GE

AF-650 GP & AF-600 FP™ High Power Service Manual

Unit Sizes 6x

Operating Instructions

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1 Introduction

1.1 Purpose

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 frequency converters in the unit size 6x range.

It provides the reader with a general view of the unit's main assemblies and a description of the internal processing. With this information, technicians should have an understanding of the frequency converter operation for troubleshooting and repair.

This manual provides instructions for the frequency converter models and voltage ranges described in the tables on the following page.

1.2 AF-6 Product Overview

AF-600 FP series frequency converters are designed for the HVAC markets. They operate in variable torque mode or constant torque down to 15 Hz and include special features and options designed for fan and pump applications.

AF-650 GPseries frequency converters are fully programmable for either constant torque or variable torque industrial applications. They are capable of operating a great variety of applications and incorporate a wide range of control and communication options.

These models are available in NEMA 1/IP21 or NEMA 12/IP54 enclosures.

1.3 For Your Safety

Frequency converters contain dangerous voltages when connected to mains. Only a competent technician should carry out service.

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

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

- Door interlock
- Space heater
- Cabinet light and outlet
- RCD monitor
- IRM monitor
- Emergency stop
- 24 VDC customer power supply

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

1. Disconnect mains prior to inspection or making repairs.
2. DO NOT touch electrical parts of frequency converter when connected to mains. After removing power from mains, wait 40 minutes before touching any electrical parts. See the label on the front of the frequency converter door for specific discharge time.
3. The STOP key on the keypad does not disconnect mains.
4. During operation and while programming parameters, the motor may start without warning. Activate the STOP key when changing data.

1.4 Electrostatic Discharge (ESD)

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

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

1.5 Unit Size Definitions

AF-600 FP 380-480 VAC Power		
kW @400 VAC	HP @460 VAC	Unit Size
500	650	61 / 63
560	750	61 / 63
630	900	62 / 64
710	1000	62 / 64
800	1200	62 / 64
1000	1350	62 / 64

Table 1.1: AF-600 FP 380-480 VAC

AF-600 FP 525-690 VAC Power			
kW @550 VAC	HP @575 VAC	kW @690 VAC	Unit Size
560	750	710	61 / 63
670	950	800	61 / 63
750	1050	900	61 / 63
950	1150	1000	62 / 64
1000	1350	1200	62 / 64
1100	1550	1400	62 / 64

Table 1.3: AF-600 FP 525-690 VAC

AF-650 GP 380-480 VAC Power		
kW @400 VAC	HP @460 VAC	Unit Size
450/ 500	600/ 650	61 / 63
500 / 560	650 / 750	61 / 63
560/ 630	750 / 900	62 / 64
630 / 710	900 / 1000	62 / 64
710 / 800	1000 / 1200	62 / 64
800 / 1000	1200 / 1350	62 / 64

Table 1.2: AF-650 GP 380-480 VAC

AF-650 GP 525-690 VAC Power			
kW @550 VAC	HP @575 VAC	kW @690 VAC	Frame Size
500 / 560	650 / 750	630 / 710	61 / 63
560 / 670	750 / 950	710 / 800	61 / 63
670 / 750	950 / 1050	800 / 900	61 / 63
750 / 850	1050 / 1150	900 / 1000	62 / 64
850 / 1000	1150 / 1350	1000 / 1200	62 / 64
1000 / 1100	1350 / 1550	1200 / 1400	62 / 64

Table 1.4: AF-650 GP 525-690 VAC

1.6 Ratings Tables

DC Voltage Levels	**380-480V & 380-500V units**	**525-690V units**
Inrush Circuit Enabled	370	550
Inrush Circuit Disabled	395	570
Inverter Undervoltage Disable	373	553
Undervoltage Warning	410	585
Inverter Undervoltage Re-Enable (warning reset)	413	602
Overvoltage Warning (w/o Brake)	817	1084
Dynamic Brake Turn-on	810	1099
Inverter Overvoltage Re-Enable (warning reset)	821	1099
Overvoltage Warning (with Brake)	828	1109
Overvoltage Trip	855	1130

Mains supply 3 x 380-480 V								
Model number		AF-600 FP	650	750	900	1000	1200	1350
		AF-650 GP	600	650	750	900	1000	1200
Light duty (LD) current ratings (110 %):								
Output current	Nominal [A] (380-440 V)		880	990	1120	1260	1460	1720
	MAX (60 sec) [A] (380-440 V)		968	1089	1232	1386	1606	1892
	Nominal [A] (441-500 V)		780	890	1050	1160	1380	1530
	MAX (60 sec) [A] (441-500 V)		858	979	1155	1276	1518	1683
Output	Nominal [kVA] (400 V)		610	686	776	873	1012	1192
	Nominal [kVA] (460 V)		621	709	837	924	1100	1219
	Nominal [kVA] (500 V)		675	771	909	1005	1195	1325
Typical shaft output	[kW] (400 V)		500	560	630	710	800	1000
	[HP] (460 V)		650	750	900	1000	1200	1350
	[kW] (500 V)		560	630	710	800	1000	1100
Heavy duty (HD) torque (160 %):								
Output current	Nominal [A] (380-440 V)		800	880	990	1120	1260	1460
	MAX (60 sec) [A] (380-440 V)		1200	1320	1485	1680	1890	2190
	Nominal [A] (441-500 V)		730	780	890	1050	1160	1380
	MAX (60 sec) [A] (441-500 V)		1095	1170	1335	1575	1740	2070
Output	Nominal [kVA] (400 V)		554	610	686	776	873	1012
	Nominal [kVA] (460 V)		582	621	709	837	924	1100
	Nominal [kVA] (500 V)		632	675	771	909	1005	1195
Typical shaft output	[kW] (400 V)		450	500	560	630	710	800
	[HP] (460 V)		600	650	750	900	1000	1200
	[kW] (500 V)		530	560	630	710	800	1000
400V Power loss Light duty (LD) [W]			10161	11822	12514	14671	17294	19280
400V Power loss Heavy duty (HD) [W]			9031	10145	10649	12492	14244	15467
460V Power loss Light duty (LD)[W]			8877	10424	11595	13215	16228	16625
460V Power loss Heavy duty (HD) [W]			8211	8861	9416	11580	13003	14554
Limits and Ranges								
Overcurrent Warning	A rms Out		1866	1786	2342	2600	2679	3514
Overcurrent Alarm (1.5 sec delay)	A rms Out		1866	1786	2342	2600	2679	3514
Earth (Ground) Fault Alarm	A rms Out		400	440	495	560	630	730
Short Curcuit Alarm	A rms Out		2256	2256	2974	3308	3384	4462
Heatsink Over Temperature ° C			95	95	95	95	95	95
Heatsink Under Temperature Warning ° C			0	0	0	0	0	0
Power Card Ambient Over Temperature ° C			68	68	68	68	68	68
Power Card Ambient Under Temperature ° C			-20	-20	-20	-20	-20	-20
Mains Phase Warning (5 sec delay)	DC Bus Ripple Vpeak		30	30	30	30	30	30
Mains Phase Alarm (25 sec delay)	DC Bus Ripple Vpeak		30	30	30	30	30	30

