Output of inverter IGBT current sensor
CT4	Hall Effect	AC capacitor current sensor
CT5	Hall Effect	AC capacitor current sensor
CT6	Hall Effect	AC capacitor current sensor
CT7	Current Transformer	External current transformer
CT8	Current Transformer	External current transformer
CT9	Current Transformer	External current transformer

Table 3.4 Current Transducers

3.3.5 Cooling Fans

All active filters are equipped with cooling fans to provide airflow along the heatsink and through the doors. All fans are powered by AC line voltage which is stepped down by an autotransformer and regulated to 200 or 230 V AC by circuitry provided on the power card. On/off and high/low speed control of the fans is provided to reduce overall acoustical noise and extend the life of the fans.

3.3.6 Fan Speed Control

The cooling fans are controlled with sensor feedback which regulates fan operation and speed control as described below.

1. IGBT thermal sensor measured temperature. The fan can be off, low speed, or high speed based on this temperature.

IGBT Thermal Sensor	Temperature
Fan turn ON low speed	113° F [45°C]
Fan low speed to high speed	122° F [50°C]
Fan high speed to low speed	104° F [40°C]
Fan turn OFF from low speed	86° F [30°C]

Table 3.5 IGBT Thermal Sensor

2. Power card ambient temperature sensor measured temperature. The fan can be off or high speed based on this temperature.

Power Card Ambient	Temperature
Fan turn ON to high speed	113° F [45°C]
Fan turn OFF from high speed	104° F [40°C]
Fan turn ON to high speed	<50° F <10° C

Table 3.6 Power Card Ambient Temperature Sensor

3. Control card thermal sensor measured temperature. The fan can be off or low speed based on this temperature.

Control Card Ambient	Temperature
Fan turn ON to low speed	131° F [55°C]
Fan turn OFF from low speed	113° F [45°C]

Table 3.7 Control Card Thermal Sensor

4. Current value. If the current injection is greater than 60% of rated current, the fan will turn on low speed.

3.3.7 Low Harmonic Drive

The low harmonic drive (LHD) consists of an active filter (AAF) section and a Adjustable frequency drive section. The AAF section actively compensates for harmonic distortion generated on line power by the Adjustable frequency drive. Apart from that, the functionality of the active filter section is the same as the stand-alone AAF active filter.

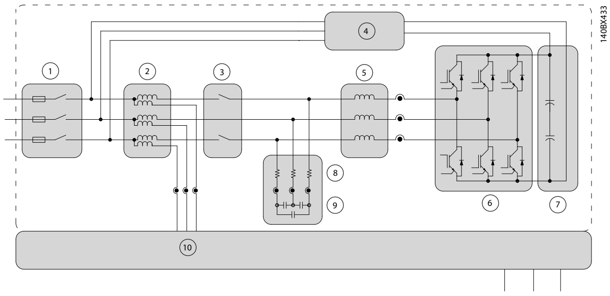


Figure 3.3 LHD Internal Circuitry

1	Line power option plate	6	Power module
2	HI (Lm) reactor	7	DC capacitors
3	Line power contactor	8	Damping resistors
4	Power card	9	AC capacitor
5	Inverter side reactor (Lc)	10	Adjustable frequency drive interconnect

Table 3.8

4 Troubleshooting

4.1 Troubleshooting Tips

Before attempting to repair a filter, here are some tips to follow to make the job easier and possibly prevent unnecessary damage to functional components.

1. Note all warnings concerning voltages present in the filter. Always check for the presence of AC input voltage and DC bus voltage before working on the unit. Some points in the filter are referenced to the negative DC bus and can be at bus potential even though it may appear on diagrams to be a neutral reference.
   Remember that voltage may be present for as long as 40 minutes on E-frame size filters or 20 minutes on D-frame size filters after removing power from the unit. See the label on the front of the filter door for the specific discharge time.
2. Never apply power to a unit that is suspected of being faulty. Many faulty components within the filter can cause damage to other components when power is applied.
3. Never attempt to defeat any fault protection circuitry within the filter. That will result in unnecessary component damage and may cause personal injury.
4. Always use factory approved replacement parts. The filter has been designed to operate within certain specifications. Incorrect parts may affect tolerances and result in further damage to the unit.
5. Read the instruction and service manuals. A thorough understanding of the unit is the best approach. When in doubt, consult the factory or authorized repair center for assistance.
6. The *After Repair Tests* should always be performed following a repair to the filter.

4.2 Fault Symptom Troubleshooting

Table 4.1 provides an inspection check list. The check list provides guidance through a variety of items to inspect during any filter service process.

The filter processor monitors inputs and outputs as well as internal filter functions, so an alarm or warning does not necessary indicate a problem within the unit itself. Many times the root cause of the problem is due to interactions between the AAF and other devices connected to the same transformer.*5 Active Filter and the Power Grid* presents detailed discussions on areas of filter and system trouble-shooting that an experienced repair technician should understand in order to make effective diagnoses. The *After Repair Tests* should always be performed following a repair to the filter.

4.3 Visual Inspection

Table 4.1 lists a variety of conditions that require visual inspection as part of any initial troubleshooting procedure.

Inspect For	Description
CT feedback and other auxiliary equipment	• Check the function and installation of current sensors that provide feedback to the active filter. • Ensure that CT feedback is connected to the AFC card correctly: MK101 (5 A), MK108 (1 A). • Check for auxiliary equipment, switches, disconnects, or input fuses/circuit breakers that may reside on the input power side of active filter. • Check the jumpers on the CT terminal. • Examine the operation and condition of these items for possible causes of operational faults.
Cable routing	• Avoid routing cables through free air. Avoid routing power line wiring and signal wiring in parallel. 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. • For North American installations, control wiring and power wiring must be in separate conduits.
Control wiring	• Check for broken or damaged wires and connections. • Ensure that the CT polarity is correct. If summation CTs are used, ensure polarity and sequence is correct. • Check that CTs have the same rating (summation CTs as well). • Check the voltage source of the signals. • Check that the maximum CT burden is not exceeded through long wiring or small square section. • Though not always necessary depending on the installation conditions, the use of shielded cable or a twisted pair is always recommended. • Ensure the shield is terminated correctly. Refer to the section on grounding shielded cables in *2 Operator Interface and Active Filter Control*. • For North American installations, control wiring and power wiring must be in separate conduits.
Cooling and clearances	• Make sure the bottom connector plate is installed. • Check the operational status of all cooling fans and fan direction. • Check the door filters. • Check for blockage or constrained air passages inside the enclosure and in the back channel. • Check that required top clearance of 225 mm (9 in) is present to ensure proper air flow for cooling.
Display	• Warnings, alarms, filter status, fault history and many other important items are available via the local control panel display on the filter.
Interior	• The active filter must be free of dirt, metal chips, moisture, and corrosion. • Check for burned or damaged power components or carbon deposits resulting from catastrophic component failure. • Check for cracks or breaks in the housings of power semiconductors and loose pieces of broken component housings inside the unit.

Inspect For	Description
EMC considerations	• Check for proper installation regarding electromagnetic compatibility. Refer to the active filter instruction manual and *5 Active Filter and the Power Grid* of this manual for further details.
Environmental conditions	• Under specific conditions, these units can be operated within a maximum ambient of 45° C (113° F). • Humidity levels must be less than 95% non-condensing. • Check for harmful airborne contaminates such as sulfur-based compounds.
Grounding	• This unit requires a dedicated ground wire from its chassis to the building ground. • Check for good ground connections that are tight and free of oxidation. • The use of a conduit or mounting the filter on to a metal surface is not a suitable ground.
Input power wiring	• Check for loose connections. • Check for blown fuses. • Check for proper fusing.
Grid conditions	• Check the grid-connected loads. • Check that the PF capacitor banks are installed and tuned. • Verify that the AC coils are in front of non-linear loads.
Vibration	• Look for any unusual amount of vibration that the unit may be subjected to. • The filter should be mounted solidly and subject to vibrations of less then 1G. • If shock mounts are employed for higher vibrations, check these for cracks or malfunction.

Table 4.1 Visual Inspection

4.4 Fault Symptoms

4.4.1 No Display

The LCP display provides two display indications. One by means of the backlit LCD alphanumeric display. The other is three LEDs near the bottom of the LCP. If the power-on LED is illuminated (green), but the backlit display is dark, this indicates that the LCP itself is defective and must be replaced.

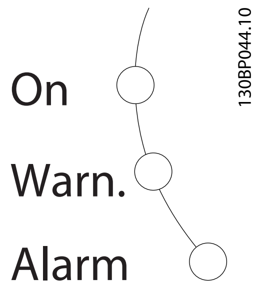


Figure 4.1

Be certain, however, that the display is completely dark. Having a single character in the upper corner of the LCP or just a dot indicates that communications may have failed with the control card. This is typically seen when a serial bus communication option has been installed in the filter and is either not connected properly or is malfunctioning.

If neither indication is available, then the source of the problem may be elsewhere. Proceed to *6.3.1 No Display Test* to carry out further troubleshooting steps.

4.4.2 Intermittent Display

Cutting out or flashing of the entire display and power LED indicates that the power supply (SMPS) is shutting down as a result of being overloaded. This may be due to improper control wiring or a fault within the filter itself.

The first step is to rule out a problem in the control wiring. To do this, disconnect all control wiring by unplugging the control terminal blocks from the control card.

If the display stays lit, then the problem is in the control wiring (external to the filter). All control wiring should be checked for shorts or incorrect connections.

If the display continues to cut out, follow the procedure for No Display as though the display were not lit at all.

4.5 Warning/Alarm Messages

4.5.1 Warning/Alarm Code List

A warning or an alarm is signaled by the LEDs on the front of the filter and by a code on the display.

A **warning** indicates a condition that may require attention or a trend that may eventually require attention. A warning remains active until the cause is no longer present. Under some circumstances, operation may continue.

A trip is the action when an alarm has appeared. The trip removes power injection to the grid and can be reset after the condition has been cleared by pressing the [reset] button or through a digital input (parameter 5-1*). The event that caused an alarm cannot damage the filter or cause a dangerous condition. Alarms must be reset to restart operation once their cause has been rectified.

This may be done in three ways:

1. Pressing the [reset] button on the LCP.
2. A digital reset input.
3. Serial communication reset signal.

NOTE!

After a manual reset using the [Reset] button on the LCP, the [Auto On] button must be pressed to restart the unit.

A **trip lock** is an action when an alarm occurs which may cause damage to the filter or connected equipment. Injection towards grid is stopped. A trip lock can only be reset after the condition is cleared by cycling power. Once the problem has been rectified, only the alarm continues flashing until the filter is reset.

An X marked in *Table 4.2* means that action occurs. A warning precedes an alarm.

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock
1	10 volts low	X		
4	Mains phase loss	(X)	(X)	(X)
5	DC link voltage high	X		
6	DC link voltage low	X		
7	DC overvoltage	X	X	
8	DC undervoltage	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)	
23	Internal fan fault	X		
24	External fan fault	X		
29	Heatsink temp	X	X	X
33	Inrush fault		X	X
34	Fieldbus communication fault	X	X	
38	Internal fault		X	X
39	Heatsink 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)		
46	Power card supply		X	X
47	24 V supply low	X	X	X
48	1.8 V supply low		X	X
60	External interlock	X		
65	Control board overtemperature	X	X	X
66	Heatsink temperature low	X		
67	Option configuration has changed		X	
68	Safe stop activated	(X)	(X)1)	
70	Illegal FC configuration			X
79	Illegal PS config		X	X
80	Drive initialized to default value		X	
250	New spare part			X
251	New type code		X	X
300	Mains contactor fault		X	
302	Capacitor overcurrent	X	X	
303	Capacitor ground fault	X		X
304	DC overcurrent	X	X	
305	Mains frequency limit		X	
306	Compensation limit	X		
308	Resistor temperature	X		X

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock
309	Mains earth fault		X	
311	Switching frequency limit		X	
314	Auto CT interrupt		X	
315	Auto CT error		X	
316	CT location error	X		
317	CT polarity error	X		
318	CT ratio error	X		
319	Runaway follower			X
320	AC resistor heatsink fault	X		
321	Voltage imbalance >3%	X		
322	5 V power card low			X
323	15 V negative supply low			X
324	15 V positive supply low			X

Table 4.2 Warning/alarm code list

(X) Programmable: dependent on parameter setting.

[1)] *Cannot be auto reset via parameter selection.*

LED indication	
Warning	yellow
Alarm	flashing red
Trip locked	yellow and red

Table 4.3

WARNING 1, 10 Volts low
The control card voltage is below 10 V from terminal 50. Remove some of the load from terminal 50, as the 10 V supply is overloaded. Max. 15 mA or minimum 590 Ω.

This condition can be caused by a short in a connected potentiometer or improper wiring of the potentiometer.

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

WARNING/ALARM 4, Mains phase loss
A phase is missing on the supply side, or the line voltage imbalance is too high.

Troubleshooting: Check the supply voltage imbalance and main fuses of the filter. Check the line cable connection for tightness.

WARNING 5, DC link voltage high
The intermediate circuit voltage (DC) is higher than the high voltage warning limit. The limit is dependent on the filter voltage rating. The unit is still active.

See rating *Table 1.4* in for the voltage limits.

WARNING 6, DC link voltage low
The intermediate circuit voltage (DC) is lower than the low voltage warning limit. The limit is dependent on the filter voltage rating. The unit is still active.

See rating *Table 1.4* in for the voltage limits.

WARNING/ALARM 7, DC overvoltage
If the intermediate DC link voltage exceeds the limit, the filter trips after a time.

See rating *Table 1.4* in for the voltage limits.

There are two different procedures for troubleshooting alarm 7, depending upon the time the alarm occurs.

Alarm 7, DC overvoltage occurs immediately after starting (run) the active filter:

- Turn off the active filter
- Measure the resistance to ground of the LCL filter, AC capacitors, and damping resistors leads with a megohmmeter to check for ground faults
- Perform AC capacitors current transducers test
- Check if the connectors on the current transducers and on the AFC card are pinned properly
- Check AC capacitors current transducers cables
- Replace the AFC card

Alarm 7, DC overvoltage occurs during the active filter operation:

- Perform the Line Power Resonance Test (*6.3.7 Line Power Resonance Test*).

WARNING/ALARM 8, DC undervoltage
If the intermediate circuit voltage (DC link) drops below the undervoltage limit, the filter checks if a 24 V backup supply is connected. If no 24 V backup supply is connected, the filter trips after a fixed time delay. The time delay varies with unit size.

See rating *Table 1.4* for the voltage limits.

Troubleshooting:

- Make sure that the supply voltage matches the filter voltage.
- Perform input voltage test (*6.3.2 Input Voltage Test*)
- Check the soft charge circuit

WARNING/ALARM 13, Over current
The inverter peak current limit (approximately 300% of the rated current) is exceeded. In general, it points to a high error in the current control loop due to damage of the active filter hardware. Unexpected high voltage spikes in the AC line voltage can cause an overcurrent alarm as well. If this alarm occurs again after alarm reset, it indicates an active filter hardware defect.

See *Table 1.3* for current trip points.

Troubleshooting:

- Check the IGBT and LCL filter components
- Perform input voltage test (*6.3.2 Input Voltage Test*)

ALARM 14, Ground fault
Sum current, measured by internal inverter IGBT current transducers, doesn't equal zero. There is a discharge from the line phases to ground, either in the cable between the filter and line power or in the filter itself.

Trip level equals 50% of filter nominal current.

Troubleshooting:

- Turn off the filter
- Measure the resistance to ground of the LCL filter components leads with a megohmmeter to check for ground faults
- Measure line to line voltages on line power active filter terminals. All three voltages should be equal to the nominal voltage of the installation.

ALARM 15, Hardware mismatch
A fitted option is not operational with the present control board hardware or software. Check any replacement parts and their programming.

Record the value of the following parameters and contact your Danfoss supplier:

15-40 FC Type

15-41 Power Section

15-42 Voltage

15-43 Software Version

15-45 Actual Typecode String

15-49 SW ID Control Card

15-50 SW ID Power Card

15-60 Option Mounted

15-61 Option SW Version (for each option slot)

ALARM 16, Short circuit
There is short-circuiting in the IGBT inverter or on the inverter terminals.

Trip level equals approximately 120% of the overcurrent trip levels (see *Table 1.3*).

Troubleshooting:

- Check the IGBTs
- Replace the power card.

WARNING/ALARM 17, Control word timeout
There is no communication to the filter.
The warning will only be active when *8-04 Control Word Timeout Function* is NOT set to *OFF*.
If *8-04 Control Word Timeout Function* is set to *Stop* and *Trip*, a warning appears and the filter ramps down until it trips, while giving an alarm.

Troubleshooting:

- Check connections on the serial communication cable
- Increase *8-03 Control Word Timeout Time*
- Check the operation of the communication equipment
- Verify a proper installation based on EMC requirements

WARNING 23, Internal fan fault
The fan warning function is an extra protective function that checks if the fan is running/mounted. The fan warning can be disabled in *14-53 Fan Monitor* ([0] Disabled).

The regulated voltage to the fans is monitored.

Troubleshooting:

- Check fan fuse
- Check fan resistance (see *6.2.5 Fan Continuity Tests*).

WARNING 24, External fan fault
The fan warning function is an extra protective function that checks if the fan is running/mounted. The fan warning can be disabled in *14-53 Fan Monitor* ([0] Disabled).

The regulated voltage to the fans is monitored.

Troubleshooting:

- Check fan fuse
- Check fan resistance (see *6.2.5 Fan Continuity Tests*).

ALARM 29, Heatsink temp
The maximum temperature of the heatsink has been exceeded. The temperature fault will not be reset until the temperature falls below a defined heatsink temperature. The trip and reset point are different based on the filter power size.

See *Table 1.4* for trip levels.

Troubleshooting:

- Ambient temperature too high.
- Incorrect clearance above and below the unit.
- Dirty heatsink.
- Blocked air flow around the unit.
- Damaged heatsink fan.

ALARM 33, Inrush fault
Too many power-ups have occurred within a short time period. Let the unit cool to operating temperature.

WARNING/ALARM 34, Serial communication bus communication fault
The serial communication bus on the communication option card is not working.

ALARM 38, Internal fault
When an internal fault occurs, a code number defined in the table below is displayed.

Troubleshooting

Cycle power

Check that the option is properly installed

Check for loose or missing wiring

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

No.	Text
0	Serial port cannot be initialized. Contact your Danfoss supplier or Danfoss Service Department.
256-258	Power EEPROM data is defective or too old
512-519	Internal fault. Contact your Danfoss supplier or Danfoss Service Department.
783	Parameter value outside of min/max limits
1024-1284	Internal fault. Contact your Danfoss supplier or the Danfoss Service Department.
1299	Option SW in slot A is too old
1300	Option SW in slot B is too old
1302	Option SW in slot C1 is too old
1315	Option SW in slot A is not supported (not allowed)
1316	Option SW in slot B is not supported (not allowed)
1318	Option SW in slot C1 is not supported (not allowed)
1379-2819	Internal fault. Contact your Danfoss supplier or Danfoss Service Department.
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 control board hardware
5124	Option in slot B: Hardware incompatible with control board hardware
5125	Option in slot C0: Hardware incompatible with control board hardware
5126	Option in slot C1: Hardware incompatible with control board hardware
5376-6231	Internal fault. Contact your Danfoss supplier or Danfoss Service Department.

Table 4.4

ALARM 39, Heatsink sensor
No feedback from the heatsink 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 gate drive card, or the ribbon cable between the power card and gate drive card.

WARNING 40, Overload of digital output terminal 27
Check the load connected to terminal 27 or remove short-circuit connection. Check *5-00 Digital I/O Mode* and *5-01 Terminal 27 Mode*.

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

WARNING 42, Overload of digital output on X30/6 or overload of digital output on X30/7
For X30/6, check the load connected to X30/6 or remove the short-circuit connection. Check *5-32 Term X30/6 Digi Out (MCB 101)*.

For X30/7, check the load connected to X30/7 or remove the short-circuit connection. Check *5-33 Term X30/7 Digi Out (MCB 101)*.

ALARM 46, Power card supply
The supply on the power card is out of range.

There are three power supplies generated by the switch mode power supply (SMPS) on the power card: 24 V, 5 V, +/- 18 V. When powered with 24 V DC with the MCB 107 option, only the 24 V and 5 V supplies are monitored. When powered with three-phase AC line voltage, all three supplied are monitored.

WARNING 47, 24V supply low
The 24 V DC is measured on the control card. The external 24 V DC backup power supply may be overloaded, otherwise contact your Danfoss supplier.

WARNING 48, 1.8V supply low
The 1.8 V DC supply used on the control card is outside of allowable limits. The power supply is measured on the control card. Check for a defective control card. If an option card is present, check for an overvoltage condition.

WARNING 60, External interlock
A digital input signal is indicating a fault condition external to the Adjustable frequency drive. An external interlock has commanded the Adjustable frequency drive to trip. Clear the external fault condition. To resume normal operation, apply 24V DC to the terminal programmed for external interlock. Reset the Adjustable frequency drive.

WARNING/ALARM 65, Control card over temperature
The cutout temperature of the control card is 176° F [80°C].

Troubleshooting

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

WARNING 66, Heatsink temperature low
This warning is based on the temperature sensor in the IGBT module. See for the temperature reading that triggers this warning.

Troubleshooting:

The heatsink temperature measured as 32° F [0°C] could indicate that the temperature sensor is defective, and therefore causing the fan speed to increase to the maximum. If the sensor wire between the IGBT and the gate drive card is disconnected, this warning is produced. Also, check the IGBT thermal sensor (see *6.2.3 Intermediate Section Tests*).

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
Loss of the 24V DC signal on terminal 37 has caused the filter to trip. To resume normal operation, apply 24V DC to terminal 37 and reset the filter.

ALARM 70, Illegal Adjustable frequency drive configuration
The control card and power card are incompatible. Contact your supplier with the type code of the unit from the nameplate and the part numbers of the cards to check compatibility.

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

ALARM 80, Drive initialized to default value
Parameter settings are initialized to default settings after a manual reset. Reset the unit to clear the alarm.

WARNING 250, New spare part
The power or switch mode power supply has been exchanged. The filter type code must be restored in the EEPROM. Select the correct type code in *14-23 Typecode Setting* according to the label on the unit. Remember to select 'Save to EEPROM' to complete.

WARNING 251, New type code
The power card or other components have been replaced and the type code changed. Reset to remove the warning and resume normal operation.

ALARM 300, Mains cont. fault
Line power contactor fault is displayed when the feedback signal indicates that the contactors are not in the expected state, i.e., either of the two contactors could not close or could not open, or there is a feedback signal error.

Troubleshooting:

Control and feedback wiring check
Verify that the control and feedback is wired correctly and there are no loose connections. The 24 V DC output of the control card is from terminal 12 and the contactor feedback goes to terminals 32 and 33. The contactor is energized from a control transformer through the power card relay.

- Perform a visual inspection of the control and feedback wiring to verify there is no damage to the wire insulation.
- Perform a continuity check to test for broken wires between the control transformer and terminal 4 on MK112.

Perform the Control Card Digital Inputs/Outputs Test (*6.3.8 Control Card Digital Inputs/Outputs Test*).

Contactors test
Perform a continuity test of the contactors between the input terminal and output terminals. If continuity is detected, replace the contactor fuse. There should also be no continuity between any two test points of the three phases for either the input or the output.

Loss of line power
A loss of AC line voltage will cause the contactors to open. Check the line power supply. Consider use of auto reset.

Other
If none of the above tests have identified the problem, replace the power card.

WARNING/ALARM 302, Cap. over current
Excessive current was detected through the AC capacitors of the LCL filter.

See for current trip points.

Troubleshooting

- Check that the nominal voltage parameter (300-10) is set correctly. If the nominal voltage parameter is set to Auto, change this parameter to nominal voltage of the installation.
- Check that the CT parameter placement (parameter 300-26) corresponds to the installation
- Perform the Line Power Resonance Test (*6.3.7 Line Power Resonance Test*)

WARNING/ALARM 303, Car. earth fault
A ground fault was detected in the LCL filter AC capacitor currents. The summed currents in the LCL filter CTs exceeds the power unit dependent (PUD) level.

Troubleshooting:

- Turn off the filter
- Measure the resistance to ground of the LCL filter components leads with a megohmmeter to check for ground faults
- Check the AC capacitors and current transducers
- Check that the connectors on current transducers and on the AFC card are pinned properly
- Check AC capacitors current transducers cables
- Replace the AFC card

WARNING/ALARM 304, DC over current
Excessive current through the DC link capacitor bank was detected in the IGBT current sensors.

Troubleshooting

- Check the electrical fuses and ensure that all three line phases are powered.
- Check that the CT parameter placement (*300-26 CT Placement*) corresponds to the installation.
- Perform the Line Power Resonance Test (*6.3.7 Line Power Resonance Test*)

ALARM 305, Mains. freq. limit
The line power frequency was outside the limits (50 Hz–60 Hz) +/-10%. Verify that the line power frequency is within product specification. The alarm may also indicate loss of line power for 1 - 3 electrical cycles.

The active filter must synchronize to the AC line voltage in order to regulate the DC link voltage and inject compensating current. The active filter utilizes a phase-locked loop (PLL) to track the AC line voltage frequency.

When the active filter starts, the PLL uses the LCL filter AC capacitor currents from the current transducers to initialize for a period of 200 ms. After the PLL initialization period, the active filter inverter will then start switching, the line power estimated voltage is used instead of the capacitor currents as input to the PLL. The PLL is not tolerant of incorrect wiring or placement of the AC capacitor current transducers.

Troubleshooting:

- Turn off the filter
- Measure the resistance to ground of the LCL filter components leads with a megohmmeter to check for ground faults
- Perform AC capacitors and current transducers test (*6 Test Procedures*).
- Check that the connectors on current transducers and on the AFC card are pinned properly
- Check AC capacitors current transducers cables
- Replace the AFC card
- Automatic switching between the grid and a generator based on certain events can cause line power loss leading to this alarm. Use auto reset if this is the cause.

ALARM 306, Compensation limit
The compensation current exceeds unit capability. Unit is running at full compensation.

Warning 306 is informational in nature, and does not indicate a malfunction.

WARNING/ALARM 308, Resistor temp
Excessive resistor heatsink temperature detected.

A temperature feedback is implemented using an NTC thermistor mounted on the damping resistor heatsink. The temperature is calculated and compared to a power unit dependent (PUD) alarm level.

Warning 308 is displayed when the PUD warning level is reached. This indicates the resistor temperature is close to the alarm level.

Troubleshooting:

Verify if:

- Ambient temperature is too high
- Incorrect clearance above and below the unit
- Dirty heatsink
- Blocked air flow around the unit
- Damaged heatsink fan

WARNING/ALARM 309, Mains earth fault
A ground fault was detected, measured by the CT line power currents.

The sum current from three line power CTs is too high. The ground fault must be detected at every sample during a period of 400 ms, for Alarm 309 to be reported.

Troubleshooting:

Check the installation line power CTs and wiring

Replace the AFC card

ALARM 311, Switch freq. limit
The average switching frequency of the unit exceeded the limit.

If the actual switching frequency exceeds 6 kHz for 10 electrical cycles, Alarm 311 is reported.

Service parameter 98-21 displays the actual switching frequency. NOTE: Do not change any service parameters unless directed to do so in this service manual.

Troubleshooting

Perform the Line Power Resonance Test (*6.3.7 Line Power Resonance Test*)

ALARM 314, Auto CT interrupt
Auto CT detection was interrupted by the user.

ALARM 315, Auto CT error
An error was detected while performing auto CT detection.

Auto CT detection does not work under the following conditions: if any sum current transformers are installed, when the active filter is supplied through a step up or step down transformers, or when the filter is <10% of the CT primary. Program the CT parameters manually if auto CT detection fails.

WARNING 316, CT location error
The auto CT function could not determine the correct locations of the CTs.

Program the CT parameters manually if auto CT detection fails.

WARNING 317, CT polarity error
The auto CT function could not determine the correct polarity of the CTs.

Program the CT parameters manually if auto CT detection fails.

WARNING 318, CT ratio error
The auto CT function could not determine the correct primary rating of the CTs.

Program the CT parameters manually if auto CT detection fails.

ALARM 319, Runaway follower
A follower AF was not commanded to run, but the feedback indicates it is running. The report value indicates the follower ID.

Troubleshooting:

- Check the follower unit
- Check the control wiring

WARNING 320, AC res. HS fault
AC resistor heatsink temperature feedback is not connected or low temperature.

WARNING 321, Volt imbalance >3%
Possible causes are a phase is missing on the supply side or the line voltage imbalance is too high.

Troubleshooting: Check the supply voltage imbalance and main fuses of the filter.

ALARM 322, 5V pwr. card low
5 V power supply from power card is low.

Troubleshooting:

- Replace the AFC card
- Replace the power card.

ALARM 323, 15V neg. supply low
The negative 15 V power supply is low.

Troubleshooting:

- Perform the AC capacitors current transducers test (*6 Test Procedures*).
- Check if the connectors on current transducers and on the AFC card are pinned properly
- Check the AC capacitors current transducers cables
- Replace the AFC card

ALARM 324, 15V pos. supply low
The positive 15 V power supply is low.

Troubleshooting:

- Perform the AC capacitors current transducers test (*6 Test Procedures*).
- Check if the connectors on current transducers and on the AFC card are pinned properly
- Check the AC capacitors current transducers cables
- Replace the AFC card

4.6 After Repair Tests

After any repair to a filter or after any testing of a filter suspected of being faulty, follow this procedure to ensure that all circuitry is functioning properly before returning the unit to operation.

1. Perform visual inspection procedures as described in *Table 4.1*.
2. Perform the static test procedures to ensure that the unit is safe to start.
3. Apply AC power to the unit.
4. Copy parameter settings to the LCP memory *0-50 LCP Copy* for backup.
5. Program the filter according to CT installation in the following parameters: Location (*300-26 CT Placement*), CT Primary Voltage (*300-22 CT Nominal Voltage*).
6. Perform an Auto CT-detection (300-29) if the following conditions are met: the CTs are installed on the PCC side (towards the transformer), CTs do not use sum transformers, the filter is not supplied through a transformer, and the filter is >10% of the CT primary.
7. Check the filter parameters according to CT installation in the following parameters: Primary Rating (*300-20 CT Primary Rating*), Sequence (*300-24 CT Sequence*), Polarity (*300-25 CT Polarity*).
8. Mount the CT short at all three CT inputs on the CT input terminal (factory pre-mounted).
9. Provide the active filter with a run command.
10. Check that the filter current shown on the LCP is lower than 15% of the nominal filter current. If higher, conduct a hardware fault inspection.
11. Stop the active filter and remove all three CT short lugs.
12. Check the filter parameters according to application requirements in the following parameters: Priority (*300-01 Compensation Priority*), Harmonic Selection Mode (*300-00 Harmonic Cancellation Mode* and *300-30 Compensation Points*), and Cos fi Reference (*300-35 Cos-phi Reference*).
13. Provide the active filter with a run command.
14. Monitor that the total harmonic current and voltage distortion is reduced. If not, check CT input/installation for faults or configuration errors.
15. Copy parameter settings to the LCP memory *0-50 LCP Copy* for backup.

5 Active Filter and the Power Grid

5.1 Grid Variations

5.1.1 Grid Configurations

Active filters operate with all typical grid configurations such as:

- 3-phase, 3-wire
- 3-phase, 4-wire
- Grounded wye
- Ungrounded/isolated wye
- Delta wire
- 50 Hz +/-10% tolerance
- 60 Hz +/-10% tolerance

5.1.2 Grid Impedance

The short-circuit impedance or percent impedance of the power supply represents the grid impedance. In supply systems with short cables (below 1640 ft [500 m]), the short-circuit impedance (impedance voltage) of the transformer or the power supply generator corresponds to a minimal value of the grid impedance on the point of common coupling (PCC). The maximal value depends on low voltage grid wiring type, length, and upper voltage level grid impedance. In the case of unknown values, the maximum is estimated as double the supply transformer short-circuit impedance value.

The correct current of the filter depends on the grid impedance. For higher grid impedance, the 10% filter correction current is reduced.

Active filters have no limitations to the lowest grid impedance. But from the installation point of view, it is important that the available short circuit current of the grid is less than potential capacitor overcurrent of 3% of the filter rating.

5.1.3 Voltage Pre-distortions

Active filters are suitable for operation under non-sinusoidal voltages. A total harmonic voltage distortion of up to 10% should not affect the active filter performance.

If active front end based drives or other active input devices are present on the same grid, the high switching noise can overload the damping resistor of the LCL filter. The amplitude of voltage harmonics above 25th order should be not higher than 3%.

WARNING/ALARM 302, Cap. over current usually indicates high voltage pre-distortions or high grid impedances.

5

5.2 Basic Troubleshooting Background

5.2.1 Line Phase Loss and Unbalanced Phase Trips

The active filter monitors phase loss by measuring the AC capacitors currents. If phase loss is detected, the filter trips with ALARM 4, Line phase loss after a time. The time response of the phase loss detection is approx. 0.5 s

When the input voltage becomes unbalanced, no phase disappears completely. ALARM 4 is not issued. However, the following trip alarms may occur:

- WARNING/ALARM 7, DC overvoltage
- WARNING/ALARM 302, Cap. overcurrent
- WARNING/ALARM 304, DC overcurrent
- ALARM 311, Switch. freq. limit
- WARNING 321, Volt. imbalance >3%

Severe imbalance of supply voltage or phase loss can easily be detected with a voltmeter by measuring the line to line voltages.

5.2.2 Voltage Dips and Flickers

Active filters are suitable for operation on grids with voltage dips and flickers. The active behavior depends on the duration, depth and affected phase number of the voltage dips. When voltage dips threaten possible damage to active filter components, the active filter stops operation with following faults:

- WARNING/ALARM 4, Mains phase loss
- ALARM 300, Mains cont. fault
- ALARM 305, Mains freq. limit

5.2.3 Compatibility with Other Equipment on the Same Line Power

Most problems are associated with the circulation of high frequency switching current harmonics, generated by active input devices through leakage capacitance of the power distribution system components, like power cables, supply transformers, and so on. The circulation of high frequency current harmonics can produce interaction with other equipment connected to the same bus, increasing the amplitude of neutral currents and activating the operation of zero-sequence relays.

Problems associated with ground protections (ground fault relays: ELCB, RCD, or GFCI)
Normally, ground faults are eliminated with zero-sequence relays connected through ring transformers or to the neutral-to-ground connection. With an active filter connected to the power distribution system, high frequency switching current harmonics sink into the ground across parasitic grid capacitances. This results in improper operation of ground fault relays.

Avoid this problem by replacing the fault relay with non-sensitive high frequency relay. To ensure effective protection and unintended tripping of protective relays, all relays must provide protection of 3-phase equipment with active current input and brief discharge at power-up. It is recommended to use a type with adjustable trip amplitude and time characteristics. Use a current sensor with a current sensitivity of more than 200 mA and not less than 0.1 second operating time.

Problems associated with UPS units
A UPS unit can become distorted by active filter switching noise in the line power supply. The power failure detector of the UPS unit can be irritated by high frequency switching harmonics in the AC line voltage. As a result, the UPS could remain on battery power, unable to reconnect the line power supply voltage.

An option to avoid this problem is tuning the power failure detector of the UPS unit by changing setup parameters. Another option is replacing the UPS with a unit not sensitive to high frequency switching harmonics.

5.2.4 Line Power Resonances

In most common cases, active filters do not affect the load in the form of a resonance condition. The active filters are capable to operate in a resonance condition to a minimum of the 31st harmonics order.

With CTs on the load side, resonant conditions occurring within the electrical power system between the active filter and the load don't interfere with active filter functioning. At light grid loads, the grid resonance frequency changes with grid loads and can interfere with the active filter. Filters with CTs installed on the PCC side (light loaded) might get unstable or experience runaway (uncontrollable) compensation. To avoid this, use either the sleep mode function to deactivate the filter at light loads or use selective harmonic compensation to omitting harmonic compensation near the light load resonance point.

In the case of line power resonances, the following trips can occur:

- WARNING/ALARM 7, DC overvoltage
- WARNING/ALARM 302, Cap. overcurrent
- WARNING/ALARM 304, DC overcurrent
- ALARM 311, Switch. freq. limit

In general, power supply grids with long cables (above 1640 ft [500 m]) have a higher probability of resonance issues compare to grids with short cables.

5.2.5 Control Logic Problems

Problems with control logic can often be difficult to diagnose, since there is usually no associated fault indication. The typical complaint is simply that the filter does not respond to a given command.

The filter is designed to accept a variety of signals. For troubleshooting, first determine what types of signals the filter is receiving. There are six digital inputs (terminals 18, 19, 27, 29, 32, 33) and two analog inputs (53 and 54). (See Filter Inputs and Outputs.) Using the status information displayed by the unit is the best method of locating problems of this nature. By selecting within parameter group 0-2* Display, line 2 or 3 of the display can be set to indicate the signals coming in. The presence of a correct reading indicates that the desired signal is detected by the microprocessor. This data also may be read in parameter group 16-6*.

If there is not a correct indication, the next step is to determine whether the signal is present at the input terminals of the filter. This can be performed with a voltmeter or oscilloscope in accordance with the Input Terminal Signal Test (see *6 Test Procedures*). 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 filter. The circuitry providing the signal along with its associated wiring must then be checked.

5.2.6 Programming Problems

CAUTION

Incorrect parameter settings will not damage the active filter but can have a very negative influence on the grid and can potentially damage other equipment connected to the grid.

Difficulty with active filter operation can be a result of improper programming of the filter parameters. Three areas where programming errors may effect the filter performance are:

- CT settings
- References and limits
- I/O configuration

Any references or limits set incorrectly will result in less than optimal filter performance. For instance, if the reference for the Cos Phi parameter is set too low, the unit will be unable to reach full compensation of reactive currents. Parameters must be set according to the requirements of the particular installation. References are set in the parameter group 300-0*.

Incorrectly set I/O configuration usually results in the filter not responding to the function as commanded. It must be remembered that for each control terminal input or output, there are corresponding parameters settings. These settings determine how the filter responds to an input signal or the type of signal present at that output. Using an I/O function must be thought of as a two step process. The desired I/O terminal must be wired properly and the corresponding parameter must be set accordingly. Control terminals are programmed in the 5-0* and 6-0* parameter groups.

5.3 Internal Active Filter Problems

The vast majority of problems related to failed filter power components can be identified by performing a visual inspection and the static tests as described in the test section. There are, however, a number of possible problems that must be diagnosed in a different manner. The following discusses many of the most common problems.

5.3.1 Overtemperature Faults

In the event that an overtemperature indication is displayed, determine whether this condition actually exists within the filter or whether the thermal sensor is defective. Of course, this can easily be detected by feeling the outside of the unit, if the overtemperature condition is still present. If not, the temperature sensor must be checked. This can be done with the use of an ohmmeter in accordance with the thermal sensor test procedure.

5.3.2 Current Feedback Problems

CAUTION

Incorrect wiring or installation of current transformers will not damage the active filter but can have a very negative influence on the grid and can potentially damage other equipment connected to the grid.

Providing suitable current feedback signals from customer’s current transformers (CT) is very important for the correct operation of the active filter. Most issues, during active filter commissioning, are related to the incorrect installation or wiring of customer’s current transformers.

It is strongly recommended prior to commissioning the active filter to perform a visual inspection of the CT installation and wiring as described in *Table 4.1*. If the visual proof is not possible, measure the CT's current feedback signals on the current transformer input terminals with a current probe rated for 1 A or 5 A, corresponding to the secondary rating of the current transformers.

Monitoring the DC link voltage and the filter output current on the LCP while operating the filter gives suitable information about CT current feedback signals. The indicated value of the DC link voltage should be nearly constant, with variations less then 20 V.

Acoustic noise from LCL filter reactors can indicate improper CT installation and operation of the active filter. The noise should be fairly even, without crashes which indicate instability of the active filter operation. Low frequency noise oscillations usually indicate oscillations on line power or in the load.

To ensure the proper operation of customer’s current transformers, it is useful to monitor the waveform of the current feedback signals. This can be done by using a current probe, rated for 5A, and an oscilloscope. Measure the current of the CTs and line current. The shape of the signal should be the same with different values.

5

5.3.3 Noise On CT Input

The control logic of the active filter provides robustness against noise on CT inputs. High frequency noise, above 3 kHz, does not affect the active filter performance. But if the amplitude of this noise is twice that of the real signal, the input analog circuitry can be saturated. As a result, the compensation quality of harmonics on line power can be adversely affected. Noise on CT inputs with high amplitude, in practical terms, is not realistic and usually indicates CT or wiring damage.

5.3.4 Effect of EMI

While Electromagnetic Interference (EMI) related disturbances to filter operation are uncommon, the following detrimental EMI effects may be seen:

- Serial communication transmission errors
- CPU exception faults
- Unexplained filter trips

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 may 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

6 Test Procedures

6.1 Introduction

WARNING

Electrical Hazard!

Touching electrical parts of the filter may be fatal even after equipment has been disconnected from AC power. Wait 20 minutes for D-frame sizes, 30 minutes for E-frame sizes after power has been removed before touching any internal components to ensure that capacitors have fully discharged. See label on front of filter door for specific discharge time.

This section contains detailed procedures for testing filters. Previous sections of this manual provide symptoms, alarms, and other conditions which require additional test procedures to further diagnose the filter. The results of these tests indicate the appropriate repair actions. Again, because the filter monitors input and external signals, the source of fault conditions may exist outside of the filter itself. Testing described here isolates many of these conditions as well. The Disassembly and Assembly Instructions describe detailed procedures for removing and replacing filter components.

Filter testing is divided into *Static Tests*, *Dynamic Tests*, and *After Repair Tests*. Static tests are conducted without power applied to the filter. Most filter 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 or faulty connections. Perform these tests on any unit suspected of containing faulty power components before applying power.

CAUTION

For dynamic test procedures, main input power is required. All devices and power supplies connected to line power are energized at rated voltage. Use extreme caution when conducting tests on a powered filter. Contact with powered components could result in electrical shock and personal injury.

Dynamic tests are performed with power applied to the filter. Dynamic tests are performed with power applied to the adjustable frequency drive.

Replace any defective component and retest the filter with the new component before applying power to the filter as described in *After Repair Drive Tests*.

CAUTION

Line Power (Primary Side) Current

Use a shorting connector on the secondary side of customer-supplied external current transformers (CT) whenever current is present on line power (primary side) and the AFC card is NOT wired to the external CT terminals. When performing service on an active filter, use a shorting connector on the secondary side of external CTs for extra safety. Failure to short out the secondary side of current transformers when current is present on the primary side and the AFC card is NOT connected could damage the current transformer.