Table 1.5: Mains supply 3 x 380-480 V

Mains supply 3 x 525 - 690 V								
Model number		AF-600 FP	750	950	1050	1150	1350	1550
		AF-650 GP	900	1000	1150	1250	1350	1550
Light duty (LD) current ratings (110 %):								
Output current	Nominal [A] (525-550 V)		763	889	988	1108	1317	1479
	MAX (60 sec) [A] (525-550 V)		839	978	1087	1219	1449	1627
	Nominal [A] (551-690 V)		730	850	945	1060	1260	1415
	MAX (60 sec) [A] (551-690 V)		803	935	1040	1166	1386	1557
Output	Nominal [kVA] (550 V)		727	847	941	1056	1255	1409
	Nominal [kVA] (575 V)		727	847	941	1056	1255	1409
	Nominal [kVA] (690 V)		872	1016	1129	1267	1506	1691
Typical shaft output	[kW] (550 V)		560	670	750	850	1000	1100
	[HP] (575 V)		750	950	1050	1150	1350	1550
	[kW] (690 V)		710	800	900	1000	1200	1400
Heavy duty (HD) torque (160 %):								
Output current	Nominal [A] (525-550 V)		659	763	889	988	1108	1317
	MAX (60 sec) [A] (525-550 V)		989	1145	1334	1482	1662	1976
	Nominal [A] (551-690 V)		630	730	850	945	1060	1260
	MAX (60 sec) [A] (551-690 V)		945	1095	1275	1418	1590	1890
Output	Nominal [kVA] (550 V)		628	727	847	941	1056	1255
	Nominal [kVA] (575 V)		627	727	847	941	1056	1255
	Nominal [kVA] (690 V)		753	872	1016	1129	1267	1506
Typical shaft output	[kW] (550 V)		500	560	670	750	850	1000
	[HP] (575 V)		650	750	950	1050	1150	1350
	[kW] (690 V)		630	710	800	900	1000	1200
600V Power loss Light duty (LD) [W]			8933	10310	11692	12909	15358	17602
600V Power loss Heavy duty (HD) [W]			7586	8683	10298	11329	12570	15258
690V Power loss Light duty (LD) [W]			9212	10659	12080	13305	15865	18173
690V Power loss Heavy duty (HD) [W]			7826	8983	10646	11681	12997	15763
Limits and Ranges								
Overcurrent Warning	A rms Out		1648	1977	2336	2471	2965	3505
Overcurrent Alarm (1.5 sec delay)	A rms Out		1648	1977	2336	2471	2965	3505
Earth (Ground) Fault Alarm	A rms Out		330	382	445	494	554	659
Short Curcuit Alarm	A rms Out		2094	2510	2980	3140	3766	4470
Heatsink Over Temperature ° C			95	105	95	95	105	95
Heatsink Under Temperature Warning ° C			0	0	0	0	0	0
Power Card Ambient Over Temperature ° C			68	68	68	68	68	68
Power Card Ambient Under Temperature ° C			-20	-20	-20	-20	-20	-20
Mains Phase Warning (5 sec delay)	DC Bus Ripple Vpeak		50	50	50	50	50	50
Mains Phase Alarm (25 sec delay)	DC Bus Ripple Vpeak		50	50	50	50	50	50

Table 1.6: Mains supply 3 x 525 - 690 V

1.7 Optional Components

1.7.1 Optional Unit Size 6x components

Units are manufactured in different configurations due to the optional components available. Depending on the unit configuration, optional equipment may be mounted in the inverter, rectifier or option cabinet. The table below lists the components available and the cabinet where it is factory installed.

Optional Component	Cabinet Location
Mains Options	
AC fuse	Rectifier or inverter
Disconnect	Option
A1 RFI filter	Option
Load share	Rectifier

1.8 Tools Required

Operating Instructions for the Drives Series Frequency Converter

Metric socket set	7–19 mm
Socket extensions	100 mm–150 mm (4 in and 6 in)
Torx driver set	T10 - T50
Torque wrench	0.675–19 Nm (6–170 in-lbs)
Needle nose pliers	
Magnetic sockets	
Ratchet	
Hex wrench set	
Screwdrivers	Standard and Philips

Additional Tools Recommended for Testing

Digital volt/ohmmeter (must be rated for 1200 VDC for 690 V units)
Analog voltmeter
Oscilloscope
Clamp-on style ammeter
Test cable p/n 6KAF6H8766
Signal test board p/n 6KAF6H8437
Power supply: 610 - 800 VDC, 250 mA to supply external power to 4 power cards and the control card.
Power supply : 24 VDC, 2 A for external 24 V power supply.

1.9 General Torque Tightening Values

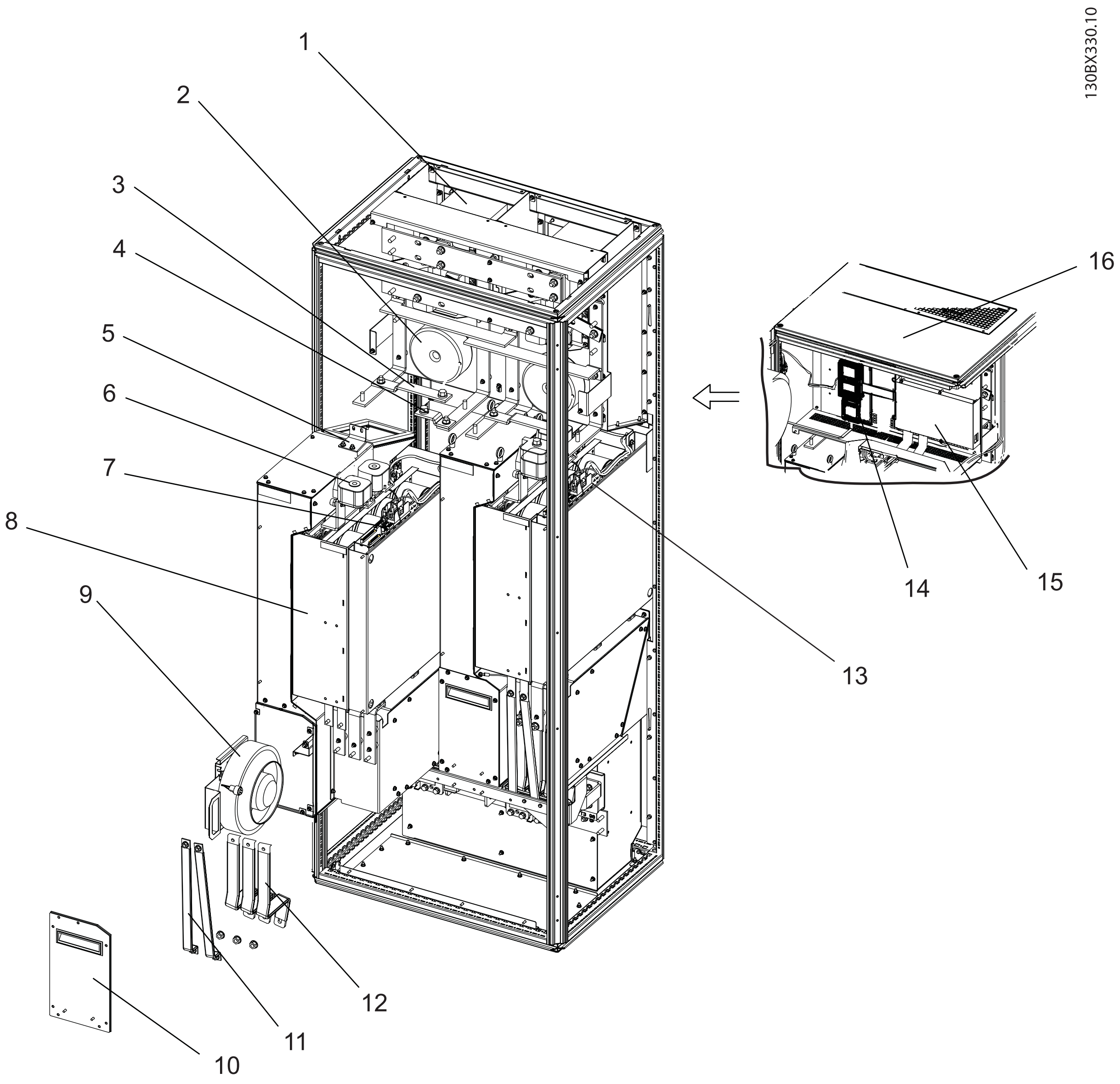
For fastening hardware described in this manual, the torque values in the table below are used. These values are not intended for SCR, diode, or IGBT fasteners. See the instructions included with those replacement parts for correct values.