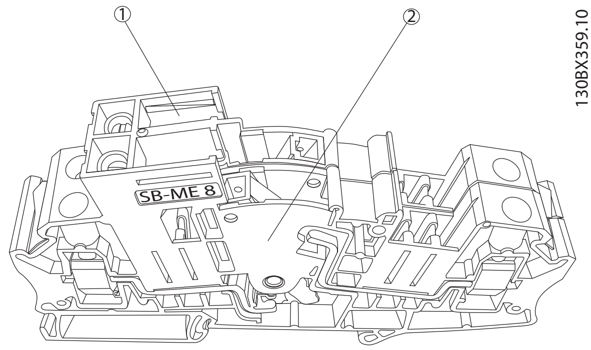


Figure 6.1 Shorting Connector

1	Shorting lug	2	Shorting connector

Table 6.1

Shorting Connector

A shorting connector must be placed on the secondary side of customer-supplied external CTs whenever current is present on line power and the AFC card is NOT wired to the external CT terminals. Failure to short out the secondary side of the CT could damage the CT.

The AFC card provides the step-down current function when connected

When the AFC card is not connected, the secondary side must be shorted

6

The shorting connector provided with most customer-supplied external CTs should be removed after the AFC card has been wired to the CT and prior to operating the active filter

For safety considerations, short the secondary side of customer-supplied external CTs anytime the AFC card is not wired to the external CT, even if current is not present on line power

Customer-supplied external CTs connect to the AFC card at MK101 (5A) or MK108 (1A)

6.1.1 Tools Required for Testing

- Digital volt/ohmmeter (must be rated for 1200 V DC for 690 V units)
- Analog voltmeter
- Megohmmeter
- Oscilloscope
- Clamp-on style amp meter
- Signal test board (p/n 176F8437) and extension board (p/n 130B3147)
- Split-bus power supply (p/n 130B3146)
- Power quality analyses Fluke 435 (p/n 130BB3173), Dranetz 4300, 4400, or similar

6.1.2 Signal Test Board

The signal test board can be used to test circuitry within the filter and provides easy access to test points. The test board plugs into connector MK104 on the power card. Its use is described in the procedures where called out. See *9.1.1 Signal Test Board (p/n 176F8437)* in *9.1.1 Test Equipment*, for detailed pin descriptions.

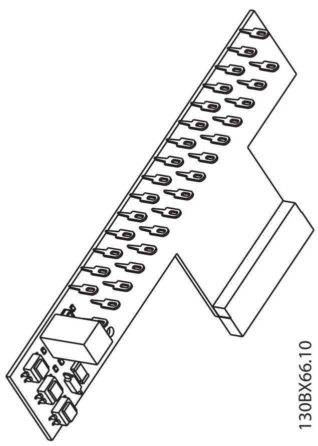


Figure 6.2 Signal Test Board

6.2 Static Test Procedures

6.2.1 Inverter Section Tests

The inverter section is contains the IGBTs for two functions; First, provide power to the DC line capacitors and, second, to inject current back into the power grid. IGBTs are grouped into modules comprised of six IGBTs. Depending on the size of the unit, either one, two, or three IGBT modules are present. The filter also has three snubber capacitors on each IGBT module.

Before starting tests, ensure that meter is set to diode scale. If removed previously, reinstall the soft charge card and power cards. Do not disconnect the cable to connector MK105 on the power card since the path for continuity would be broken.

6.2.1.1 Inverter Test Part I

1. Connect the positive (+) meter lead to the (+) positive DC bus connector MK105 (A) on the power card.
2. Connect the negative (–) meter lead to LC inductor secondary side terminals L1, L2, and L3 in sequence.

Each reading should show infinity. The meter will start at a low value and slowly climb toward infinity due to capacitance within the filter being charged by the meter.

6.2.1.2 Inverter Test Part II

1. Reverse the meter leads by connecting the negative (–) meter lead to the positive (+) DC bus connector MK105 (A) on the power card.
2. Connect the positive (+) meter lead to LC inductor secondary side terminals L1, L2, and L3 in sequence.

Each reading should show a diode drop.

Incorrect reading
An incorrect reading in any inverter test indicates a failed IGBT module. Replace the IGBT module according to the disassembly instructions in *7 D-Frame Sizes Disassembly and Assembly Instructions* or *8 E-Frame Sizes Disassembly and Assembly Instructions*. It is further recommended for units with two IGBT modules that both modules be replaced even if the second module tests correctly.

6.2.1.3 Inverter Test Part III

1. Connect the positive (+) meter lead to the negative (-) DC bus connector MK105 (B) on the power card.
2. Connect the negative (–) meter lead to LC inductor secondary side terminals L1, L2, and L3 in sequence.

Each reading should show a diode drop.

6.2.1.4 Inverter Test Part IV

Inverter test part IV

1. Reverse the meter leads by connecting the negative (–) meter lead to the negative (-) DC bus connector MK105 (B) on the power card.
2. Connect the positive (+) meter lead to LC inductor secondary side terminals L1, L2, and L3 in sequence.

Each reading should show infinity. The meter will start at a low value and slowly climb toward infinity due to capacitance within the filter being charged by the meter.

Incorrect reading
An incorrect reading in any inverter test indicates a failed IGBT module. Replace the IGBT module according to the disassembly instructions in *7 D-Frame Sizes Disassembly and Assembly Instructions* or *8 E-Frame Sizes Disassembly and Assembly Instructions*. It is further recommended for units with two IGBT modules that both modules be replaced even if the second module tests correctly.

6.2.2 Gate Resistor Test

Indications of a failure in this circuit
IGBT failures may be caused by the filter being exposed to repeated ground fault faults or by extended filter operation outside of its normal operating parameters.

Mounted to each IGBT module is an IGBT gate resistor board containing, among other components, the gate resistors for the IGBT transistors. Based on the nature of the failure, a defective IGBT can produce good readings from the previous tests. In nearly all cases, the failure of an IGBT will result in the failure of the gate resistors.

Located on the gate drive card near each of the gate signal leads is a 3-pin test connector. These are labeled MK 250, 350, 450, 550, 650, 750, 850.

For the sake of clarity, refer to the 3 pins as one, two, and three, reading left to right. Pins 1 and 2 of each connector are in parallel with the gate drive signal sent to the IGBTs. Pin 1 is the signal and Pin 2 is common.

1. With ohmmeter, measure pins 1 and 2 of each test connector. Reading should indicate 7.8 K Ω for D-frames and 3.9 K Ω for E-frames.

Incorrect reading
An incorrect reading indicates that either the gate signal wires are not connected from the gate drive card to the gate resistor board or the gate resistors are defective. Connect the gate signal wires, or if the resistors are defective, the entire IGBT module assembly requires replacement. Replace the IGBT module according to the disassembly procedures in *7 D-Frame Sizes Disassembly and Assembly Instructions* or *8 E-Frame Sizes Disassembly and Assembly Instructions*.

6.2.3 Intermediate Section Tests

The intermediate section of the filter is made up of the DC bus capacitors, and the balance circuit for the capacitors.

1. Test for short circuits with the ohmmeter set on Rx100 scale or, for a digital meter, select diode.
2. Measure across the positive (+) DC terminal (A) and the negative (–) DC terminal (B) on connector MK105 on the power card. Observe the meter polarity.
3. The meter will start out with low ohms and then move towards infinity as the meter charges the capacitors.
4. Reverse meter leads on connector MK105 on the power card.
5. The meter will peg at zero while the capacitors are discharged by the meter. The meter then begins moving slowly toward two diode drops as the meter charges the capacitors in the reverse direction. Although the test does not ensure the capacitors are fully functional, it ensures that no short circuits exist in the intermediate circuit.

Incorrect reading
A short circuit could be caused by a short in the soft charge or inverter section. Be sure that the tests for these circuits have already been performed successfully. A failure in one of these sections could be read in the intermediate section since they are all routed via the DC bus.

The only likely cause would be a defective capacitor within the capacitor bank.

There is not an effective test of the capacitor bank when it is fully assembled. Although it is unlikely that a failure within the capacitor bank would not be indicated by a physically damaged capacitor, if suspect, the entire capacitor bank must be replaced. Replace the capacitor bank in accordance with the disassembly procedures in *7 D-Frame Sizes Disassembly and Assembly Instructions* or *8 E-Frame Sizes Disassembly and Assembly Instructions*.

6.2.4 Heatsink Temperature Sensor Test

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 a temperature sensor mounted internally. The sensor is wired from the IGBT module to the gate drive card connector MK100. For filters with two IGBTs, the sensor on the right module is used. For filters with three IGBT modules, the center module is used.

On the gate drive card, the resistance signal is converted to a frequency signal. The frequency signal is sent to the power card for processing. The temperature data is used to regulate fan speed and to monitor for over and under temperature conditions.

1. Use ohmmeter set to read ohms.
2. Unplug connector MK100 on the gate drive card and measure the resistance across the cable leads.

The relationship between temperature and resistance is nonlinear. At 77° F [25° C], the resistance will be approximately 5 k Ω. At 32° F [0° C], the resistance will be approximately 13.7 k Ω. At 140° F [60° C], the resistance will be approximately 1.5 k Ω. The higher the temperature, the lower the resistance.

6.2.5 Fan Continuity Tests

Make all continuity checks using an ohmmeter set to Rx1 scale. A digital or analog ohmmeter can be used. Some instability may result when measuring resistance of a transformer with a multimeter. This can be reduced by turning off the auto-ranging function and setting the measurement manually.

To aid in making the measurements, unplug the MK107 from the power card.

Checking continuity of connections
For the following tests, read connector MK107 on the power card.

1. Measure from L3 (T) to MK107 terminal 16. Reading of <1 Ω should be indicated.
2. Measure from L2 (S) to MK107 terminal 1. Reading of <1 Ω should be indicated.

Incorrect reading
An incorrect reading would indicate a faulty cable connection. Replace the cable assembly.

6.2.5.1 Fan Fuse Test

1. Test the fan fuses on the soft charge mounting plate by checking the continuity across the fuse.

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

6.2.5.2 Ohm Test of Transformer

For the following tests, read the plug end of the wire connected to MK107 on the power card.

1. Measure between MK107 terminals 1 and 16. Should read approximately 4 Ω.
2. Measure between MK107 terminals 16 and 12. Should read approximately 3 Ω.
3. Measure between MK107 terminals 1 and 12. Should read approximately 1 Ω.

Incorrect reading
An incorrect reading would indicate a defective fan transformer. Replace the fan transformer.

When finished, reconnect the MK107.

6.2.5.3 Ohm Test of Fans

Ohm test of fans Measure between terminals 11 and 13 of power card connector MK107.

Incorrect reading

Disconnect CN5 and measure the resistance between pins 1 and 2 on the fan side of the connector. Reading should be approximately 4 Ω. If incorrect, replace fan F2.

Disconnect CN4. Measure the resistance across 1 and 2 on the fan side. Reading should be approximately 200 Ω.

Incorrect reading
Isolate the faulty fan as follows.

a. Disconnect the wiring from the fan terminals.
b. Read across the fan terminals on each fan. A reading of 400 Ω is expected. Replace any defective fans.

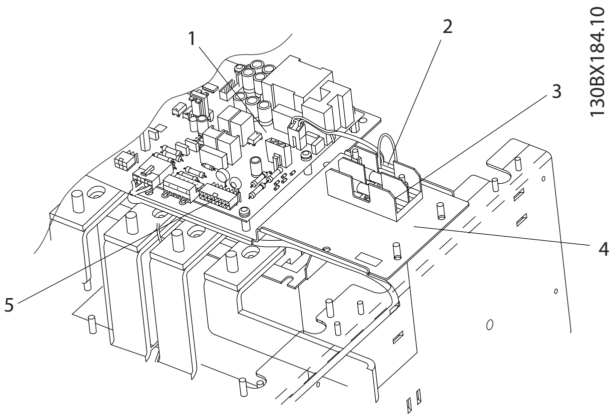


Figure 6.3 Fan and DC Bus Fuse Locations

1	Power card	4	Mounting plate
2	DC bus fuse	5	MK107
3	Fan fuse		

Table 6.2

6.2.6 AC Line power Contactor and Soft Charge Contactor Tests

The AC line power contactor and soft charge contactor can be tested for continuity using an ohmmeter set to Rx1 scale.

Measure resistance across each set of contacts in both the energized and non-energized state.

1. Place meter leads across the contact sets (L1 – T1, L2 – T2, L3 – T3) in turn. The non-energized state should read open (infinite resistance).
2. Repeat step 1 in the energized state.

NOTE!

In most cases, depressing the plunger on the top of the contactor does not allow closing the contacts. The energized state should read 0 (or near 0) Ω.

3. Using meter leads, measure resistance across each set of auxiliary contacts Aux 1 – Aux 2. Reading values for the non-energized state should be infinite resistance, and near 0 Ω for energized state of the AC Line power contactor and soft charge contactor.

NOTE!

The AC line power contactor and soft charge contactor have an electronic coil, therefore using an ohmmeter to test the coil by measuring the resistance across the coil is not possible. In general, the ohmmeter should measure 1–5 M Ω. Low values indicate on coil damaging.

6.3 Dynamic Test Procedures

NOTE!

Test procedures in this section are numbered for reference only. Tests need not be performed in this order. Perform tests only as necessary.

⚠WARNING

Electrical Hazard

Never disconnect the input cabling to the filter with power applied due to danger of severe injury or death.

CAUTION

Take all the necessary safety precautions for system start up before applying power to the filter.

6.3.1 No Display Test

A filter with no display can be the result of several causes. A single character in the display or a dot in the upper corner of the display indicates a communication error and is typically caused by an option card not being properly installed. When this condition occurs, the green power-on LED is illuminated.

If the LCD display is dark and the green power-on LED is not lit, proceed with the following tests.

First test for proper input voltage.

6.3.2 Input Voltage Test

1. Apply power to filter.
2. Use the DVM to measure the input AC line voltage between the filter input terminals in sequence:
   L1 to L2
   L1 to L3
   L2 to L3

All measurements must be within the range of 342–550 V AC. Readings of less than 342 V AC indicate problems with the input AC line voltage.

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

6

Danfoss calculates line imbalance per an IEC specification.

Imbalance = 0.67 X (Vmax – Vmin)/Vavg

For example, if three 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 Vavg, resulting in an imbalance of 3%.

Although the filter can operate at higher line imbalances, the lifetime of components, such as DC bus capacitors, will be shortened.

Incorrect reading

CAUTION

Open (blown) input fuses or tripped circuit breakers usually indicate a more serious problem. Before replacing fuses or resetting breakers, perform static tests described in *6 Test Procedures*.

An incorrect reading here requires checking the line power supply. Typical items to check would be:

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

If the Input Voltage Test was successful check for voltage to the control card.

6.3.3 Control Card Basic Voltage Test

1. Measure the control voltage at terminal 12 with respect to terminal 20. The meter should read between 21 and 27 V DC.

An incorrect reading could indicate the supply is loaded down by a fault in the customer connections. Unplug the terminal strip and repeat the test. If this test is successful, then continue. Remember to check the customer connections. If still unsuccessful, proceed to the Switch Mode Power Supply (SMPS) test.

2. Measure the 10 V DC control voltage at terminal 50 with respect to terminal 55. The meter should read between 9.2 and 11.2 V DC.

An incorrect reading here could indicate the supply is loaded down by a fault in the customer connections. Unplug the terminal strip and repeat the test. If this test is successful, then continue. Remember to check the customer connections. If still unsuccessful, proceed to the SMPS test.

A correct reading of both control card voltages would indicate the LCP or the control card is defective. Replace the LCP with a known good one. If the problem persists, replace the control card in accordance with the disassembly procedures in *7 D-Frame Sizes Disassembly and Assembly Instructions* or *8 E-Frame Sizes Disassembly and Assembly Instructions*.

6.3.4 Switch Mode Power Supply (SMPS) Test

For this procedure, provide 650 V using the split-bus power supply. The SMPS derives its power from the DC bus. The first indication that the DC bus is charged is the DC bus charge indicator light located on the power card being lit. This LED however can be lit at a voltage still too low to enable the power supplies.

First test for the presence of the DC bus.

1. Insert the signal test board into the power card connector MK104.
2. Connect the negative (-) meter lead to terminal 4 (common) of the signal board. With a positive (+) meter lead, check the following terminals on the signal board.

Terminal	Supply [V]	Voltage Range [V DC]
11	+18	16.5–19.5
12	-18	-16.5–-19.5
23	+24	23–25
24	+5	4.75–5.25

Table 6.3

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

Red LED +/- 18 V DC supplies present

Yellow LED +24 V DC supply present

Green LED +5 V DC supply present

The lack of any one of these power supplies indicates the low voltage supplies on the power card are defective. This assumes that the proper DC bus voltage was read at power card connector MK105 (A) and (B). Replace the power card in accordance with the disassembly procedures in *7 D-Frame Sizes Disassembly and Assembly Instructions* or *8 E-Frame Sizes Disassembly and Assembly Instructions*.

6.3.5 Current Sensors Test CT1, CT2, CT3

For this procedure, provide 650 V using the split-bus power supply.

Testing current feedback with the signal test board.

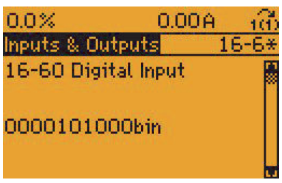
1. Remove power to filter. Make sure the DC bus is fully discharged.
2. Install the signal test board into power card connector MK104.
3. Apply power to the filter with the 650 V split-bus power supply.
4. Using a DVM, connect the negative (-) meter lead to terminal 4 (common) of the signal test board.
5. Measure the AC voltage at terminals 1, 2, and 3 of the signal test board in sequence. These terminals correspond with current sensors CT1, CT2, and CT3, respectively. Expect a reading near zero volts but no greater than +/-15 mV.

A reading of greater than 15 mVv suggests that the corresponding current sensor be replaced.

6.3.6 Input Terminal Signal Tests

The presence of signals on either the digital or analog input terminals of the filter can be verified on the filter display. Digital or analog input status can be selected or read in parameters 16-60 through 16-64.

Digital inputs
With digital inputs displayed, control terminals 18, 19, 27, 29, 32, and 33 are shown left to right, with a 1 indicating the presence of a signal.



130BB038.10

Figure 6.4

If the desired signal is not present in the display, the problem may be either in the external control wiring to the filter or a faulty control card. To determine the fault location, use a voltmeter to test for voltage at the control terminals.

Verify the control voltage power supply is correct as follows.

1. With a voltmeter measure voltage at control card terminal 12 and 13 with respect to terminal 20. The meter should read between 21 and 27 V DC.

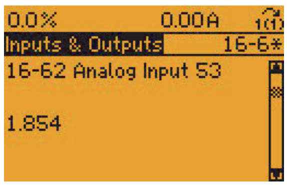
If the 24 V supply voltage is not present, replace the control card.

If 24 V is present, proceed with checking the individual inputs as follows

2. Connect the (-) negative meter lead to reference terminal 20.
3. Connect the (+) positive meter lead to the terminals in sequence.

The presence of a signal at the desired terminal should correspond to the digital input display readout. A reading of 24 V DC indicates the presence of a signal. A reading of 0 V DC indicates no signal is present.

Analog inputs
The value of signals on analog input terminals 53 and 54 can also be displayed. The voltage or current in mA, depending on the switch setting, is shown in line 2 of the display.



130BB039.10

Figure 6.5

If the desired signal is not present in the display, the problem may be either in the external control wiring to the filter or a faulty control card. To determine the fault location, use a voltmeter to test for a signal at the control terminals.

Verify the reference voltage power supply is correct as follows.

1. With a voltmeter, measure the voltage at control card terminal 50 with respect to terminal 55. The meter should read between 9.2 and 11.2 V DC.

If the 10 V supply voltage is not present, conduct *6.3.3 Control Card Basic Voltage Test* earlier in this section.

6

If the 10 volts is present proceed with checking the individual inputs as follows.

2. Connect the (-) negative meter lead to reference terminal 55.
3. Connect the (+) positive meter lead to desired terminal 53 or 54.

For analog input terminals 53 and 54, a DC voltage between 0 and +10 V DC should be read to match the analog signal being sent to the filter. Or a reading of 0.9 to 4.8 V DC corresponds to a 4 to 20 mA signal.

Note that a (-) minus sign preceding any reading above indicates a reversed polarity. In this case, reverse the wiring to the analog terminals.

6.3.7 Line Power Resonance Test

Resonances can occur in systems when the filter is able transfer energy between itself and other energy storage devices with no damping. If often occurs between a filter and other non-tuned capacitor banks. In case of resonance faults, investigate if the grid contains other capacitor banks and disconnect these, if possible. It might also be advisable to de-tune the capacitors by adding reactors.

1. Check the CT installation wiring.
2. Check the voltage imbalance value. It should be below 3%.
3. Mount the CT shorter on all three CT inputs on the CT input terminal. Give the active filter a run command. If Alarm 7, DC overvoltage, occurs, go to the troubleshooting procedure for Alarm 7. If no Alarm 7 occurs, go to the next step.
4. Remove CT short lugs.
5. Program the filter for the selective harmonic compensation mode (*300-00 Harmonic Cancellation Mode* harmonic selection mode) and program the filter for compensation of the 5th and 7th harmonics only (*300-30 Compensation Points*, compensation points for 5th and 7th harmonics set to zero, and other harmonics to the maximal value).
6. Give the filter a run command and observe whether the voltage distortion is reduced in the 5th and 7th harmonics. If not, check CT input/ installation and configuration for faults again.
7. Program step by step the filter for compensation, other harmonics, and monitor the AC output filter current indicated on the LCP or by direct measurements with a current probe. A high current indicates possible resonance points in the power supply. Ground these points by changing the order of compensated harmonics and disable by programming the active filter.

6.3.8 Control Card Digital Inputs/Outputs Test

Control card test digital inputs/outputs test

Use the following procedure to test the control card, and replace the control card if a problem is found.

1. Power the control card from a 24 V DC backup. Do not power the active filter from AC line voltage.
2. Program the digital inputs for PNP using parameter 5-00.
3. Verify the voltage across T12 and T20 is 24V DC using a multi-meter.
4. Verify that T32 is “0” using parameter 16-60.
5. Use a jumper wire to connect T12 and T32.
6. Verify that T32 is “1” using parameter 16-60.
7. Remove the jumper wire.
8. Verify that T33 is “0” using parameter 16-60.
9. Use a jumper wire to connect T12 and T33.
10. Verify that T33 is “1” using parameter 16-60.
11. Remove the jumper wire.
12. Change parameter 5-00 back to the previous value, if changed earlier.

6.4 After Repair Tests

After any repair to a filter or after any testing of a filter suspected of being faulty, follow this procedure to ensure that all circuitry is functioning properly before returning the unit to operation.

1. Perform visual inspection procedures as described in *Table 4.1*.
2. Perform the static test procedures to ensure that the unit is safe to start.
3. Apply AC power to the unit.
4. Copy parameter settings to the LCP memory *0-50 LCP Copy* for backup.
5. Program the filter according to CT installation in the following parameters: Location (*300-26 CT Placement*), CT Primary Voltage (*300-22 CT Nominal Voltage*).

6. Perform an Auto CT-detection (300-29) if the following conditions are met: the CTs are installed on the PCC side (towards the transformer), CTs do not use sum transformers, the filter is not supplied through a transformer, and the filter is >10% of the CT primary.
7. Check the filter parameters according to CT installation in the following parameters: Primary Rating (*300-20 CT Primary Rating*), Sequence (*300-24 CT Sequence*), Polarity (*300-25 CT Polarity*).
8. Mount the CT short at all three CT inputs on the CT input terminal (factory pre-mounted).
9. Provide the active filter with a run command.
10. Check that the filter current shown on the LCP is lower than 15% of the nominal filter current. If higher, conduct a hardware fault inspection.
11. Stop the active filter and remove all three CT short lugs.
12. Check the filter parameters according to application requirements in the following parameters: Priority (*300-01 Compensation Priority*), Harmonic Selection Mode (*300-00 Harmonic Cancellation Mode* and *300-30 Compensation Points*), and Cos fi Reference (*300-35 Cos-phi Reference*).
13. Provide the active filter with a run command.
14. Monitor that the total harmonic current and voltage distortion is reduced. If not, check CT input/installation for faults or configuration errors.
15. Copy parameter settings to the LCP memory *0-50 LCP Copy* for backup.

7 D-Frame Sizes Disassembly and Assembly Instructions

7.1 Electrostatic Discharge (ESD)

CAUTION

Filters contain dangerous voltages when connected to AC line voltage. No disassembly should be attempted with power applied. Remove power to the filter and wait at least 20 minutes to let the filter capacitors fully discharge. Only a competent technician should carry out service.

ELECTROSTATIC DISCHARGE (ESD)
Many electronic components within the filter 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.

CAUTION

Use proper electrostatic discharge (ESD) procedures to prevent damage to sensitive components when servicing the filter.

NOTE!

Frame size is used throughout this manual wherever procedures or components differ between filters based upon the unit's physical size. Refer to the tables in the Introduction section to determine frame size definitions. See for E-frame sizes disassembly and assembly instructions.

7.2 Passive Section (Top) Instructions

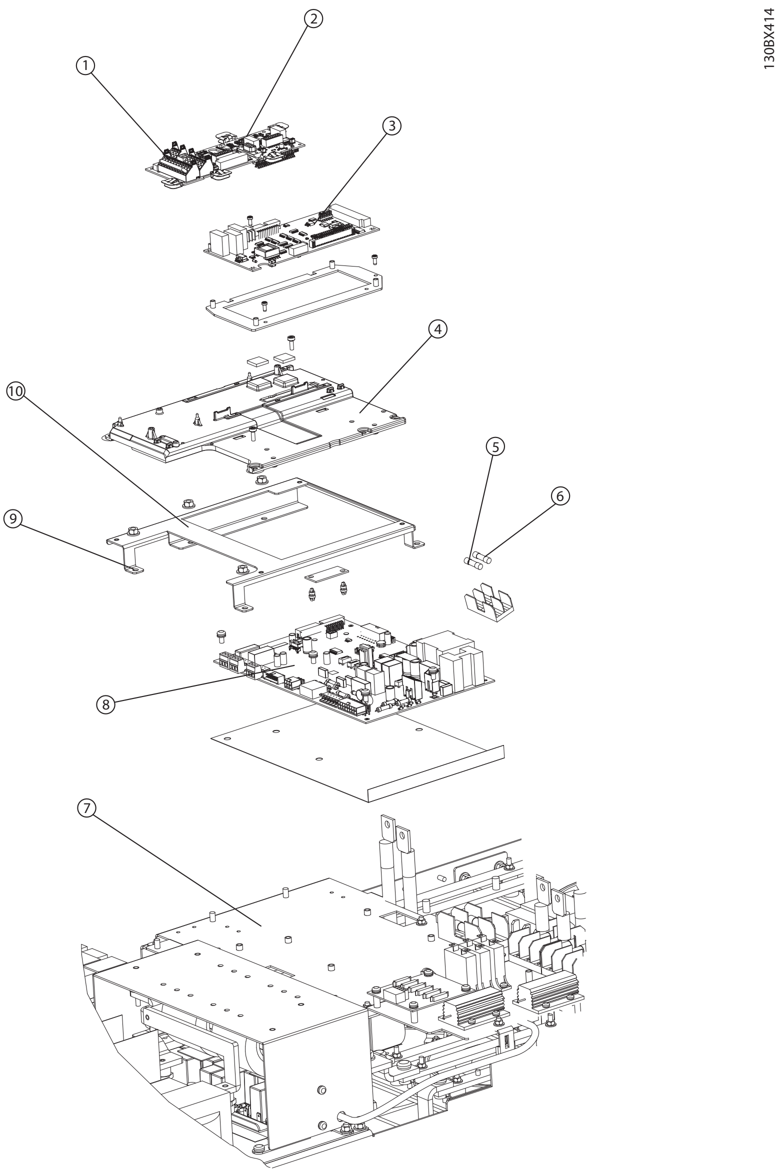


Figure 7.1 Control Card and Mounting Plate, Support Bracket, Active Filter Card, and Power Card and Mounting Plate

1	Control card terminal block	6	FU4
2	Control card	7	Power card mounting plate
3	Active filter (AAF) card	8	Power card
4	Control card mounting plate	9	Mounting nut
5	FU5	10	Control card assembly support bracket

Table 7.1

7.2.1 Control Card and Control Card Mounting Plate

1. Open the front panel door.
2. Unplug the LCP ribbon cable from the control card.

CAUTION

Line Power (Primary Side) Current

Use a shorting connector on the secondary side of customer-supplied external current transformers (CT) whenever current is present on line power (primary side) and the AFC card is NOT wired to the external CT terminals. When performing service on an active filter, use a shorting connector on the secondary side of external CTs for extra safety. Failure to short out the secondary side of current transformers when current is present on the primary side and the AFC card is NOT connected could damage the current transformer.

3. Remove capacitors CT cable from terminal MK103 of AAF card.
4. Remove the external CT cable from terminal MK101 or MK108 in the AAF card.
5. Remove ribbon cables from FC100 and MK100 on the AAF card.
6. Remove the control card terminal blocks.
7. Remove the 4 screws (T-20) securing the control card mounting plate to the control assembly support bracket.
8. Remove the control card mounting plate.

Reinstall in reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.2.2 Control Assembly Support Bracket

1. Remove the control card mounting plate in accordance with the procedure.
2. Remove the 5 mounting nuts (0.39 in [10 mm]).
3. Remove the control assembly support bracket.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.2.3 Active Filter Card

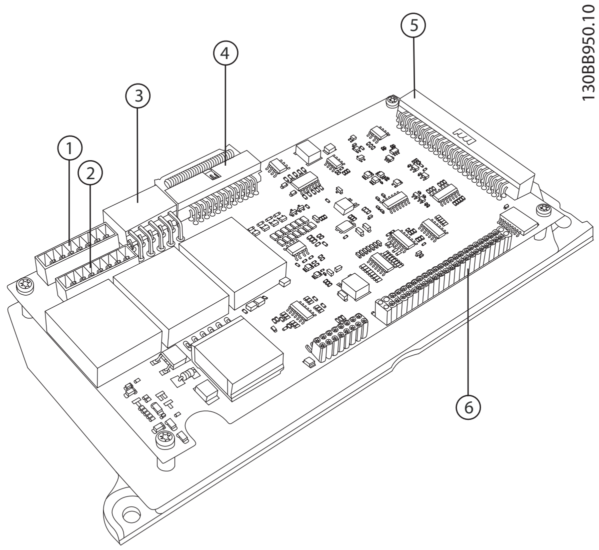


Figure 7.2 Advanced Active Filter Card

1	MK101	4	MK107
2	MK108	5	MK100
3	MK103	6	FK100

Table 7.2

CAUTION

Line Power (Primary Side) Current

Use a shorting connector on the secondary side of customer-supplied external current transformers (CT) whenever current is present on line power (primary side) and the AFC card is NOT wired to the external CT terminals. When performing service on an active filter, use a shorting connector on the secondary side of external CTs for extra safety. Failure to short out the secondary side of current transformers when current is present on the primary side and the AFC card is NOT connected could damage the current transformer.

1. Note if cable is connected to MK101 (5A) or MK108 (1A) for reassembly.
2. Remove plugs MK100, MK103, MK107, FK100, and MK101 (5A) or MK108 (1A) from AAF card.
3. Remove AAF card by removing the 4 mounting screws (T-10).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7

7.2.4 Power Card

The power card may remain attached to the power card mounting plate, if the power card mounting plate is to be removed.

1. Remove the control assembly support bracket in accordance with the procedure.
2. Unplug power card connectors MK102, MK103, MK105, MK106, MK107 MK109, and both MK112 connectors.
3. Remove the 7 mounting screws (T-25) from the power card.
4. Remove the power card from the plastic standoff at the top right of the power card.
5. Remove the current scaling card from the power card by pushing in the retaining clips on the standoffs. KEEP THIS SCALING CARD FOR FUTURE REINSTALLATION OF ANY REPLACEMENT POWER CARD. The scaling card controls signals operating with this specific filter. The scaling card is not part of the replacement power card.
6. Retain power card insulation for reassembly.

Reinstall in the reverse order of this procedure. When installing the power card, ensure that the insulator sheet is installed behind the power card. See *Table 1.7* for torque tightening values.

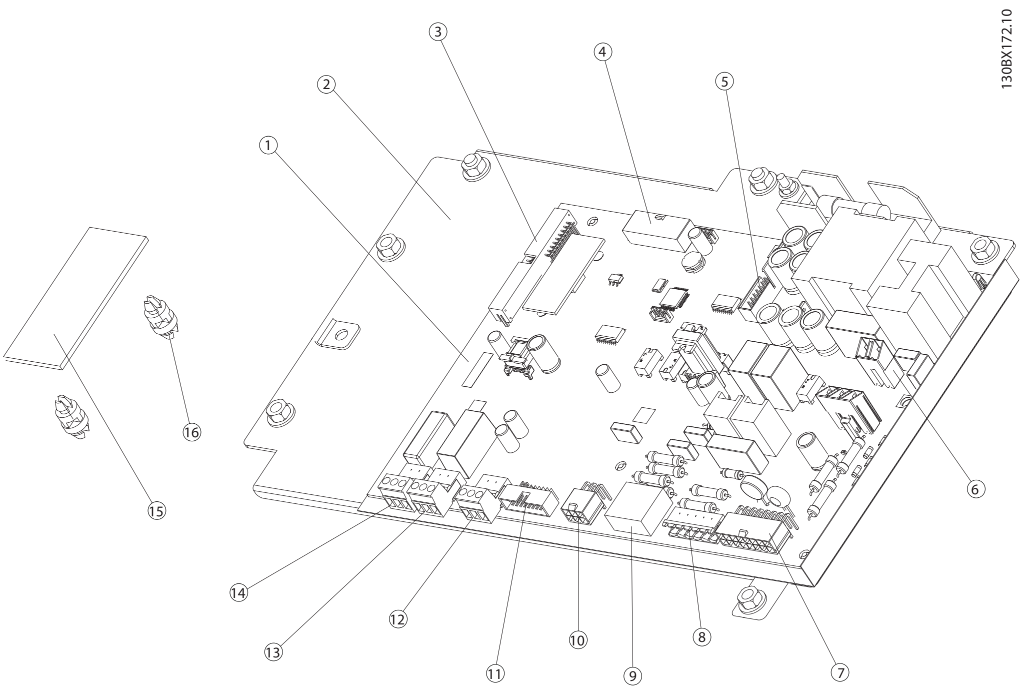


Figure 7.3 Power Card Terminals and Scaling Card

1	Power card PCA3	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 PCA4
8	FK103	16	Current scaling card standoff

Table 7.3

7.2.5 Power Card Mounting Plate

1. Remove the control assembly mounting bracket in accordance with procedure.
2. The power card mounting plate can be removed with the power card still mounted, if so desired. If the power card is to be removed, remove it in accordance with the power card procedure.
3. To remove the power card mounting plate with the power card attached, unplug power card connectors MK102, MK103, MK105, MK106, MK107 MK109, MK110, and FK112.
4. Remove the nut (0.30 in [7 mm]) attaching the MK102 ring lug to the power card mounting plate.
5. Note the position of the red and white cables from the FU4 and FU5 fuse block for reassembly. Unplug the cables.
6. Disconnect the red wires from the AC input contactors by removing the retaining nut (0.32 in [8 mm]).
7. Remove the cables from the top side of fuses FU6, FU14, and FU15 and disconnect the inline connector going to FU12.
8. Note the color of the cables (red, white and black) on FU11, FU12, and FU13 for proper reinstallation. Remove the cables from the top and bottom of fuses FU11, FU12, and FU13.
9. Remove the power card mounting plate by removing seven (0.32 in [8 mm]) nuts.

Reinstall in the reverse order of this procedure. The ring lug for the wire assembly that connects to power card connector MK102 attaches to the right mounting stud on the top of the power card mounting plate. See *Table 1.7* for torque tightening values.

7.2.6 AC Capacitors

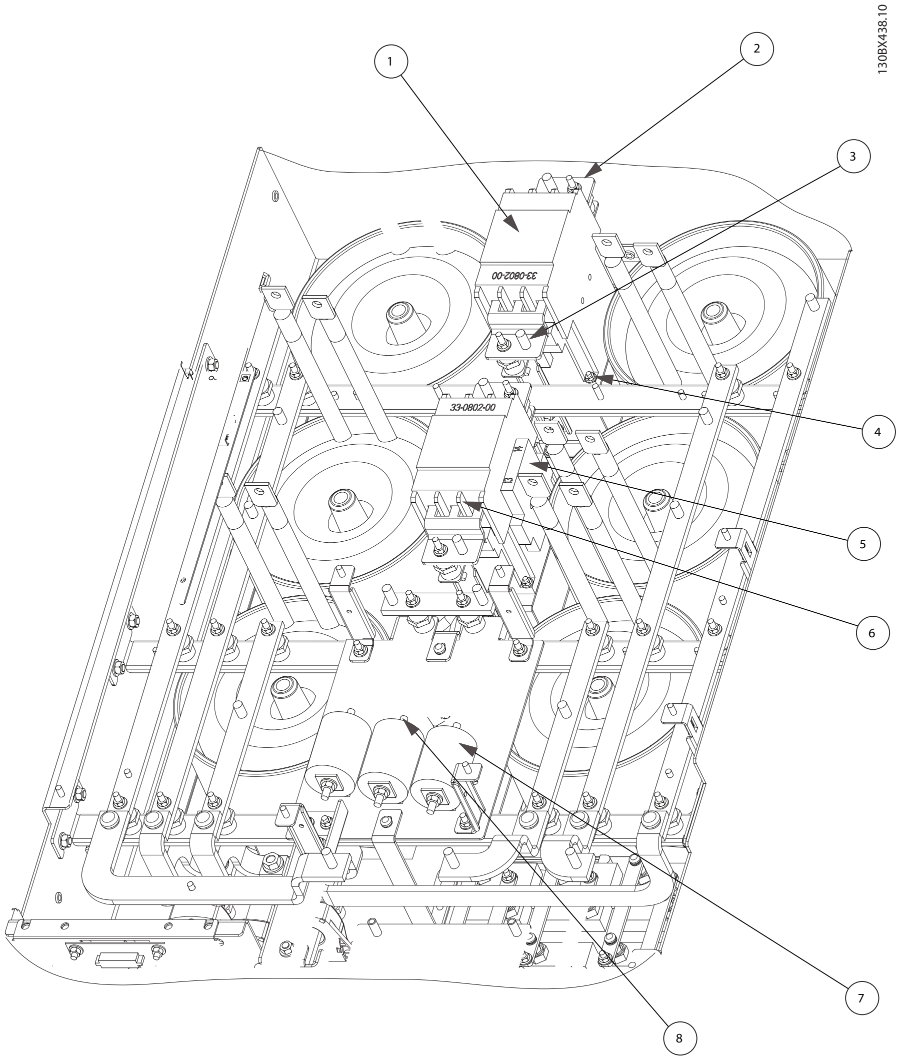


Figure 7.4 AC Capacitors and AC Contactors

1	AC contactor	5	Auxiliary contactor
2	AC contactor terminal bracket	6	Line power contactor terminal (U, V, W)
3	AC contactor terminal bracket retaining nut	7	AC capacitor
4	AC contactor mounting screw	8	AC capacitor retaining nut (top)

Table 7.4

1. Remove the control assembly support bracket in accordance with the procedure.
2. Remove the power card mounting plate in accordance with the procedure.
3. Remove the nut (0.43 in [11 mm]) from each side of the AC capacitor and the lug wires.
4. Remove the AC capacitor by cutting the cable tie securing the AC capacitor.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.2.7 AC Capacitor Current Sensor (CT4, CT5, CT6)

1. Remove the control assembly support bracket in accordance with the procedure.
2. Remove the power card mounting plate in accordance with the procedure.
3. Prior to removing the current sensor cabling, note the direction of the cable routing through the current sensor and number of wraps (3) for proper reinstallation. The direction of the cable and number of wraps is phase sensitive to the sensor function.
4. Remove the nut (0.43 in [11 mm]) from the top side of the corresponding capacitor in order to remove the lug cable which goes through the current sensor.
5. Remove the Molex connector (not shown) from the current sensor.
6. Remove the current sensor by removing the nuts (0.30 in [7 mm]), one on each side of the current sensor.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.2.8 AC Contactors

Prior to removing cables from the AC contactors, note the mounting orientation of the AC contactors and connection of all cables for proper reinstallation.

1. Remove the nut (0.39 in [10 mm]) from the top and bottom of the contactor terminal bracket.
2. Loosen the three screws on the main contactor terminals to allow removal of the contactor terminal bracket.
3. Disconnect the coil wires from terminals A1 and A2 by loosening the retaining screws (not shown).
4. Disconnect the wires from the auxiliary contactors by loosening the retaining screw.
5. Remove the AC contactor by removing the four mounting nuts (0.32 in [8 mm]).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.2.9 MOVs

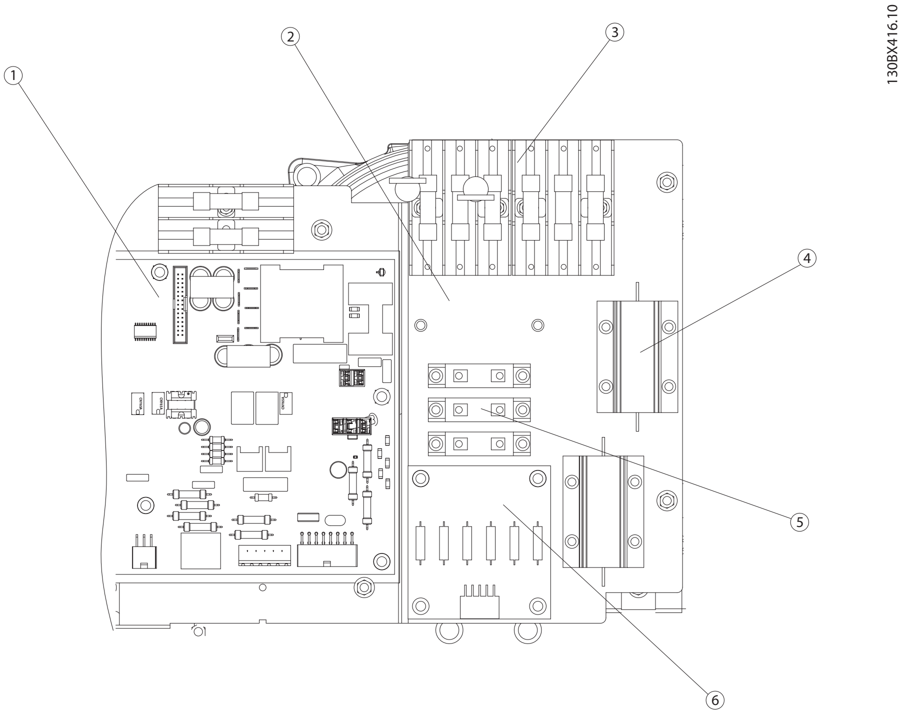


Figure 7.5 MOVs, Discharge Card, and Soft Charge Resistor

1	Power card	4	Soft charge resistor
2	Power card mounting plate	5	MOV
3	Fuse block	6	Discharge card

Table 7.5

1. Disconnect the wires from the terminals on the right and left of the MOV by loosening the retaining screws.
2. Remove the MOV by removing the two screws (T-20) right and left.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.2.10 Discharge Card

1. Disconnect MK100 from the discharge card.
2. Remove the discharge card by removing the four screws (T-25).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.2.11 Soft Charge Resistor

1. Disconnect the cable going to fuses FU14 and FU 15 and the AC contactors.
2. Remove the soft charge resistor by removing the 4 retaining nuts (0.30 in [7 mm]).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3 Active Side (Bottom) Instructions

7.3.1 Input Terminal Mounting Plate

CAUTION

Two Person Lift

The input terminal mounting plate supports various customer-ordered options. The input terminal mounting plate with options attached can exceed 35 kg (60 lbs). Assistance is required for removal. Failure to provide assistance when during removal could result in personal injury.