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

Table 1.7: Torque Values Table

1

1.10 Exploded Views



Inverter cabinet exploded view (cabinet with 2 inverter modules shown). Units with 3 inverter modules are similar.

1	DC link inductor	9	Module heatsink fan
2	Fan transformer	10	Fan door cover
3	(-)DC bus bar	11	(Optional) brake output bus bar
4	(+)DC bus bar	12	Motor output bus bar
5	Mounting bracket	13	SMPS fuse and fan fuse
6	DC Fuse	14	Control card
7	Panel connectors	15	MDCIC board
8	Inverter module	16	Top cover plate

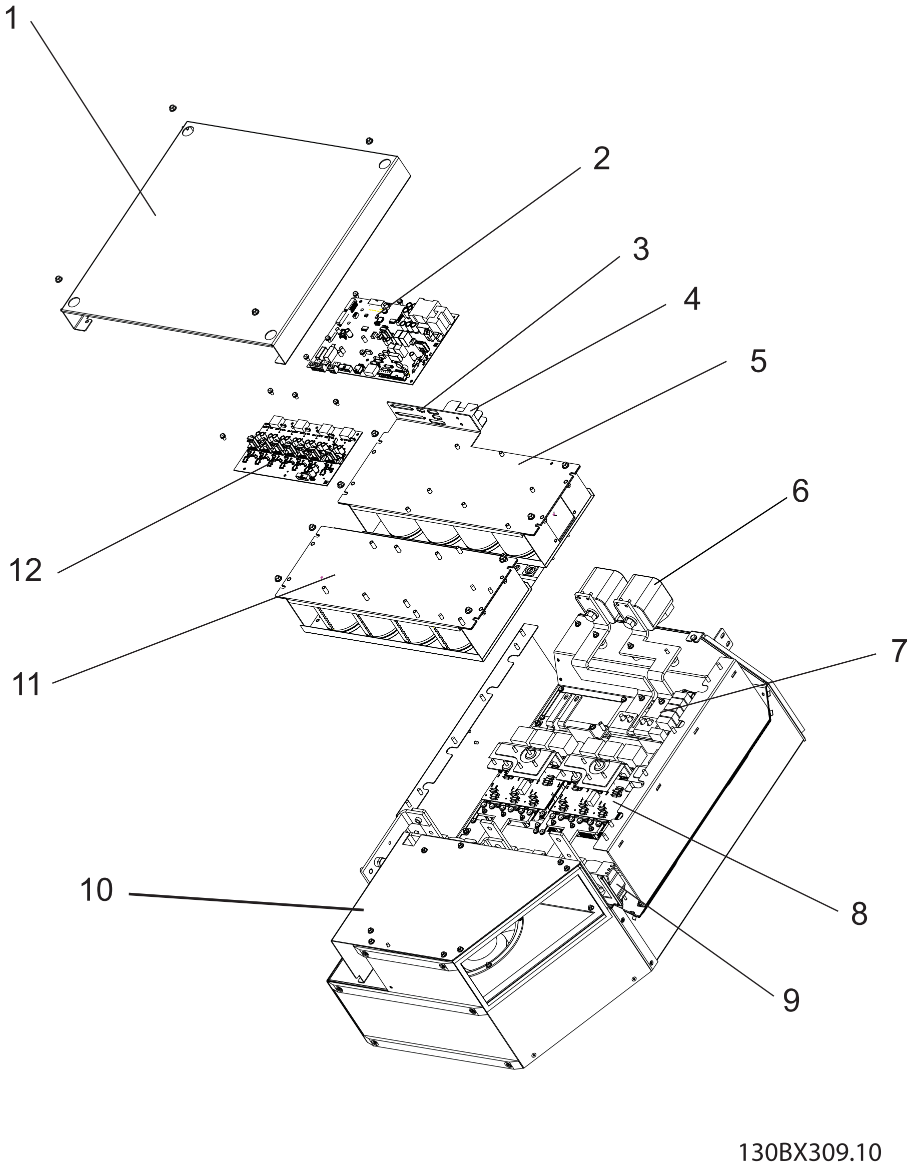


Illustration 1.1: Inverter module exploded view

1	Right side cover plate	7	High frequency board
2	Inverter power card	8	IGBT module
3	Panel connectors	9	Current sensor
4	SMPS fuse and fan fuse	10	Fan assembly
5	Upper capacitor bank assembly	11	Lower capacitor bank assembly
6	DC bus fuses	12	Gate driver card

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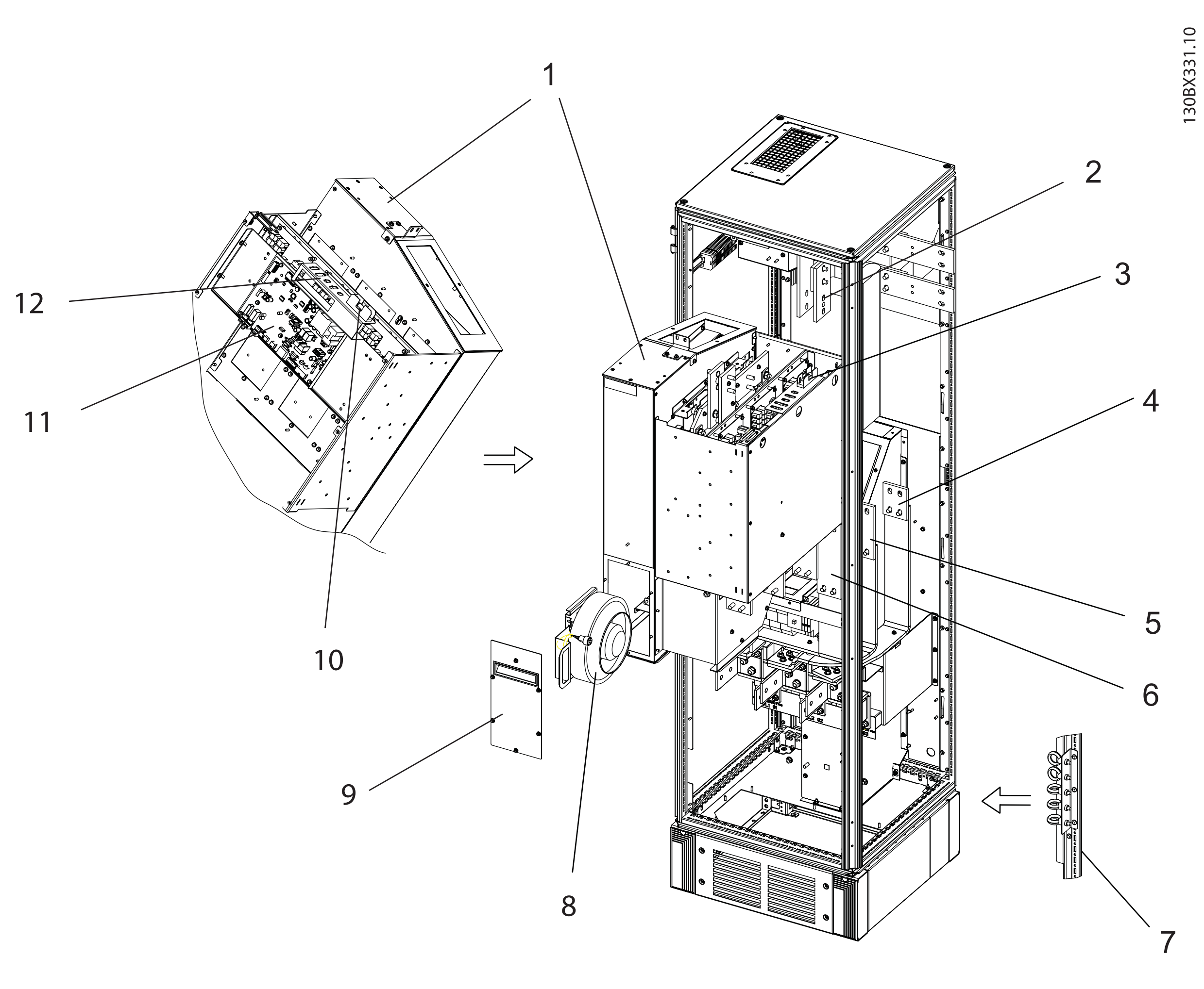
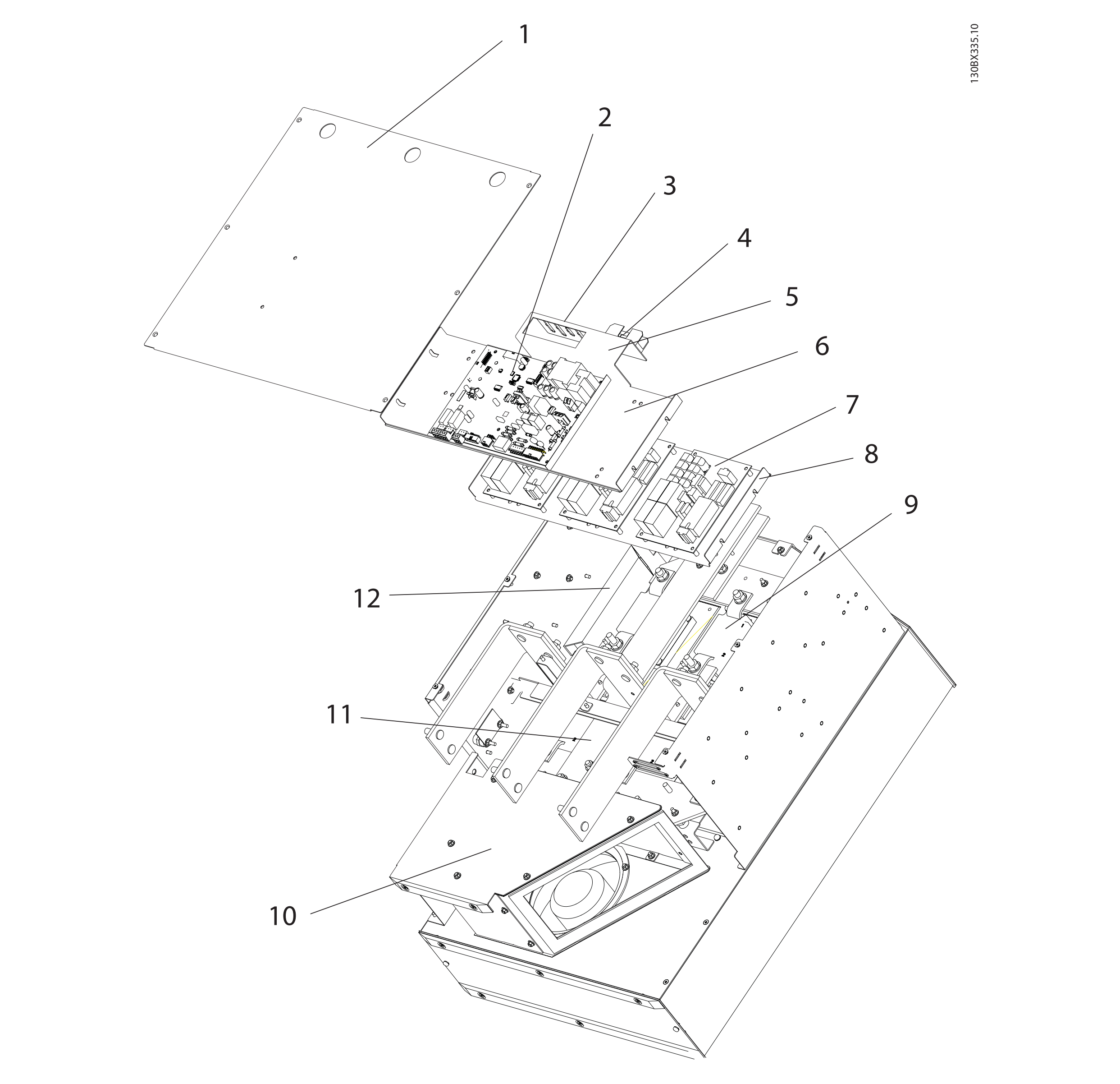