Note that the input terminal mounting plate provides mounting for various options. The fused disconnect option is shown.

1. Disconnect the line power input wiring from terminals L1, L2, L3 and the ground connector.
2. Remove the 3 cross bus bars between the input terminals and the input inductor. (These are located above the optional RFI filter if the RFI filter is present.) Remove three nuts (0.67 in [17 mm]) (not shown), three (T-40) screws, and (0.51 in [13 mm]) nuts from the passive side of the unit.
3. Remove input terminal mounting plate by removing eight (0.39 in [10 mm]) retaining nuts from plate.

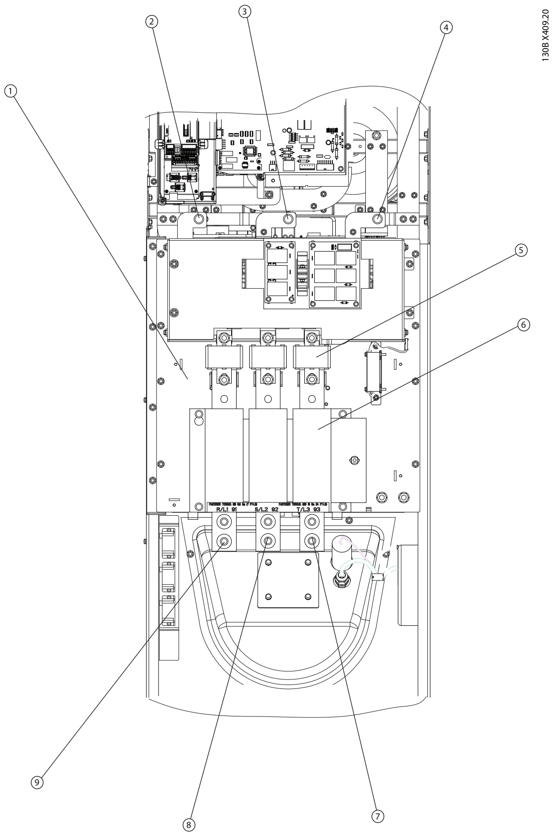


Figure 7.6 Input Terminal Mounting Plate

1	Input terminal mounting plate	6	Line power disconnect (optional)
2	Cross bus bar terminal	7	L3
3	Cross bus bar terminal	8	L2
4	Cross bus bar terminal	9	L1
5	Line power disconnect fuse (optional)		

Table 7.6

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.2 Gate Drive Card

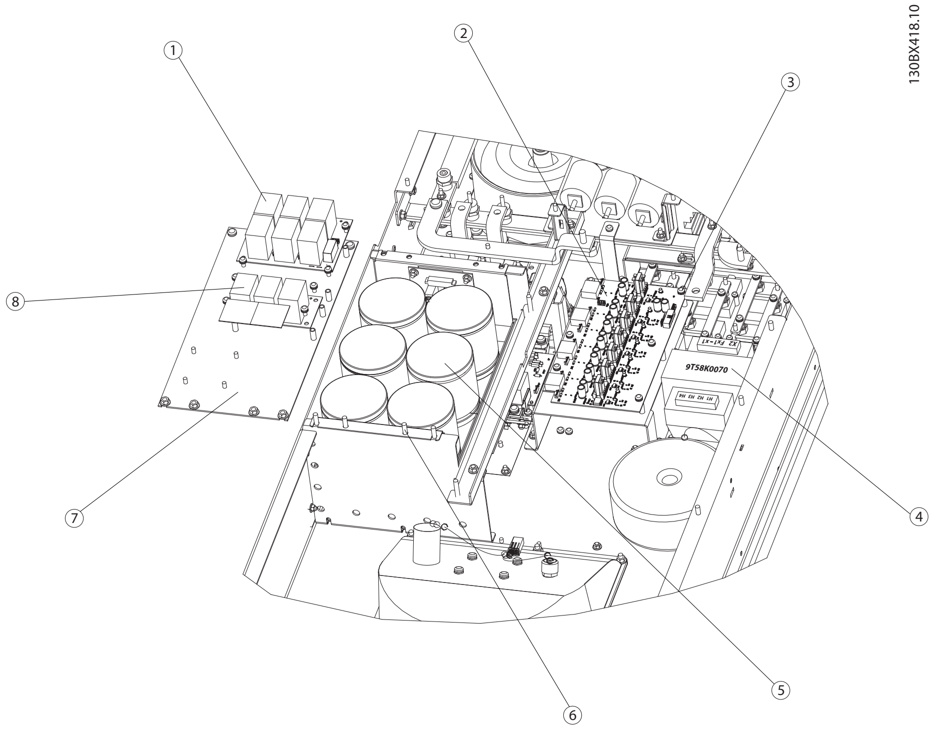


Figure 7.7 Gate Drive Card, Contactor Transformer, CM and RM RFI Cards, and Capacitor Bank Assembly

1	Common mode RFI filter	5	Capacitor bank
2	Gate drive card	6	Capacitor bank retaining screw
3	Gate drive card mounting screw	7	Capacitor bank plate
4	Contactor transformer	8	Differential mode RFI filter

Table 7.7

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Disconnect MK100, MK101, MK102, MK103, MK104, and MK106 from the gate drive card.
3. Remove the gate drive card by removing the six screws (T-25).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.3 Contactor Transformer

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Disconnect CM4 (not shown).
3. Remove the contactor transformer by removing four screws (0.39 in [10 mm]).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.4 Common Mode (CM) RFI Filter Card

1. Disconnect the cables from MK1, MK5, MK6, and MK7.
2. Remove the common mode RFI filter card by removing the four screws (T-25) from the standoffs.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.5 Differential Mode (DM) RFI Filter Card

1. Disconnect the cables from MK105, MK106, and MK107
2. Remove the differential mode RFI filter card by removing the four screws (T-25) from the standoffs.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.6 Capacitor Bank Assembly

Note that the RFI filter can remain attached to the cover plate when removing the capacitor bank assembly. Disconnect the wiring from the RFI filter when leaving the filter attached.

1. Note the color of the wires attached to the DC bus terminals on the right side of the capacitor bank assembly for proper reassembly.
2. Remove the two nuts (0.39 in [10 mm]) from the DC bus terminals (not shown).
3. Remove the capacitor bank assembly by removing the four retaining nuts (0.39 in [10 mm]) at the bottom of the capacitor bank assembly and four retaining nuts (T-30) from the top.

NOTE!

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.7 IGBT Modules

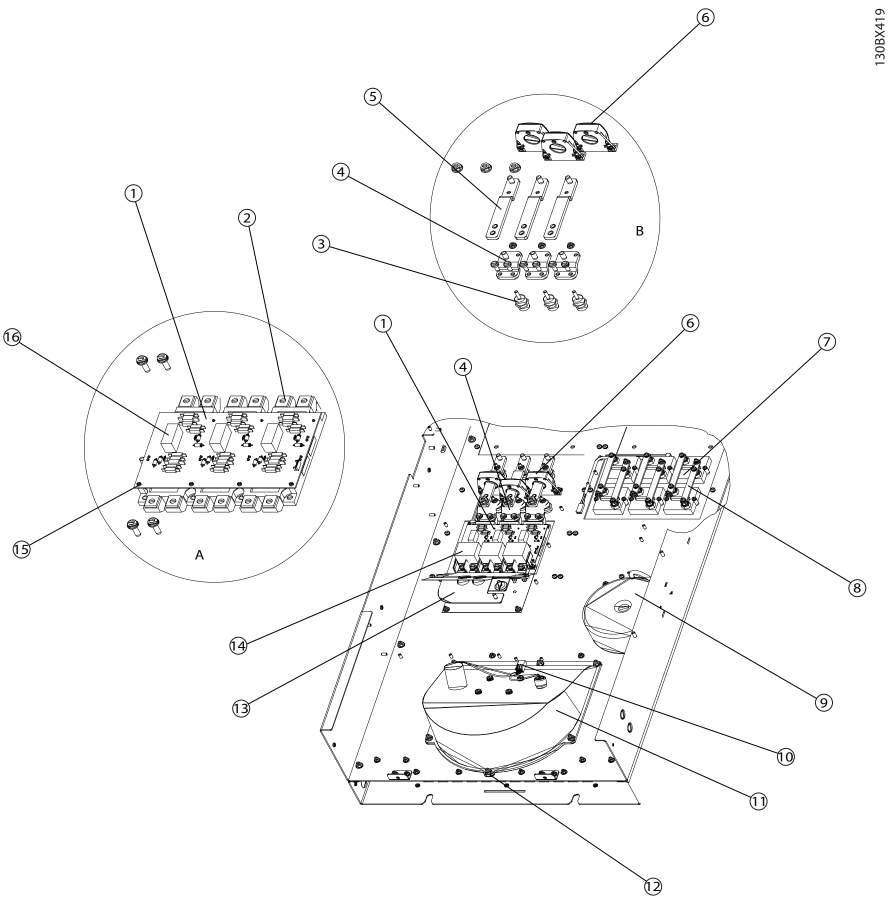


Figure 7.8 IGBT Modules, IGBT Current Sensors, Damping Resistors, Fan and Fan Transformer

1	IGBT module	9	Fan transformer
2	Retaining screw	10	Fan Molex connector
3	Current sensor standoff	11	Fan
4	IGBT intermediate bus bar	12	Retaining screw
5	Current sensor bus bar	13	DC bus assembly
6	Current sensor	14	Snubber capacitor
7	Damping resistor	15	Retaining screw
8	Damping resistor bus bar	16	MK100

Table 7.8

NOTE!

Note that for ease of access, the input terminal mounting plate may be removed prior to this procedure.

1. Remove the capacitor bank assembly in accordance with the procedure.
2. Disconnect the gate leads MK100, MK200, MK300 and the thermal sensor MK10 from the IGBT module.
3. Remove the IGBT snubber capacitors and DC bus assembly by removing the six retaining screws (T-30) from the bottom terminals of the IGBT module.
4. At the top of the IGBT module, remove the six (T-25) retaining screws (two each for the U, V, and W intermediate IGBT output bus bars.
5. Remove the nut (0.51 in [13 mm]) connecting the current sensor bus bar to the intermediate IGBT bus bar.
6. Remove the IGBT intermediate bus bar by removing the retaining nut (0.32 in [8 mm]).
7. Remove the IGBT module by removing the eight mounting screws (T-25).
8. Note that a Mylar shield covers the lower eight retaining screws. Take proper care to avoid damage to the shield. Remove the IGBT module by removing the eight screws (T-25).
9. Clean the heatsink surface with a mild solvent or alcohol solution.

Reassembly

1. Replace the IGBT module in accordance with the instructions provided with the replacement kit. Note that tightening pattern and torque values described in kit must be complied with.
2. Reassemble the remaining parts in reverse order of their removal.

See *Table 1.7* for torque tightening values.

7.3.8 IGBT Current Sensors CT1, CT2, and CT3

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Remove the nuts (0.51 [13 mm]) from both ends of the current sensor bus bar.
3. Remove the retaining nut (0.32 [8 mm]) from the current sensor standoff.
4. Disconnect the current sensor cable (not shown).
5. Remove the current sensor by removing the retaining nuts (0.32 in [8 mm]), one on each side of the current sensor.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.9 Damping Resistors

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Remove the damping resistor bus bars by removing the screws (T-20).
3. Remove the damping resistor by removing the screws (T-20) on either side of the damping resistor.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.10 Fan Transformer

1. Disconnect the line power input cabling from terminals L1, L2, L3, and the ground connector.
2. Disconnect the inline connector from the fan transformer (not shown).
3. Remove the fan transformer by removing the nut (0.51 in [13 mm]) in the center of the fan transformer.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

7.3.11 Fan

1. Disconnect the line power input cabling from terminals L1, L2, L3, and the ground connector.
2. Disconnect the Molex connector from the fan assembly.
3. Remove the fan assembly by removing six nuts (0.39 in [10 mm]).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8 E-Frame Sizes Disassembly and Assembly Instructions

8.1 Electrostatic Discharge (ESD)

CAUTION

Filters contain dangerous voltages when connected to AC line voltage. No disassembly should be attempted with power applied. Remove power to the filter and wait at least 40 minutes to let the filter capacitors fully discharge. Only a competent technician should carry out service.

ELECTROSTATIC DISCHARGE (ESD)
Many electronic components within the filter 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.

CAUTION

Use proper electrostatic discharge (ESD) procedures to prevent damage to sensitive components when servicing the filter.

NOTE!

Frame size is used throughout this manual wherever procedures or components differ between filters based upon the unit's physical size. Refer to *8 E-Frame Sizes Disassembly and Assembly Instructions* to determine E-frame size definitions.

8

8.2 Passive Section (Top) Instructions

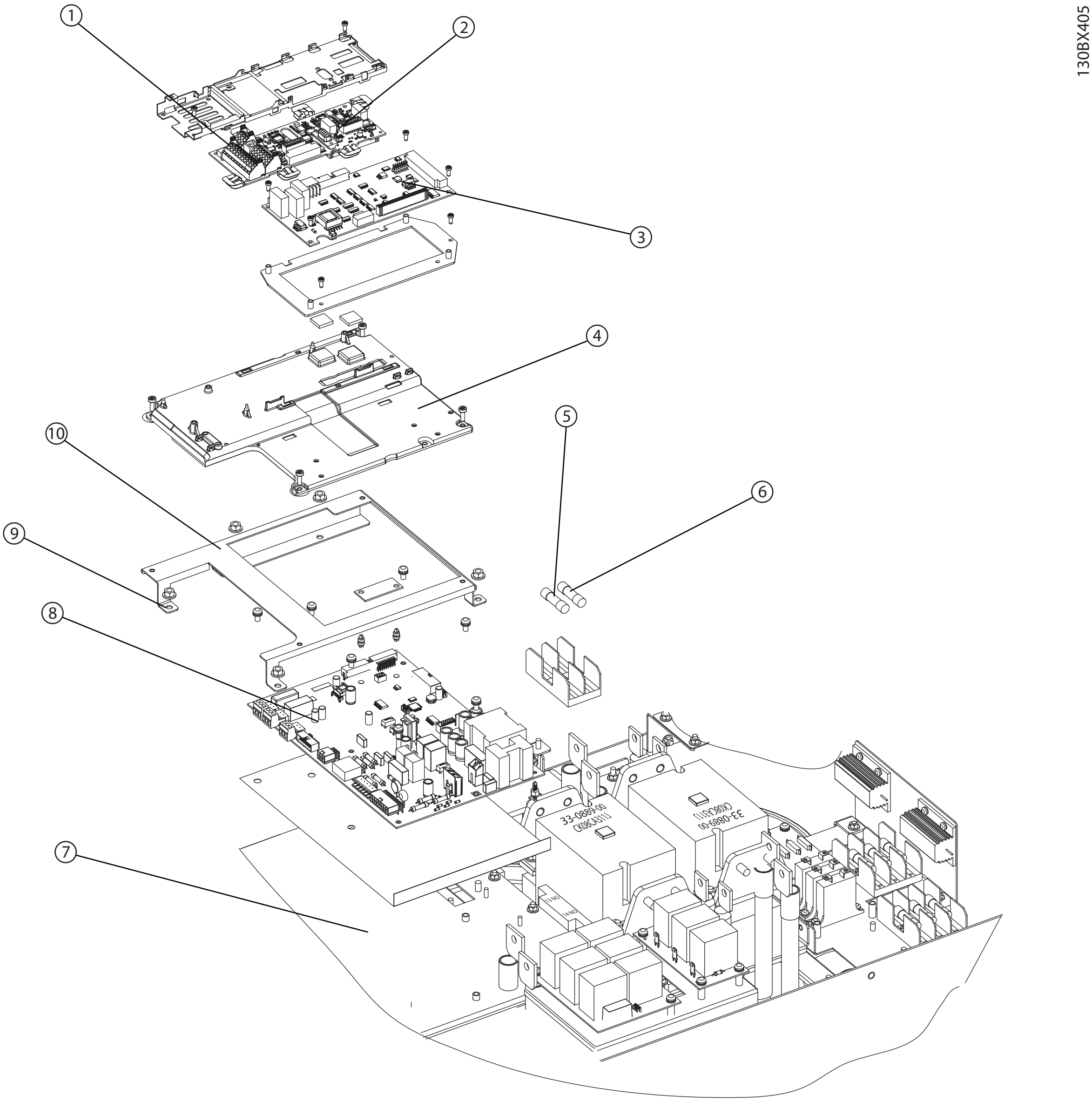


Figure 8.1 Control Card and Mounting Plate, Support Bracket, Power Card and Mounting Plate

1	Control card terminal block	6	FU4
2	Control card	7	Power card mounting plate
3	Active filter (AAF) card	8	Power card
4	Control card mounting plate	9	Mounting nut
5	FU5	10	Control card assembly support bracket

Table 8.1

8.2.1 Control Card and Control Card Mounting Plate

1. Open the front panel door.
2. Unplug the LCP ribbon cable from the control card.

CAUTION

Line Power (Primary Side) Current
Use a shorting connector on the secondary side of customer-supplied external current transformers (CT) whenever current is present on line power (primary side) and the AFC card is NOT wired to the external CT terminals. When performing service on an active filter, use a shorting connector on the secondary side of external CTs for extra safety. Failure to short out the secondary side of current transformers when current is present on the primary side and the AFC card is NOT connected could damage the current transformer.

3. Remove capacitors CT cable from terminal MK103 of AAF card.
4. Remove the external CT cable from terminal MK101 or MK108 in the AAF card.
5. Remove ribbon cables from FC100 and MK100 on the AAF card.
6. Remove the control card terminal blocks.
7. Remove the 4 screws (T-20) securing the control card mounting plate to the control assembly support bracket.
8. Remove the control card mounting plate.

Reinstall in reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.2 Control Assembly Support Bracket

1. Remove the control card mounting plate in accordance with the procedure.
2. Remove the 5 mounting nuts (0.39 in [10 mm]).
3. Remove the control assembly support bracket.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.3 Active Filter Card

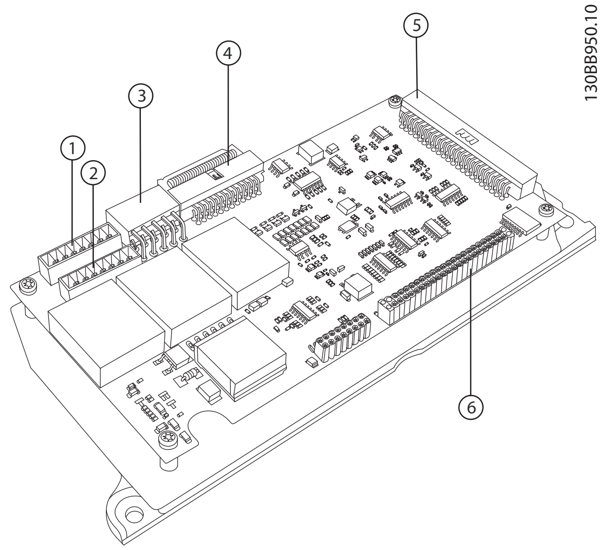


Figure 8.2 Advanced Active Filter Card

1	MK101	4	MK107
2	MK108	5	MK100
3	MK103	6	FK100

Table 8.2

CAUTION

Line Power (Primary Side) Current
Use a shorting connector on the secondary side of customer-supplied external current transformers (CT) whenever current is present on line power (primary side) and the AFC card is NOT wired to the external CT terminals. When performing service on an active filter, use a shorting connector on the secondary side of external CTs for extra safety. Failure to short out the secondary side of current transformers when current is present on the primary side and the AFC card is NOT connected could damage the current transformer.

1. Note if cable is connected to MK101 (5A) or MK108 (1A) for reassembly.
2. Remove plugs MK100, MK103, MK107, FK100, and MK101 (5A) or MK108 (1A) from AAF card.
3. Remove AAF card by removing the 4 mounting screws (T-10).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8

8.2.4 Power Card

The power card may remain attached to the power card mounting plate, if the power card mounting plate is to be removed.

1. Remove the control assembly support bracket in accordance with the procedure.
2. Unplug power card connectors MK102, MK103, MK105, MK106, MK107 MK109, and both MK112 connectors.
3. Remove the 7 mounting screws (T-25) from the power card.
4. Remove the power card from the plastic standoff at the top right of the power card.
5. Remove the current scaling card from the power card by pushing in the retaining clips on the standoffs. KEEP THIS SCALING CARD FOR FUTURE REINSTALLATION OF ANY REPLACEMENT POWER CARD. The scaling card controls signals operating with this specific filter. The scaling card is not part of the replacement power card.
6. Retain power card insulation for reassembly.