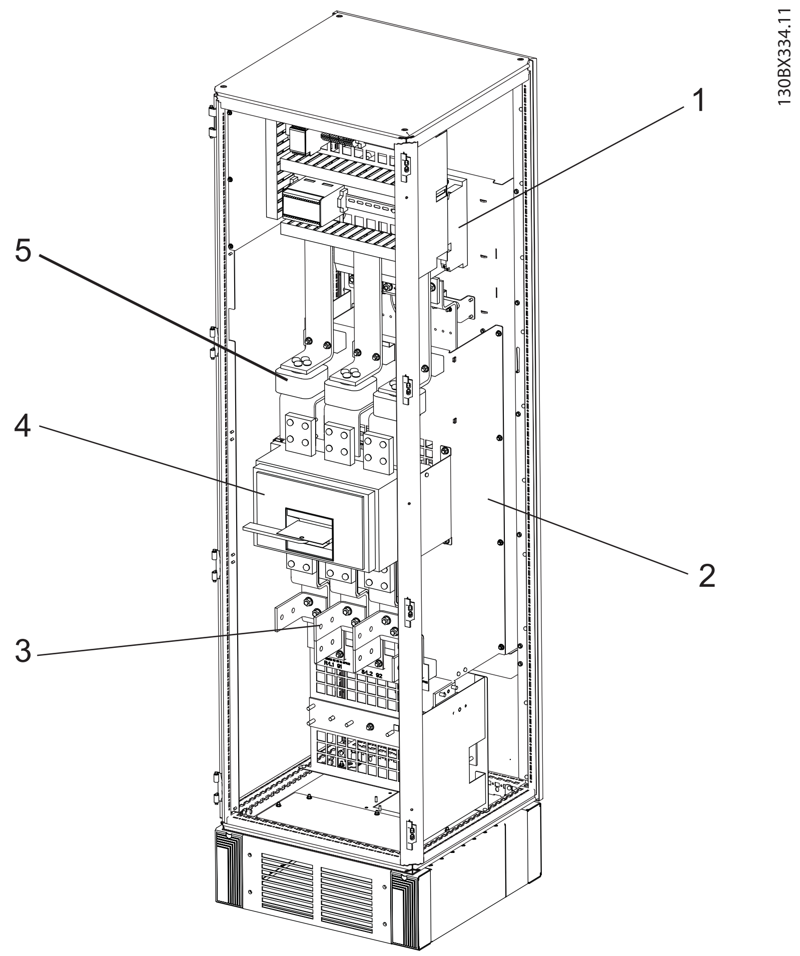
Rectifier cabinet exploded view

1	Rectifier module	7	Module lifting eye bolts (mounted on vertical strut)
2	DC bus bar	8	Module heatsink fan
3	SMPS fuse	9	Fan door cover
4	(Optional) back AC fuse mounting bracket (T)	10	SMPS fuse
5	(Optional) middle AC fuse mounting bracket (S)	11	Power card
6	(Optional) front AC fuse mounting bracket (R)	12	Panel connectors



Rectifier module exploded view

1	Rectifier module cover plate	7	Soft charge cards
2	Power card	8	Soft charge card mounting plate
3	Panel connectors	9	SCR module
4	SMPS fuse	10	Fan assembly
5	Power card mounting plate flange	11	Diode module
6	Power card mounting plate	12	Soft charge resistor



Option cabinet exploded view

1	Contactor	4	Circuit breaker or disconnect
2	RFI filter	5	AC mains/line fuses
3	Mains AC power input terminals		

2 Operator Interface and Control

2.1 Introduction

Frequency converters are designed with self-diagnostic circuitry to isolate fault conditions and activate display messages which greatly simplify troubleshooting and service. The operating status of the frequency converter is displayed in real-time. Virtually every command given to the frequency converter results in some indication on the Keypad display. Fault logs are maintained within the frequency converter for fault history.

The frequency converter monitors supply and output voltages along with the operational condition of the motor and load. When the frequency converter issues a warning or alarm, it cannot be assumed that the fault lies within the frequency converter itself. In fact, for most service calls, the fault condition will be found outside of the frequency converter. Most of the warnings and alarms that the frequency converter displays are generated by response to faults outside of the frequency converter. This service manual provides techniques and test procedures to help isolate a fault condition whether in the frequency converter or elsewhere.

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

2.2 Operating the Frequency Converter

2.2.1 Operation and Programming Through the Keypad

The Keypad is the user interface to the controller.

The Keypad has several user functions: to start, stop, and control motor speed when in local control along with displaying operational data, warnings and cautions, as well as programming controller functions, and to manually reset the controller after a fault when auto-reset is inactive.

2.2.2 Keypad

The Keypad is divided into four functional groups:

1. LCD display area
2. Menu display keys for status options, programming, and error message history
3. Navigation keys for programming functions, moving the display cursor, and speed control in local operation (along with status indicator lights)
4. Operation mode keys and reset

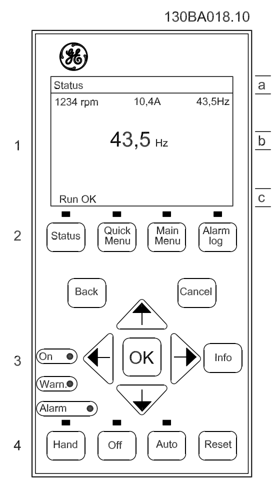


Illustration 2.1: Keypad

2.2.3 Display Area

a. The top line shows controller status when in status mode or two variables selected in par. K-10 *Active Set-up*, such as direction of rotation or active set-up

b. The motor values displayed are selected by parameter choices in par. K-20 *Display Line 1.1 Small*, par. K-21 *Display Line 1.2 Small*, par. K-22 *Display Line 1.3 Small*, par. K-23 *Display Line 2 Large*, and par. K-24 *Display Line 3 Large*. Each value has dimension scaling. A flashing alarm or warning message replaces the display in the case of a fault or pending fault condition.
The operating variables shown in the figure are motor speed (1.1), motor current (1.2), motor power (1.3), and drive output frequency (2) in large scale. Use the [INFO] key for definition of the displayed operating variables.

c. Automatically generated mode and status messages appear on this line.

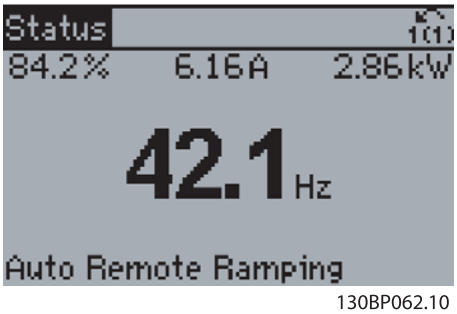


Illustration 2.2: Keypad Display Area

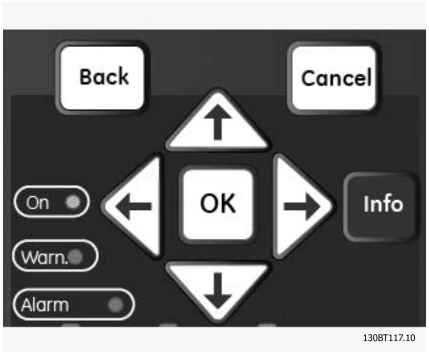
2.2.4 Menu Keys

Menu keys are used for parameter set-up, toggling through status display modes during normal operation, and viewing fault log data.

Status Press and hold the Status key to toggle between status read-out displays in the Keypad display area. Press [Status] in any other display mode to return to the status display. Pressing [Status] plus [UP] or [DOWN] arrows adjusts the display brightness.
Quick Menu Allows access to the most common functions for restoring the controller.
Main Menu Provides access to all programming parameters. Press and hold the [Main Menu] key to access any parameter by entering the parameter number.
Alarm Log Displays a list of the last five alarms. For additional details about an alarm, select the alarm number using the arrow keys and press [OK]. Details about the frequency converter before it entered the alarm mode are displayed.

2.2.5 Navigation Keys

Navigation keys are used for programming functions, moving the display cursor, and speed control in local controller operation. Controller status indicator lights are also located in this area.

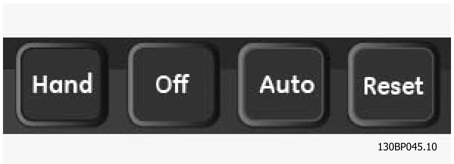


Back Reverts to the previous step or list in the navigation structure.
Cancel The last change or command will be cancelled, as long as the display mode has not changed.
Info Press [Info] for information about a command, parameter, or function in any display mode. For example, in status mode, each display is defined. In menu mode, menu options are explained. Exit Info mode by pressing [Info], [Back], [Cancel], or [Status].
Navigation Arrow Keys The four navigation arrows are used to move a cursor between the different items available in menu or alarm log modes. For operation in Hand Mode, the up and down arrows regulate controller speed.
OK Used to select a highlighted parameter from a parameter list or to enable a parameter choice.
LED indicator lights The green ON LED is activated and display panel lit when the frequency converter receives power from mains voltage, a DC bus terminal, or an external 24 V supply.
When a pending fault condition is being approached, the yellow warning light will come on and a text display appears in the display area. A fault condition causes the alarm LED to flash red and a text display appears in the display area.

Darkened LED lights on the Keypad do not mean that the drive has no dangerous internal voltage. Do not assume the unit contains no voltage when the indicator lights are off.

2.2.6 Controller Operation Keys

Operation keys for local or auto (remote) control are found at the bottom of the Keypad along with Off and Reset.



[**Hand**] Starts or operates the motor in local control through the Keypad. Use the up and down arrow keys to give the motor a speed command. The key can be Enabled [1] or Disabled [0] via par. K-40 *[Hand] Button on Keypad*.

NB!
External stop signals activated by means of control signals or a serial bus will override a *start* command via the Keypad.

The following control signals will still be available when [Hand] is activated:

[Hand] - [Off] - [Auto] - [Reset] keys

Coasting stop inverse (motor coasting to stop)

Reversing

Set-up select

Stop command from serial communication

Quick stop

DC brake

Off Stops the connected motor. The key can be Enabled [1] or Disabled [0] in par. K-41 *[Off] Button on Keypad*. If no external stop function is selected and the OFF key is inactive the motor can only be stopped by disconnecting the mains supply.

[Auto] Enables the controller to be controlled via the control terminals and/or serial communication. A start signal applied on control terminals and/or the serial bus will start the controller. The key can be Enabled [1] or Disabled [0] in par. K-42 *[Auto] Button on Keypad*.

NB!
An active HAND-OFF-AUTO signal via digital inputs has higher priority than the [Hand] and [Auto] control keys.

Reset This resets the controller after an alarm condition has been cleared. For an alarm (trip), power must be recycled to the controller before pressing the reset key. The key can be Enabled [1] or Disabled [0] in par. K-43 *[Reset] Button on Keypad*.

2.2.7 Tips and Tricks

*	For the majority of applications the Quick Menu, Quick Set-up and Function Set-up provides the simplest and quickest access to all the typical parameters required.
*	Whenever possible, performing an Auto tune will ensure best shaft performance.
*	Display contrast can be adjusted by pressing [Status] and [▲] for a darker display or by pressing [Status] and [▼] for a brighter display.
*	Under [Quick Menu] and [Changes Made], any parameter that has been changed from factory settings is displayed.
*	Press and hold the [Main Menu] key for 3 seconds to access any parameter
*	For service purposes, it is recommended to copy all of the parameters to the Keypad, see par. K-50 *Keypad Copy* for further information.

Table 2.1: Tips and tricks

NB!
Exchanging or adding a new control card, power card, or option card -- or updating the card's software - requires a manual restore of the drive for proper operation.

2.2.8 Restore Factory Settings

There are two ways to restore the drive to factory settings: Recommended restore and manual restore.
Please be aware that they have different impact according to the below description.

Recommended restore (via par. H-03 *Restore Factory Settings*)

1. Select par. H-03 *Restore Factory Settings*
2. Press [OK]
3. Select [2] Restore Factory Settings
4. Press [OK]
5. Remove power to unit and wait for display to turn off.
6. Reconnect power and the frequency converter is reset. Note that first start-up takes a few more seconds
7. Press [Reset]

Par. H-03 *Restore Factory Settings* restores all except:
Par. SP-50 *RFI Filter*
Par. O-30 *Protocol*
Par. O-31 *Address*
Par. O-32 *Drive Port Baud Rate*
Par. O-35 *Minimum Response Delay*
Par. O-36 *Max Response Delay*
Par. O-37 *Maximum Inter-Char Delay*
Par. ID-00 *Operating Hours* to par. ID-05 *Over Volt's*
Par. ID-20 *Historic Log: Event* to par. ID-22 *Historic Log: Time*
Par. ID-30 *Alarm Log: Error Code* to par. ID-32 *Alarm Log: Time*

Manual restore

NB!
When carrying out manual restore, serial communication, RFI filter settings and fault log settings are reset.
.

1. Disconnect from mains and wait until the display turns off.

2a. Press [Status] - [Main Menu] - [OK] at the same time while power up for keypad

3. Release the keys after 5 s

4. The frequency converter is now programmed according to default settings

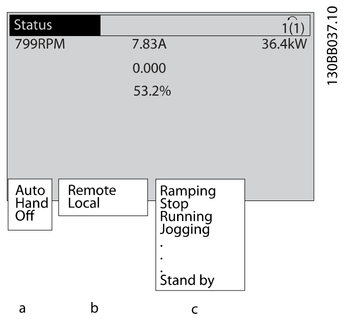
The Manual Restore restores all except:
Par. ID-00 *Operating Hours*
Par. ID-03 *Power Up's*
Par. ID-04 *Over Temp's*
Par. ID-05 *Over Volt's*

2

2.3 Status Messages

Status messages appear in the bottom of the display - see the example below.
The left part of the status line indicates the active operation mode of the frequency converter.
The centre part of the status line indicates the references site.
The last part of the status line gives the operation status, e.g. *Running, Stop or Stand by*.

Other status messages may appear related to the software version and frequency converter type.



Operation Mode

Off The frequency converter is stopped. The drive does not react to any control signal until [Auto] or [Hand] on the Keypad are pressed.

[**Auto**] The drive is started and stopped by external commands via the control terminals and/or the serial communication.

[**Hand**] The frequency converter is started from the Keypad. Only *stop* commands, alarm resets (Reset), *reversing*, DC brake, and *set-up selection* signals can be applied to the control terminals.

Reference Site

Remote The Reference is given via external signals (analog or digital), serial communication, or internal preset references.

Local The reference is given via the Keypad.

Operation Status

AC Brake

AC Brake was selected in par. B-10 *Brake Function*. The motor is slowed down via the active down ramp and feeds the drive with generative energy. The AC Brake over-magnetizes the motor to achieve a controlled end of the active ramp.

Auto tune finish OK

Enable complete or reduced Auto tune was selected in par. P-04 *Auto Tune*. The Auto tune was carried out successfully.

Auto tune ready

Enable complete or reduced Auto tune was selected in par. P-04 *Auto Tune*. The auto tune is ready to start. Press [Hand] on the Keypad to start.

Auto tune running

Enable complete or reduced Auto tune was selected in par. P-04 *Auto Tune*. The Auto tune process is in progress.

Braking

The brake chopper is in operation. Generative energy is absorbed by the brake resistor.

Braking max.

The brake chopper is in operation. The power limit for the brake resistor defined in par. B-12 *Brake Power Limit (kW)* is reached.

Bus Jog 1

PROFIDrive profile was selected in par. O-10 *Control Word Profile*. The Jog 1 function is activated via serial communication. The motor is running with par. O-90 *Bus Jog 1 Speed*.

Bus Jog 2

PROFIDrive profile was selected in par. O-10 *Control Word Profile*. The Jog 2 function is activated via serial communication. The motor is running with par. O-91 *Bus Jog 2 Speed*.

Catch up

The output frequency is corrected by the value set in par. F-62 *Catch up/slow Down Value*.

1. Catch up is selected as a function for a digital input (parameter group E-##). The corresponding terminal is active.
2. Catch up was activated via serial communication.

Coast

1. Coast inverse has been selected as a function for a digital input (parameter group E-##). The corresponding terminal is not connected.
2. Coast is on 0 on serial communication.

Control ready

PROFIDrive profile was selected in par. O-10 *Control Word Profile*. The drive needs the second part (e.g. 0x047F) of the two-part start command via serial communication to allow starting. Using a terminal is not possible.