Reinstall in the reverse order of this procedure. When installing the power card, ensure that the insulator sheet is installed behind the power card. See *Table 1.7* for torque tightening values.

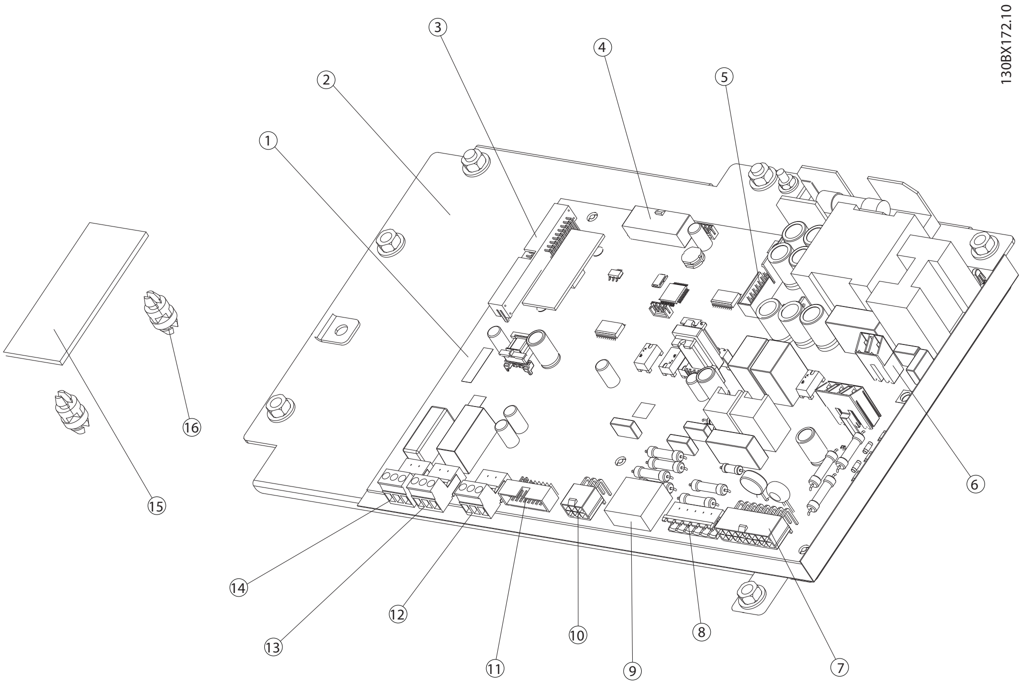


Figure 8.3 Power Card Terminals and Scaling Card

1	Power card PCA3	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 PCA4
8	FK103	16	Current scaling card standoff

Table 8.3

8.2.5 Power Card Mounting Plate

1. Remove the control assembly mounting bracket in accordance with procedure.
2. The power card mounting plate can be removed with the power card still mounted, if so desired. If the power card is to be removed, remove it in accordance with the power card procedure.
3. To remove the power card mounting plate with the power card attached, unplug connectors MK102, MK105, MK107, MK109, and MK112.
4. Remove the nut (0.30 in [7 mm]) attaching the MK102 ring lug to the power card mounting plate.
5. Note the position of the red and white cables from the FU4 and FU5 fuse block for reassembly. Unplug the cables.
6. Remove the power card mounting plate by removing seven (0.32 in [8 mm]) nuts.

Reinstall in the reverse order of this procedure. The ring lug for the wire assembly that connects to power card connector MK102 attaches to the right mounting stud on the top of the power card mounting plate. See *Table 1.7* for torque tightening values.

8.2.6 AC Capacitors

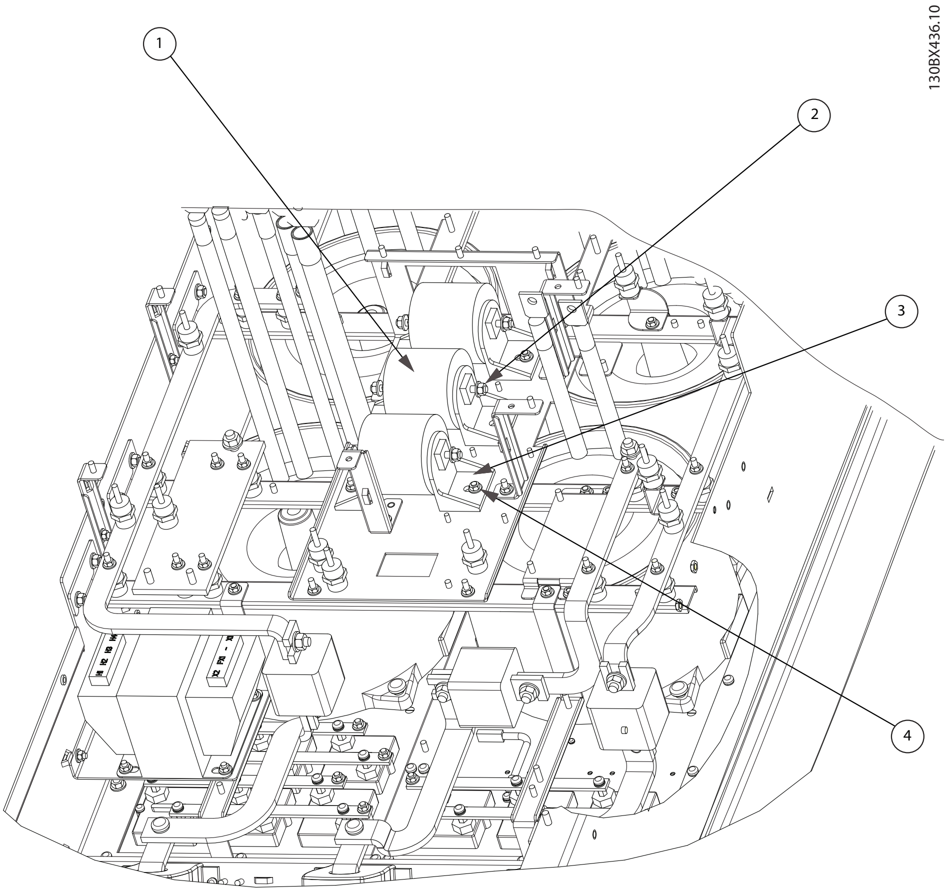


Figure 8.4 AC Capacitors

1	AC capacitor	3	AC capacitor mounting bracket
2	AC capacitor retaining nut	4	AC capacitor mounting bracket retaining nut

Table 8.4

1. Remove the control assembly support bracket in accordance with the procedure.
2. Remove the power card mounting plate in accordance with the procedure.
3. Remove the nut (0.43 in [11 mm]) from each side of the AC capacitor and the lug wires.
4. Remove the AC capacitor by removing the nut (0.32 in [8 mm]) from each side of the AC capacitor mounting bracket.

Note that removing the top most capacitor may require removing the center capacitor for ease of access.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.7 AC Capacitor Current Sensor (CT4, CT5, CT6)

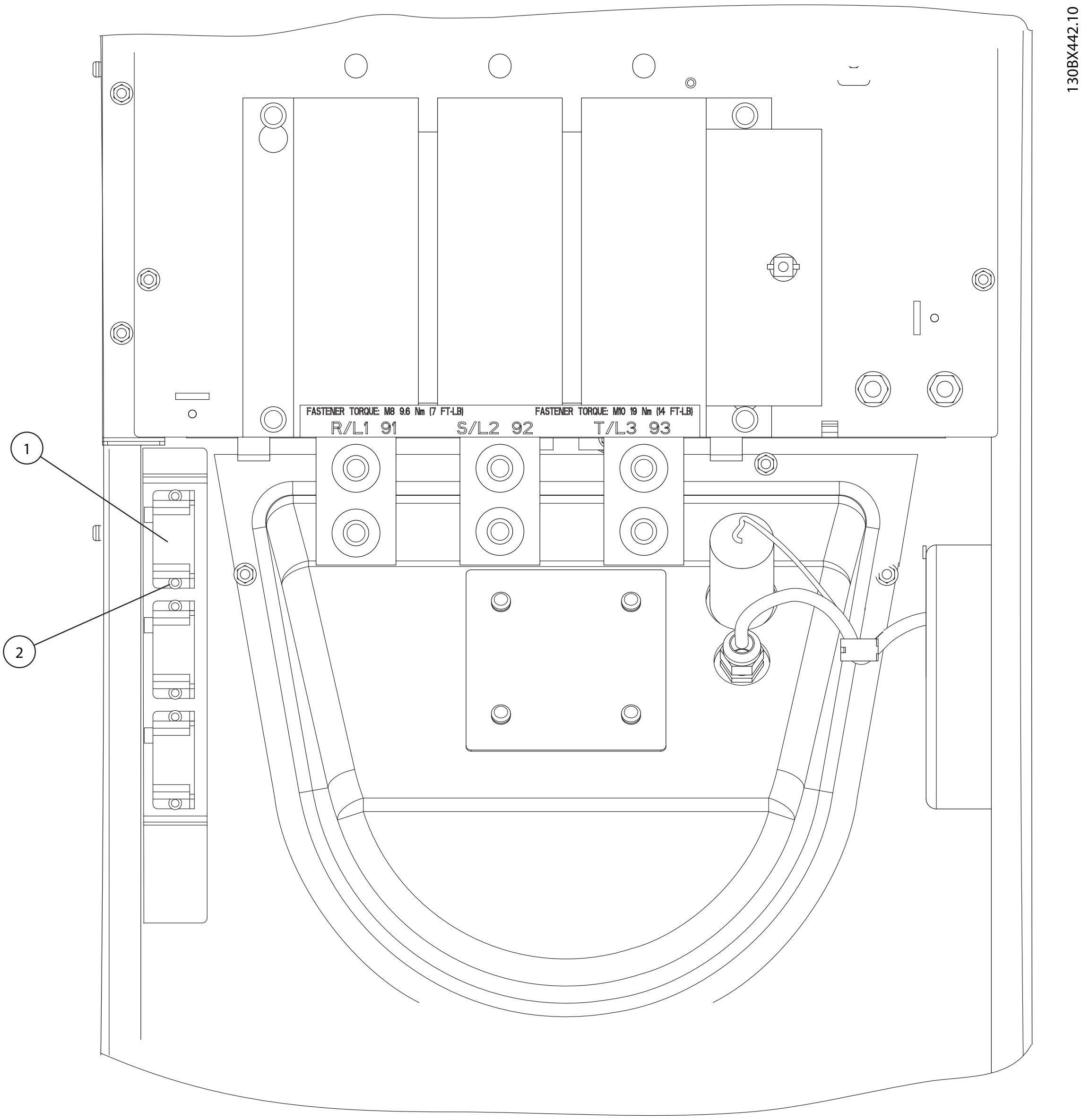


Figure 8.5

1	AC capacitor current sensor	2	Retaining nut

Table 8.5

8

NOTE!

Note that AC current sensors are located in different locations in LHD units than AAF. All other procedure steps apply.

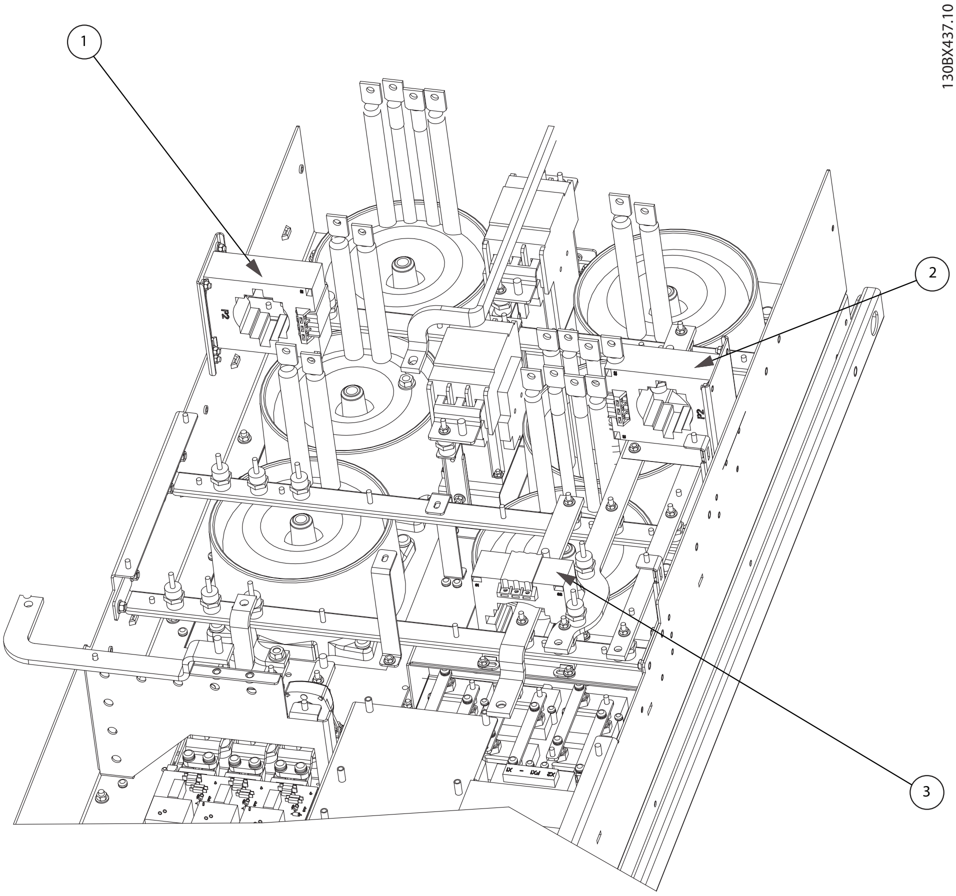


Figure 8.6 LHD AC Capacitor Current Sensor Locations

1	AC capacitor current sensor (U)	3	AC capacitor current sensor (W)
2	AC capacitor current sensor (V)		

Table 8.6

1. Prior to removing the current sensor cabling, note the direction of the cable routing through the current sensor for proper reinstallation. Direction of the cable is phase sensitive to the sensor function.
2. Remove the nut (0.43 in [11 mm]) from the corresponding capacitor in order to remove the lug cable which goes through the current sensor.
3. Remove the Molex connector (not shown) from the current sensor.
4. Remove the current sensor by removing the nuts (0.30 in [7 mm]), one on each side of the current sensor.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.8 AC Contactors

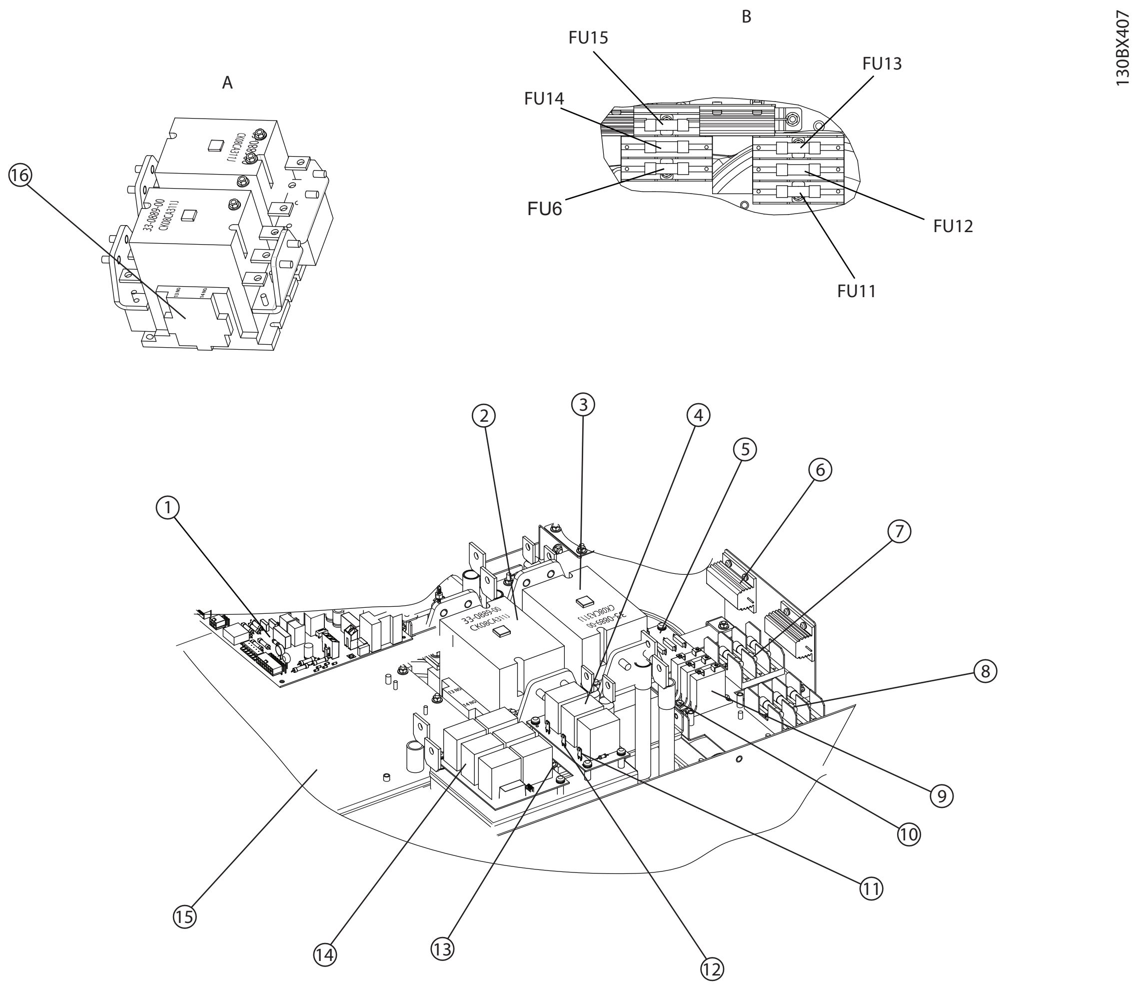


Figure 8.7 AC Contactors, CM and DM RFI Filters, MOVs, Discharge Card, and Soft Charge Resistor

1	Power card (PCA3)	9	MOV
2	AC contactor (L3)	10	MOV retaining nut
3	AC contactor (L1)	11	MK107
4	Differential mode RFI card	12	MK106
5	Discharge card (PCA16)	13	MK1
6	Soft charge resistor	14	Common mode RFI card
7	Fuses (FU6, FU14, FU15)	15	Power card mounting plate
8	Fuses (FU11, FU12, FU13)	16	Auxiliary contactor

Table 8.7

Prior to removing cables from the AC contactors, note the mounting orientation of the AC contactors and connection of all cables for proper reinstallation.

1. Remove the five nuts (0.39 in [10 mm]) the AC interconnect bus assembly and remove the cabling from each side of the AC contactor. Remove the AC interconnect bus assembly.
2. Disconnect the coil wires from terminals A1 and A2 by loosening the retaining screws (not shown).
3. Disconnect the wires from the auxiliary contactors by loosening the retaining screw.
4. Remove the AC contactor by removing the four mounting nuts (0.39 in [10 mm]).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.9 Common Mode (CM) RFI Filter Card

1. Disconnect the cables from MK1, MK5, MK6, and MK7.
2. Remove the common mode RFI filter card by removing the four screws (T-25) from the standoffs.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.10 Differential Mode (DM) RFI Filter Card

1. Disconnect the cables from MK105, MK106, and MK107
2. Remove the differential mode RFI filter card by removing the four screws (T-25) from the standoffs.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.11 MOVs

1. Disconnect the wires from the terminals on the top and bottom of the MOV by loosening the retaining screws.
2. Remove the MOV by removing the two screws (T-20) top and bottom.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.12 Discharge Card

1. Disconnect MK100 from the discharge card.
2. Remove the discharge card by removing the four screws (T-25).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.2.13 Soft Charge Resistor

1. Disconnect the cable going to fuses FU14 and FU 15 and the AC contactors.
2. Remove the soft charge resistor by removing the 4 retaining nuts (0.30 in [7 mm]).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3 Active Section (Bottom) Instructions

8.3.1 Input Terminal Mounting Plate

CAUTION

Two Person Lift
The input terminal mounting plate supports various customer-ordered options. The input terminal mounting plate with options attached can exceed 35 kg (60 lbs). Assistance is required for removal. Failure to provide assistance when during removal could result in personal injury.

Note that the input terminal mounting plate provides mounting for various options. The fused disconnect option is shown.

1. Disconnect the line power input wiring from terminals L1, L2, L3 and the ground connector.
2. Remove the 3 cross bus bars between the input terminals and the input inductor. (These are located above the optional RFI filter if the RFI filter is present.) Remove three nuts (0.67 in [17 mm]) (not shown), three (T-40) screws, and (0.51 in [13 mm]) nuts from the passive side of the unit.
3. Remove input terminal mounting plate by removing eight (0.39 in [10 mm]) retaining nuts from plate.