Ctrl. decel

A function with Ctrl. decel was selected in par. SP-10 *Line failure*. The Mains Voltage is below the value set in par. SP-11 *Line Voltage at Input Fault*. The drive decels the motor using a controlled decel.

Current High

In par. H-71 *Warning Current High*, a current limit is set. The output current of the drive is above this limit.

Current Low

In par. H-70 *Warning Current Low*, a current limit is set. The output current of the drive is below this limit.

DC Hold

The motor is driven with a permanent DC current, par. B-00 *DC Hold Current*. DC hold is selected in par. H-80 *Function at Stop*. A Stop command (e.g. Stop (inverse)) is active.

DC Stop

The motor is momentarily driven with a DC current, par. B-01 *DC Brake Current*, for a specified time, par. B-02 *DC Braking Time*.

1. DC Brake is activated (OFF) in par. B-03 *DC Brake Cut In Speed [RPM]* and a Stop command (e.g. Stop (inverse)) is active.
2. DC Brake (inverse) is selected as a function for a digital input (parameter group E-##). The corresponding terminal is not active.
3. The DC Brake is activated via serial communication.

DC Voltage U0

In par. H-41 *Motor Control Principle* U/f and in par. H-80 *Function at Stop* DC Voltage U0 is selected. A Stop command (e.g. Stop (inverse)) is activated. The voltage selected according to the par. H-55 *U/f Characteristic - U* [0] (UF Characteristic – U[V]) is applied to the motor.

Feedback high

In par. H-77 *Warning Feedback High*, an upper feedback limit is set. The sum of all active feedbacks is above the feedback limit.

Feedback low

In par. H-76 *Warning Feedback Low*, a lower feedback limit is set. The sum of all active feedbacks is below the feedback limit.

Flying start

In par. H-09 *Start Mode*, the Flying start function is activated. The drive is testing if the connected motor is running with a speed that is in the adjusted speed range. The process was started by connecting a digital input (parameter group E-##) programmed as Coast inverse or by connecting to mains.

Freeze output

The remote reference is active and the momentarily given speed is saved.

1. Freeze output was selected as a function for a digital input (Group E-##). The corresponding terminal is active. Speed control is only possible via the terminal functions Speed up and Speed down.
2. Hold ramp is activated via serial communication.

Freeze output request

A freeze output command has been given, but the motor will remain stopped until a *Run permissive* signal is received via a digital input.

Freeze Ref.

Freeze Ref. was chosen as a function for a digital input (parameter group E-##). The corresponding terminal is controlled. The drive saves the actual reference. Changing the reference is now only possible via terminal functions Speed up and Speed down.

Jog request

A JOG command has been given, but the motor will be stopped until a *Run permissive* signal is received via a digital input.

Jogging

The motor is running with par. C-21 *Jog Speed [RPM]*.

1. Jog was selected as function for a digital input (parameter group E-##). The corresponding terminal (e.g. Terminal 29) is active.
2. The Jog function is activated via the serial communication.
3. The Jog function was selected as a reaction for a monitoring function (e.g. No signal). The monitoring function is active.

Kinetic backup

In par. SP-10 *Line failure*, a function was set as kinetic backup. The Mains Voltage is below the value set in par. SP-11 *Line Voltage at Input Fault*. The drive is running the motor momentarily with kinetic energy from the inertia of the load.

Motor check (AF-650 GP only)

In par. H-80 *Function at Stop*, the function Motor check was selected. A stop command (e.g. Stop inverse) is active. To ensure that a motor is connected to the drive, a permanent test current is applied to the motor.

Off1

PROFIDrive profile was selected in par. O-10 *Control Word Profile*. The OFF 1 function is activated via serial communication. The motor is stopped via the ramp.

Off2

PROFIDrive profile was selected in par. O-10 *Control Word Profile*. The OFF 2 function is activated via serial communication. The output of the drive is disabled immediately and the motor coasted.

Off3

PROFIDrive profile was selected in par. O-10 *Control Word Profile*. The OFF 3 function is activated via serial communication. The motor is stopped via the ramp.

OVC control

Overvoltage Control is activated in par. B-17 *Over-voltage Control*. The connected motor is supplying the drive with generative energy. The Overvoltage Control adjusts the UF ratio to run the motor in controlled mode and to prevent the drive from tripping.

PowerUnit Off

Only with frequency converters with installed option (ext. 24 V supply). The mains supply to the frequency converter is cut off, but the control card is still supplied with 24 V.

Pre-magnetize

Pre-magnetization is selected in par. H-80 *Function at Stop*. A stop command (e.g. Stop inverse) is activated. A suitable constant magnetizing current is applied to the motor.

Protection md

The AF-650 GP/AF-600 FP has detected a critical status (e.g. an overcurrent, overvoltage). To avoid tripping the frequency converter (alarm), protection mode is activated, which includes reducing the switching frequency to 4 kHz. If possible, protection mode ends after approximately 10 s. Activation of protection mode can be restricted by adjusting the par. SP-26 *Trip Delay at Drive Fault*.

QStop

The motor is stopped using a quick stop ramp par. C-23 *Quick Stop Decel Time*.

1. Quick stop inverse was chosen as a function for a digital input (parameter group E-##). The corresponding terminal is not active.
2. The Quick stop function was activated via serial communication.

Ramping

The motor is accelerating/decelerating using the active Accel/Decel. The reference, a limit value or a standstill is not yet reached.

Ref. high

In par. H-75 *Warning Reference High* a reference high limit is set. The sum of all active references is above the reference limit.

Ref. low

In par. H-74 *Warning Reference Low* a reference low limit is set. The sum of all active references is below the reference limit.

Run on ref.

The drive is running in the reference range. The feedback value matches the set reference value.

Run request (AF-600 FP only)

A start command has been given, but the motor will be stopped until a *Run permissive* signal is received via digital input.

Running

The motor is driven by the drive, the ramping phase is done and the motor revolutions are outside the *On Reference* range. Occurs when one of the motor speed limits (Par. F-15/F-16/F-17 or F-18) is set, but the maximum reference is outside this range.

Sleep Boost (AF-600 FP only)

The boost function in par. AP-45 *Setpoint Boost* is enabled. This function is only possible in *Closed loop* operation.

Sleep Mode (AF-600 FP only)

The sleep mode function is enabled by means of either No Flow Detection or Minimum Speed Detection or via an external signal applied to one of the digital input (parameter group E-##). This means that at present the motor has stopped, but that it will restart automatically when required.

Speed down

The output frequency is corrected by the value set in par. F-62 *Catch up/slow Down Value*.

1. Speed down was selected as a function for a digital input (parameter group E-##). The corresponding terminal is active.
2. Speed down was activated via serial communication.

Speed high

In par. H-73 *Warning Speed High*, a value is set. The speed of the motor is above this value.

Speed low

In par. H-72 *Warning Speed Low*, a value is set. The speed of the motor is below this value.

Standby

[Auto] The drive starts the motor using a start signal in a digital input (if the parameter is programmed accordingly) or via serial communication.

Start delay

In par. F-24 *Holding Time*, the delay of the starting time was set. A Start command was activated and the delay time is still running. The motor will start after the delay time has expired.

Start fwd/rev

Enable start forward and *Enable start reverse* were selected as functions for two different digital inputs (parameter group E-##). To start the motor, a direction dependent start signal has to be given and the corresponding terminal has to be active.