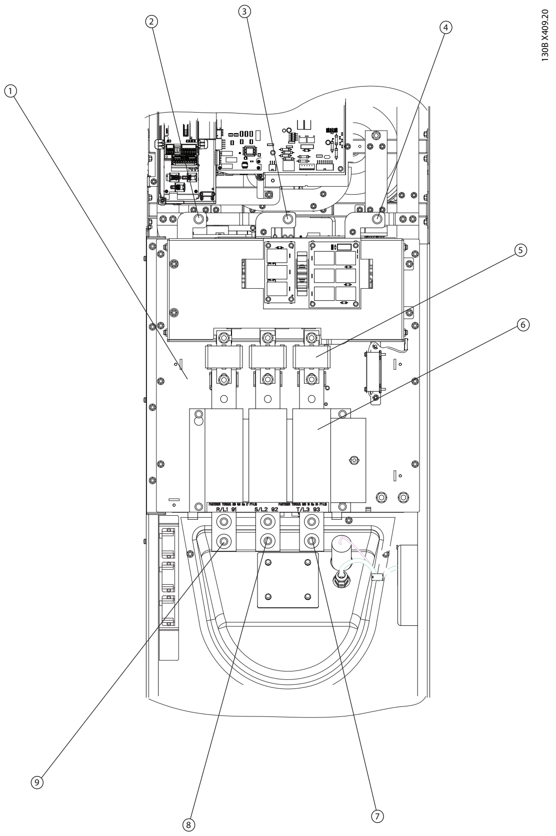


Figure 8.8 Input Terminal Mounting Plate

1	Input terminal mounting plate	6	Line power disconnect (optional)
2	Cross bus bar terminal	7	L3
3	Cross bus bar terminal	8	L2
4	Cross bus bar terminal	9	L1
5	Line power disconnect fuse (optional)		

Table 8.8

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3.2 Gate Drive Card Mounting Plate

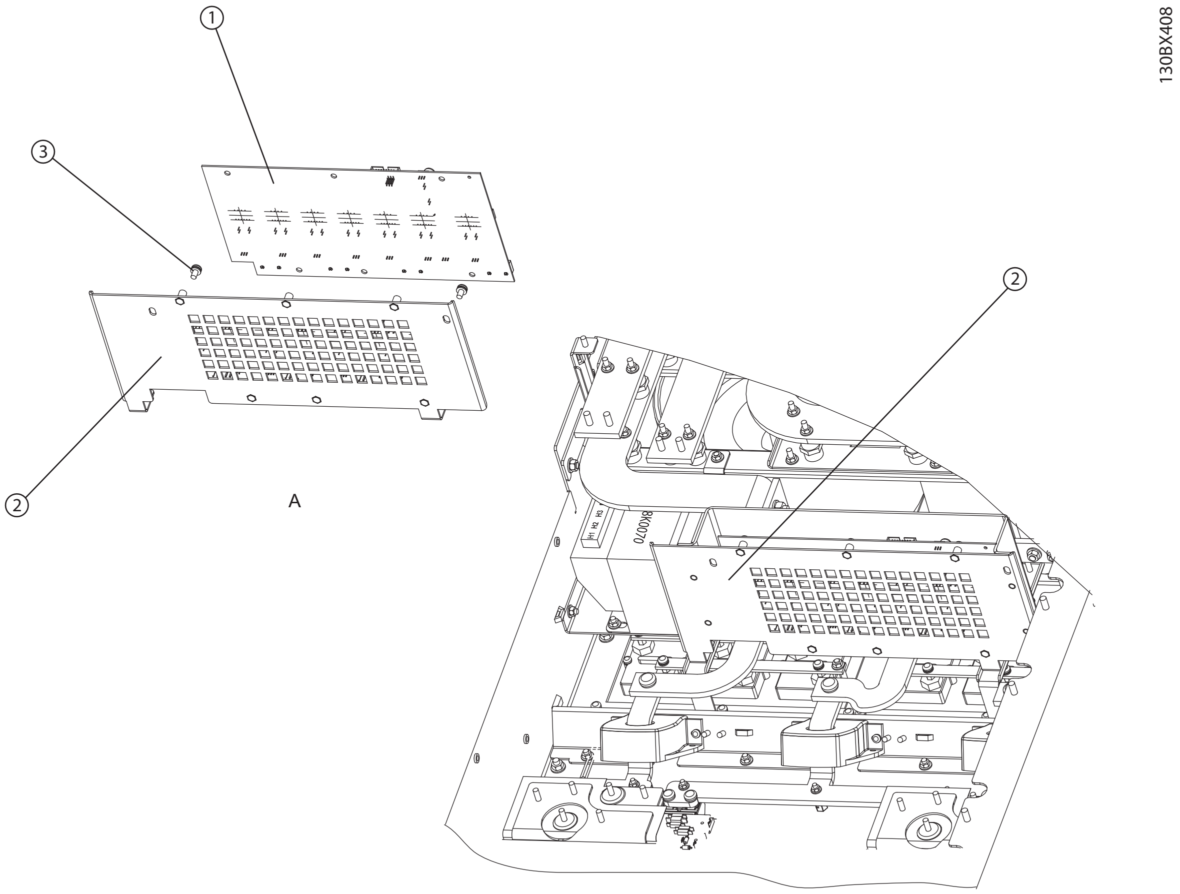


Figure 8.9 Gate Drive Card and Mounting Plate

1	Gate drive card	3	Retaining screw (T-25)
2	Gate drive card mounting plate		

Table 8.9

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Disconnect cables from gate drive card connectors MK100, MK101, and MK106. Note that cables connected to MK102, MK103, and MK104 can be disconnected easier after removing the mounting plate part way.
3. Remove the gate drive card mounting plate by removing two screws (0.32 in [8 mm]) in the front of the plate and two screws (0.32 in [8 mm]) at the back of the plate on the vertical mounting tabs (not shown). Disconnect cables MK102, MK103, and MK104.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3.3 Gate Drive Card

1. Remove the gate drive card mounting plate in accordance with the procedure.
2. Remove the gate drive card by removing six screws (T-25).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3.4 Upper Capacitor Bank Assembly

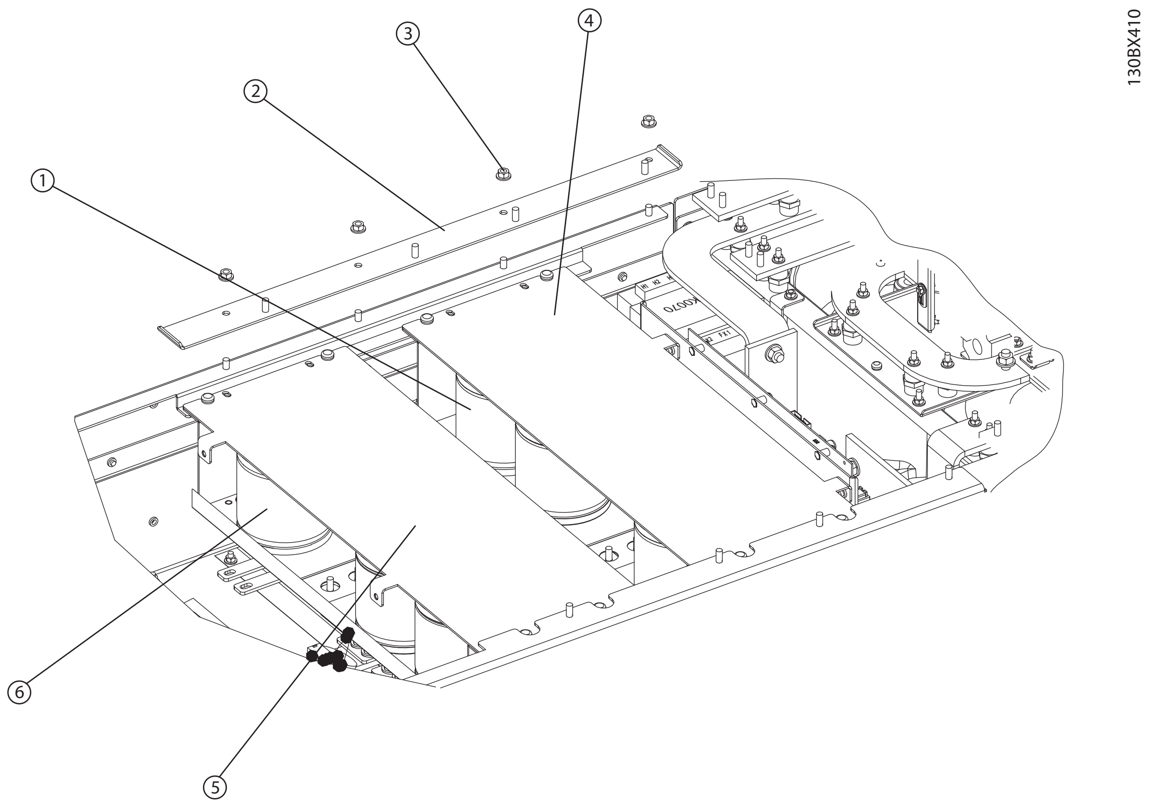


Figure 8.10 Upper Capacitor Bank Assembly

1	Upper capacitor bank	4	Upper capacitor bank cover plate
2	Input terminal mounting plate support bracket	5	Lower capacitor bank cover plate
3	Retaining nut (0.39 in [10 mm])	6	Lower capacitor bank

Table 8.10

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Remove the input terminal mounting plate support bracket by removing four nuts (0.39 in [10 mm]).
3. The capacitor bank connection to the DC bus bars can be seen recessed in the gap between the upper and lower capacitor banks. A minimum extension of 6 in [150 mm] is required. Remove the 6 electrical connection nuts (0.32 in [8 mm]) for the upper capacitor bank on the DC bus bars.
4. Note that the weight of the capacitor bank is approximately 20 lbs [9 kg].
5. Remove the capacitor bank (with attached cover plate) by removing the four screws (T-30).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3.5 Lower Capacitor Bank Assembly

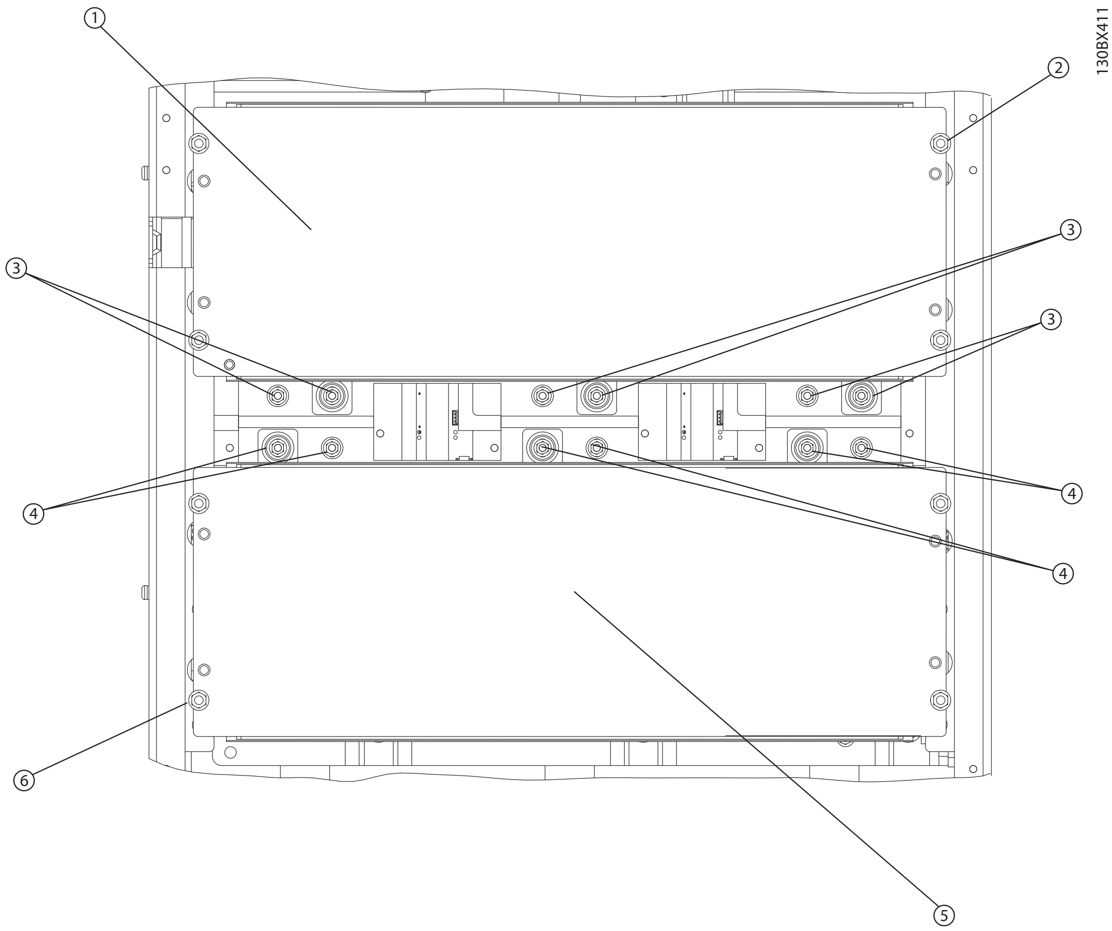


Figure 8.11 Lower Capacitor Bank Assembly

1	Upper capacitor bank	4	Lower capacitor bank electrical connection nut
2	Upper capacitor bank retaining nut	5	Lower capacitor bank
3	Upper capacitor bank electrical connection nut	6	Lower capacitor bank retaining nut

Table 8.11

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Remove the input terminal mounting plate support bracket by removing four nuts (0.39 in [10 mm]).
3. The capacitor bank connection to the DC bus bars can be seen recessed in the gap between the upper and lower capacitor banks. A minimum extension of 6 in [150 mm] is required. Remove the six electrical connection nuts (0.32 in [8 mm]) for the lower capacitor bank on the DC bus bars.
4. Note that the weight of the capacitor bank is approximately 20 lbs [9 kg].
5. Remove the capacitor bank (with attached cover plate) by removing the four screws (T-30).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3.6 IGBT Modules

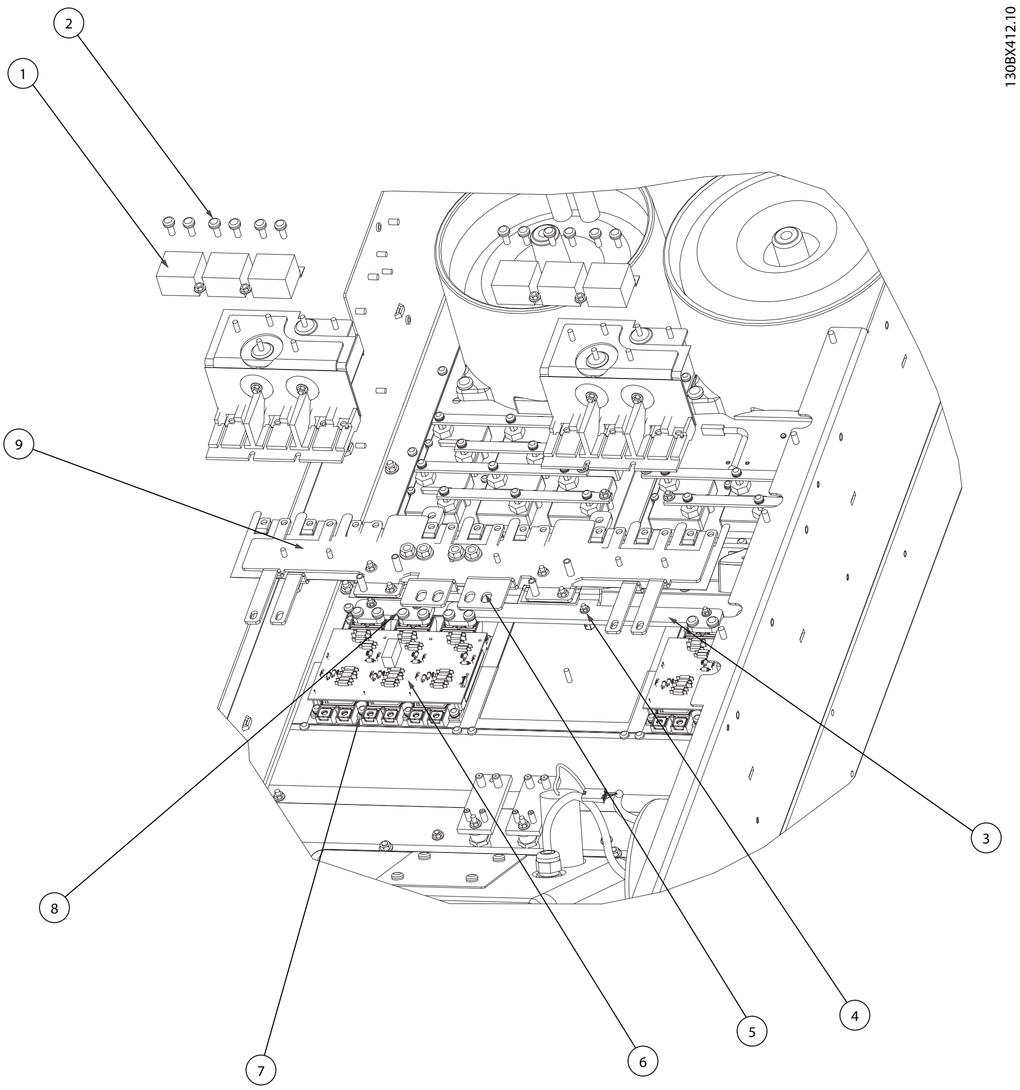


Figure 8.12 IGBT Modules

1	Snubber	6	IGBT module
2	Snubber retaining screw (step 3)	7	IGBT module retaining screw (step 9)
3	Intermediate IGBT output bus bar (step 7)	8	Top IGBT module retaining screw (step 6)
4	Intermediate IGBT output bus bar retaining nut (step 7)	9	IGBT bus bar assembly
5	Bottom retaining nuts IGBT bus bar assembly (step 4)		

Table 8.12

1. Remove the capacitor banks in accordance with the procedure.
2. Note the IGBT signal cables connected between the gate drive card connectors MK100 (temperature sensor), MK102 (U), MK103 (V) and MK104 (W) and the IGBTs for reassembly (not shown). Disconnect the cables at the connectors on the IGBT modules.
3. Remove the 12 (T-25) retaining screws (6 on each module) on the lower portion of the IGBT modules. These screws also attach the snubber capacitors to the IGBT modules. Remove the snubber capacitors.
4. Remove the four (0.51 in [13 mm]) retaining nuts at the bottom of the IGBT bus bar assembly.
5. Remove the IGBT bus bar assembly.
6. At the top end of the IGBT module, remove the 12 (T-25) retaining screws (4 each for the U, V and W intermediate IGBT output bus bars).
7. Loosen the retaining nut (0.32 in [8 mm]) from the three intermediate IGBT output bus bars to provide access to IGBTs.
8. Remove the screw (T-30) on the top end of the intermediate IGBT bus bar to allow access to the IGBT module for removal.
9. Note that a Mylar shield covers lower 8 retaining screws. Take proper care to avoid damage to the shield. Remove the two IGBT modules by removing the 16 (T-25) screws (8 per module) and sliding the modules free from under the bus bars.
10. Clean the heatsink surface with a mild solvent or alcohol solution.

8

Reassembly

1. Replace the IGBT module in accordance with the instructions provided with the replacement kit. Note that tightening pattern and torque values described in kit must be complied with.
2. Reassemble the remaining parts in reverse order of their removal.

See *Table 1.7* for torque tightening values.

8.3.7 IGBT Current Sensors CT1, CT2, and CT3

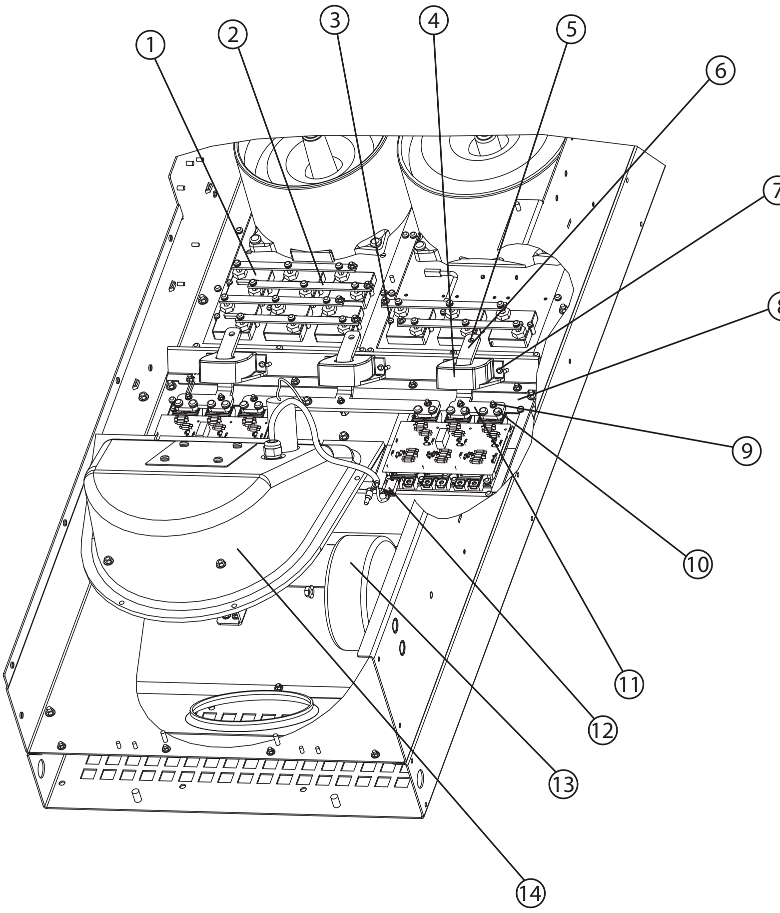


Figure 8.13 IGBT Current Sensor, Fan and Fan Transformer, and Damping Resistors

1	Damping resistor	8	Intermediate current sensor bus bar
2	Damping resistor bus bar	9	Intermediate IGBT bus bar standoff
3	Damping resistor retaining nut (T-20)	10	Intermediate IGBT bus bar retaining screw
4	Current sensor	11	Intermediate IGBT bus bar (bottom)
5	Top intermediate IGBT bus bar retaining nut	12	Molex fan connector
6	Intermediate IGBT bus bar (top)	13	Fan transformer
7	Current sensor retaining screw	14	Fan assembly

Table 8.13

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Remove the upper capacitor bank in accordance with the procedure.
3. Remove four screws (T-30) attaching the IGBT intermediate bus bars to the IGBT module.
4. On the other end of the IGBT intermediate bus bar, remove the retaining screw (T-30).
5. Remove the standoff nuts (0.32 in [8 mm]) from IGBT intermediate bus bar.
6. Disconnect the current sensor cable (not shown).

8

7. Remove the current sensor by removing the nut (0.32 in [8 mm]), one on each side of the current sensor.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3.8 Fan Transformer

1. Disconnect the line power input cabling from terminals L1, L2, L3, and the ground connector.
2. Disconnect the inline connector from the fan transformer (not shown).
3. Remove the fan transformer by removing the nut (0.51 in [13 mm]) in the center of the fan transformer.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3.9 Fan

1. Disconnect the line power input cabling from terminals L1, L2, L3, and the ground connector.
2. Disconnect the Molex connector from the fan assembly.
3. Remove the fan assembly by removing six nuts (0.39 in [10 mm]).

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

8.3.10 Damping Resistors

1. Remove the input terminal mounting plate in accordance with the procedure.
2. Remove the damping resistor bus bars by removing the screws (T-20).
3. Remove the damping resistor by removing the screws (T-20) on either side of the damping resistor.

Reinstall in the reverse order of this procedure. See *Table 1.7* for torque tightening values.

9 Special Test Equipment

9.1 Test Equipment

Test tools have been developed to aid in troubleshooting these products. It is highly recommended for repair and servicing this equipment that these tools be available to the technician. Without them, some troubleshooting procedures described in this manual cannot be carried out. Although some test points can be found inside the filter to probe for similar signals, the test tools provide a safe and sure location for making necessary measurements. Test equipment described in this section is available from Danfoss.

CAUTION

Using the test cable allows powering the filter without having to charge DC bus capacitors. Main input power is required and all devices and power supplies connected to line power are energized at rated voltage. Use extreme caution when conducting tests on a powered filter. Contact with powered components could result in electrical shock and personal injury.

9.1.1 Signal Test Board (p/n 176F8437)

The signal test board provides access to a variety of signals that can be helpful in troubleshooting the filter.

The signal test board is plugged into power card connector MK104. Points on the signal test board can be monitored with or without the DC bus disabled. In some cases, the filter will need the DC bus enabled and operating a load to verify some test signals.

The following is a description of the signals available on the signal test board. *6 Test Procedures*of this manual describes when these tests would be called for and what the signal should be at that given test point.

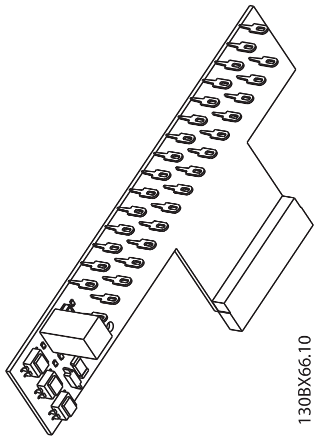
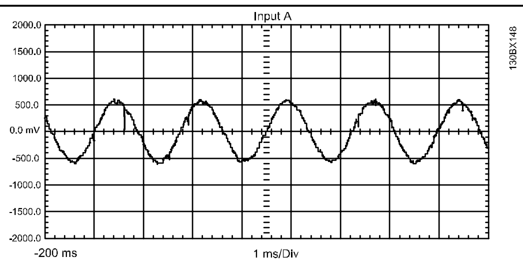
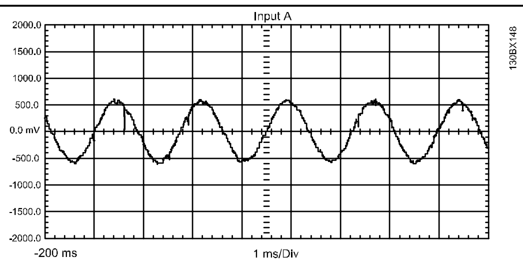
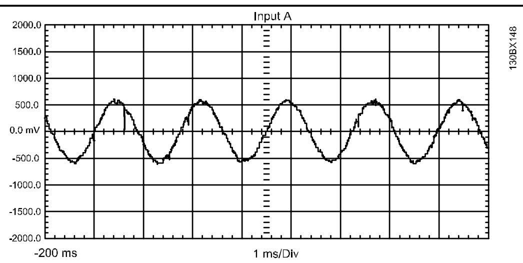


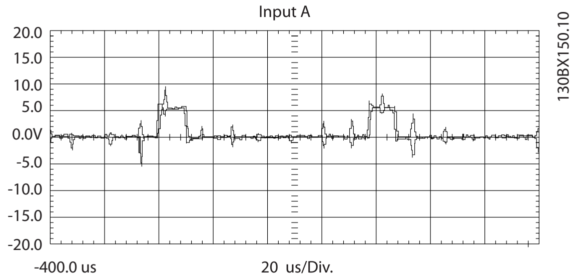
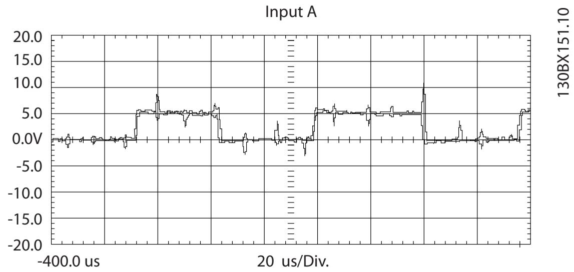
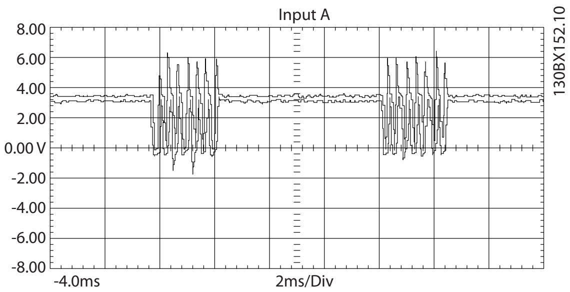
Figure 9.1 Signal Test Board

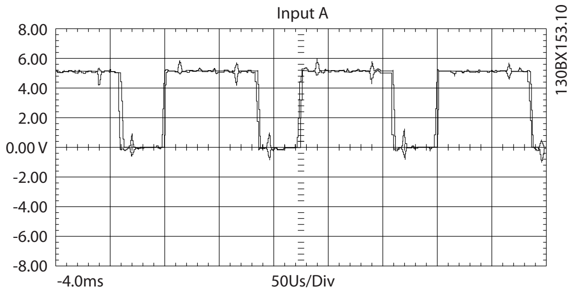
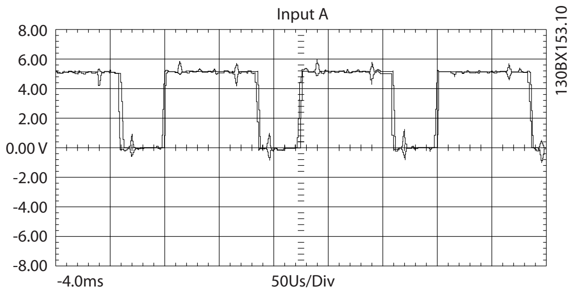
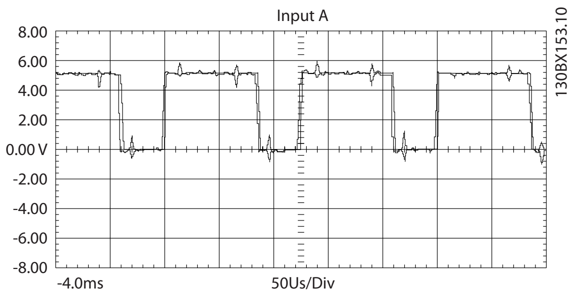
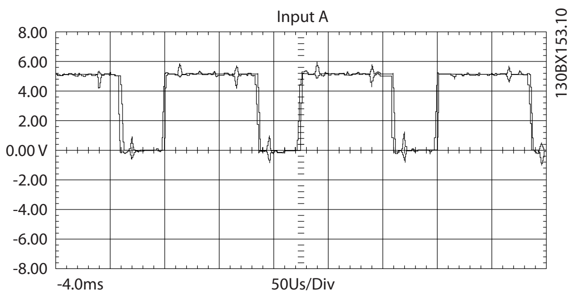
9.1.2 Signal Test Board Pin Outs: Description and Voltage Levels

The tables on the following pages list the pins located on the signal test board. For each pin, its function, description, and voltage levels are provided. Details on performing tests using the test fixture are provided in *6 Test Procedures* of this manual. Other than power supply measurements, most of the signals being measured are made up of waveforms.

Although in some cases, a digital voltmeter can be used to verify the presence of such signals, it cannot be relied upon to verify that the waveform is correct. An oscilloscope is the prefered instrument. However, when similar signals are being measured at multiple points, a digital voltmeter can be used with some degree of confidence. By comparing several signals to each other, such as gate drive signals, and obtaining similar readings, it can be concluded each of the waveforms match one another and are therefore correct. Values are provided for using a digital voltmeter for testing as well.

Pin No.	Schematic Acronym	Function	Description	Reading Using a Digital Voltmeter
1	IU1	Current sensed, U phase, not conditioned	 Approx 400 mV RMS @100% load	.937 V ACpeak @ 165% of CT current rating. AC waveform @ output frequency of the filter.
2	IV1	Current sensed, V phase, not conditioned	 Approx 400 mV RMS @100% load	.937 V ACpeak @ 165% of CT current rating. AC waveform @ output frequency of the filter.
3	IW1	Current sensed, W phase, not conditioned	 Approx 400 mV RMS @100% load	.937 V ACpeak @ 165% of CT current rating. AC waveform @ output frequency of the filter.
4	COMMON	Logic common	This common is for all signals.	
5	AMBT	Ambient temp.	Used to control FAN high and low fan speeds.	1 V DC approximately equal to 25C
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 to 19.5 V DC	The red LED indicates voltage is present between VPOS and VNEG terminals.	+18 V DC regulated supply +16.5 to 19.5 V DC
12	VNEG	-18 V DC regulated supply -16.5 to 19.5 V DC	The red LED indicates voltage is present between VPOS and VNEG terminals.	-18 V DC regulated supply -16.5 to 19.5 V DC

Pin No.	Schematic Acronym	Function	Description	Reading Using a Digital Voltmeter
13	DBGATE	Brake IGBT gate pulse train	 Varies w/ brake duty cycle	Voltage drops to zero when brake is turned off. Voltage increases to 4.04 V DC as brake duty cycle reaches max.
14	BRT_ON	Brake IGBT 5V logic level signal.	 Varies w/ brake duty cycle	5.10 V DC level with the brake turned off. Voltage decreases to zero as brake duty cycle reaches max.
15		Not used		
16	FAN_TST	Control signal for fans	Indicates Fan Test switch is activated to force the fans on high	+5V DC – disabled 0 V DC – fans on high
17	FAN_ON	Pulse train to gate SCR's for fan voltage control. In sync with line freq.	 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 SCR front end is enabled or disabled.	0.6 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	O V switch must be off - 1 V DC = 450 V DC [T4/T5] - 1 V DC = 610 V DC [T7]
23	VDD	+24 V DC power supply	Yellow LED indicates voltage is present.	+24 V DC regulated supply +23 to 25 V DC

Pin No.	Schematic Acronym	Function	Description	Reading Using a Digital Voltmeter
24	VCC	+5.0 V DC regulated supply. +4.75–5.25 V DC	The green LED indicates voltage is present.	+5.0 V DC regulated supply +4.75–5.25 V DC
25	GUP_T	IGBT gate signal, buffered, U phase, positive. Signal originates on the control card.	 2v/div 100us/div Run@10 Hz	2.2–2.5 V DC Equal on all phases TP25-TP30
26	GUN_T	IGBT gate signal, buffered, U phase, negative. Signal originates on the control card.	 2v/div 100us/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 the control card.	 2v/div 100us/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 the control card.	 2v/div 100us/div Run@10 Hz	2.2–2.5 V DC Equal on all phases TP25-TP30

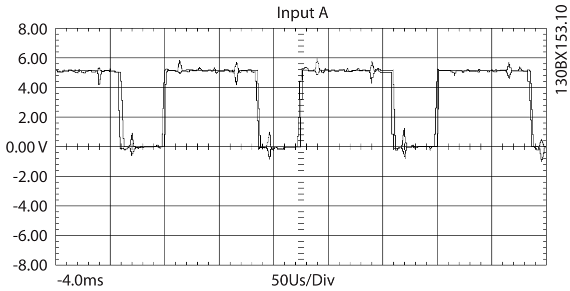
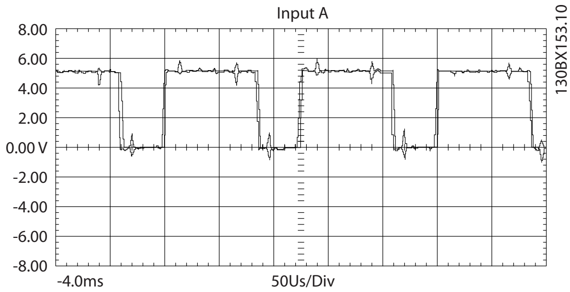
Pin No.	Schematic Acronym	Function	Description	Reading Using a Digital Voltmeter
29	GWP_T	IGBT gate signal, buffered, W phase, positive. Signal originates on the control card.	 2v/div 100us/div Run@10 Hz	2.2–2.5 V DC Equal on all phases TP25-TP30
30	GWN_T	IGBT gate signal, buffered, W phase, negative. Signal originates on the control card.	 2v/div 100us/div Run@10 Hz	2.2–2.5 V DC Equal on all phases TP25-TP30

Table 9.1

9

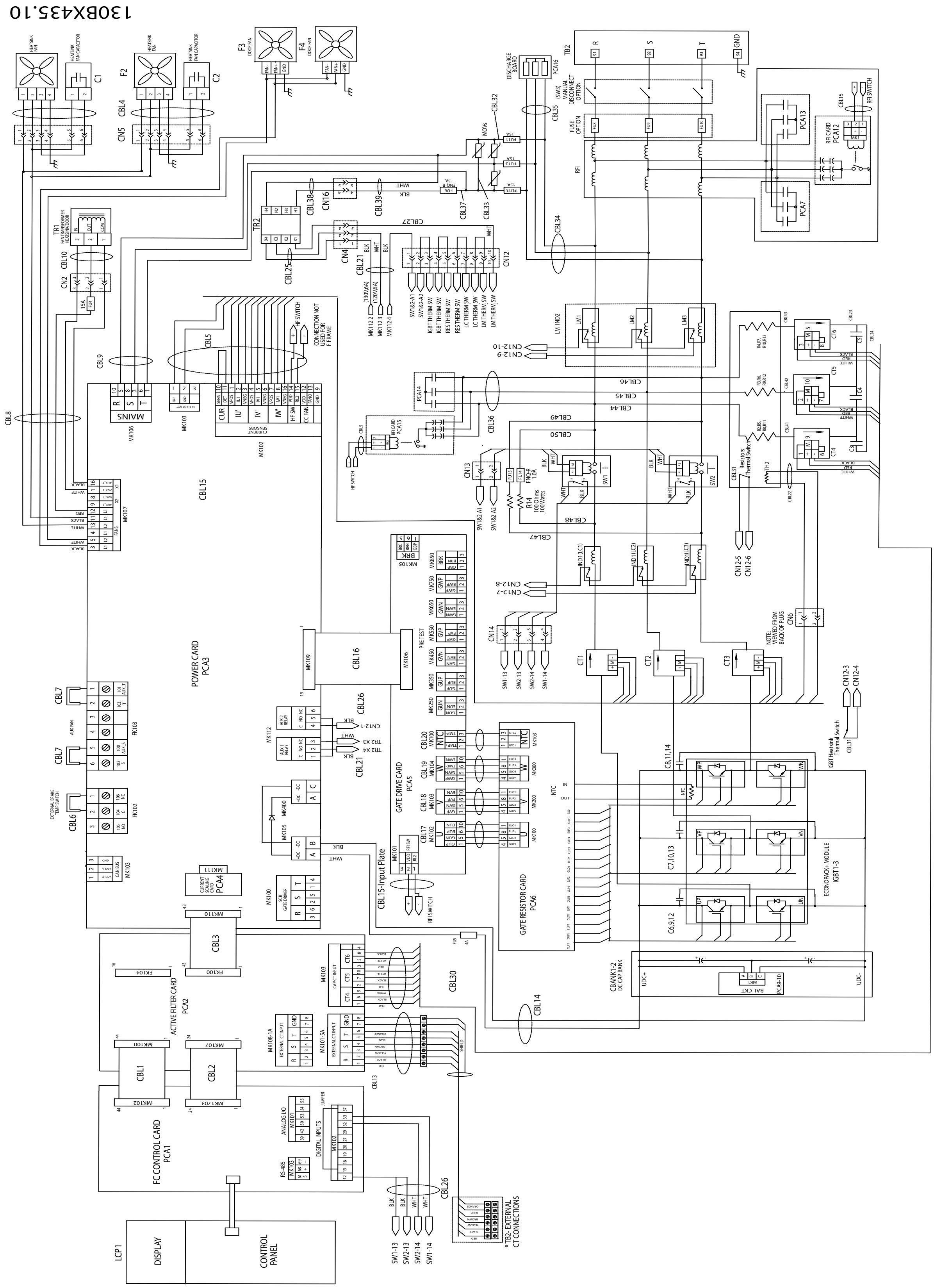


Figure 10.1 AAF Electrical Block Diagram

10

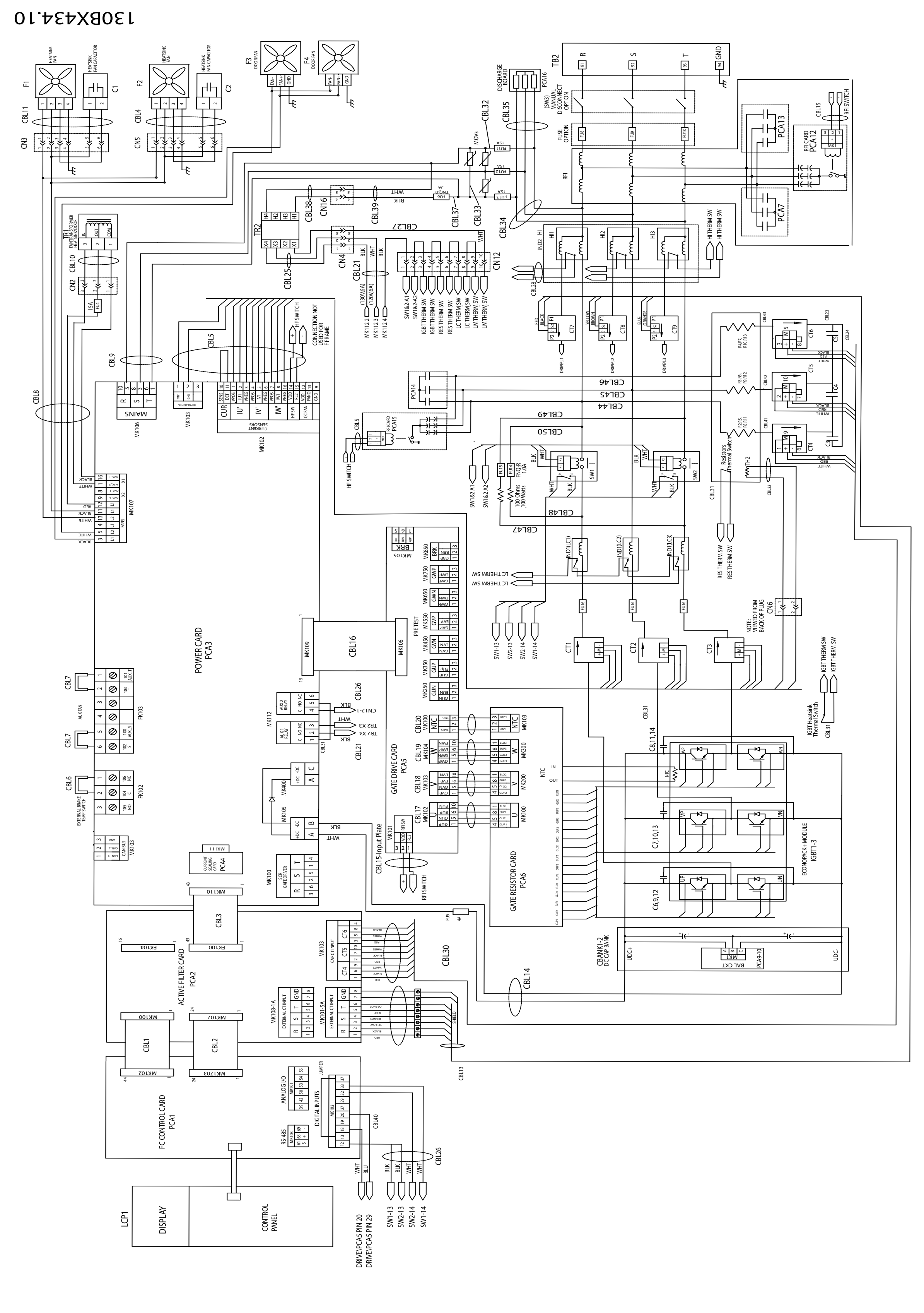


Figure 10.2 LHD Electrical Block Diagram

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