Start inhibit

PROFIDrive profile was selected in par. O-10 *Control Word Profile*. The start inhibition is active. The drive needs the first part (e.g. 0x047E) of the two-part start command via serial communication to allow starting. See also operation status control ready.

Stop

[Off] was pressed on the Keypad or Stop inverse was selected as a function for a digital input (Group E-##). The corresponding terminal is not active.

Trip

An alarm occurred. It is possible, provided the cause of the alarm is cleared, to reset the alarm via a *Reset* signal ([Reset] key on the Keypad, a control terminal or serial communication).

Trip lock

A serious alarm occurred. It is possible, provided the cause of the alarm was cleared, to reset the alarm after the mains have been switched off and on again. This can be done via a *reset* signal ([Reset] on the Keypad, a control terminal or serial communication).

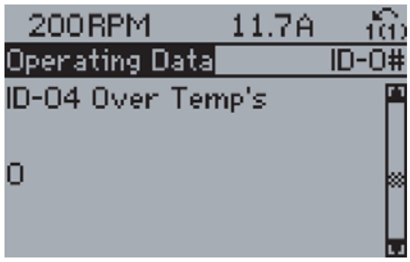
Unit/Drive not ready

PROFIDrive profile was selected in par. O-10 *Control Word Profile*. A control word is sent to the drive via serial communication with Off 1, Off 2 and Off 3 active. Start inhibit is active. To enable start, see operation status Start inhibit.

2

2.4 Service Functions

Service information for the frequency converter can be shown on display lines 3 and 4. Included in the data are counters that tabulate operating hours, power ups and trips; fault logs that store frequency converter status values present at the 20 most recent events that stopped the frequency converter; and frequency converter nameplate data. The service information is accessed by displaying items in the frequency converter's ID-## parameter group.



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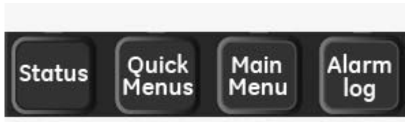
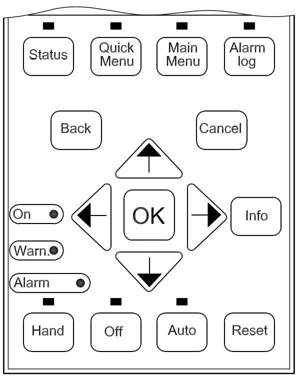
Parameter settings are displayed by pressing the [Main Menu] key on the Keypad.



130BP045.10

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

130BA027.10



See the Drives Series Programming Guide for detailed information on accessing and displaying parameters and for descriptions and procedures for service information available in the ID-## parameter group.

2.5 Frequency Converter Inputs and Outputs

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

Another control source is through serial communication from a serial bus. A serial communication protocol supplies commands and references to the frequency converter, can program the frequency converter, and reads status data from the frequency converter. The serial bus connects to the frequency converter through the RS-485 serial port or through a communication option card.

The third way is through signal wiring connected to the frequency converter control terminals (see illustration below). The frequency converter control terminals are located below the frequency converter Keypad. Improperly connected control wiring can be the cause of a motor not operating or the frequency converter not responding to a remote input.

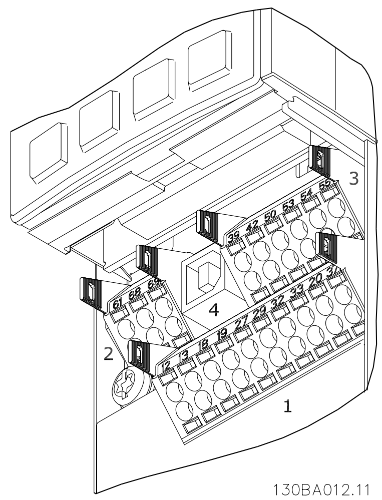


Illustration 2.3: Control Terminals

2.5.1 Input signals

The frequency converter can receive two types of remote input signals: digital or analog. Digital inputs are wired to terminals 18, 19, 20 (common), 27, 29, 32, and 33. Analog or digital inputs are wired to terminals 53 or 54 and 55 (common). The terminal functions are set by a switch found by removing the Keypad. Some options may include additional terminals.

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

Digital signals are a simple binary 0 or 1 which, in effect, act as a switch. Digital signals are controlled by a 0 to 24 VDC signal. A voltage signal lower than 5 VDC is a logic 0. A voltage higher than 10 VDC is a logic 1. Zero is open, one is close. Digital inputs to the frequency converter are switched commands such as start, stop, reverse, coast, reset, and so on. (Do not confuse these digital inputs with serial communication formats where digital bytes are grouped into communication words and protocols.)

The RS-485 serial communication connector is wired to terminals (+) 68 and (-) 69. Terminal 61 is common and may be used for terminating screens only when the control cable run between frequency converters, not between frequency converters and other devices. See Earthing Screened Cables in this section for correct methods for terminating a screened control cable.

2.5.2 Output signals

The frequency converter also produces output signals that are carried through either the RS-485 serial bus or terminal 42. Output terminal 42 operates in the same manner as the inputs. The terminal can be programmed for either a variable analog signal in mA or a digital signal (0 or 1) in 24 VDC. In addition, a pulse reference can be provided on terminals 27 and 29. Output analog signals generally indicate the frequency converter frequency, current, torque and so on to an external controller or system. Digital outputs can be control signals used to open or close a damper, for example, or send a start or stop command to auxiliary equipment.

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

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

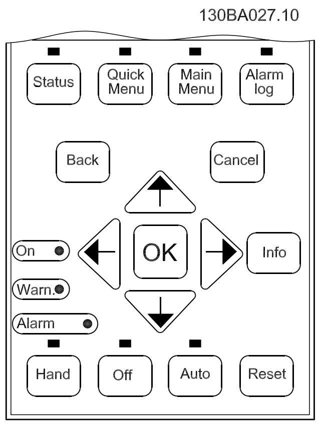
2.6 Control Terminals

Control terminals must be programmed. Each terminal has specific functions it is capable of performing and a numbered parameter associated with it. See table *Control Terminals and Associated Parameters*. 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 Keypad.

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



See the Programming Guide 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] key as discussed previously, or a voltmeter may be used to check for voltage at the control terminal. See procedure details at *Input Terminal Test* in Section *Test Procedures*.

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

1. wired properly
2. powered
3. programmed correctly for the intended function
4. receiving a signal

2

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. Some options provide additional terminals. See illustration below.

Terminal No.	Function
01, 02, 03 and 04, 05, 06	Two Form C output relays. Maximum 240 VAC, 2 A. Minimum 24 VDC, 10 mA or 24 VAC, 100 mA. Can be used for indicating status and warnings. Physically located on the power card.
12, 13	24 VDC power supply to digital inputs and external transducers. The maximum output current is 200 mA.
18, 19, 27, 29, 32, 33	Digital inputs for controlling the frequency converter. R = 2 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.
20	Common for digital inputs.
37	0–24 VDC input for safety stop AF-650 GP only.
39	Common for analog and digital outputs.
42	Analog and digital outputs for indicating values such as frequency, reference, current and torque. The analog signal is 0/4 to 20 mA at a maximum of 500 Ω. The digital signal is 24 VDC at a minimum of 500 Ω.
50	10 VDC, 15 mA maximum analog supply voltage for potentiometer or thermistor.
53, 54	Selectable for 0 to 10 VDC voltage input, R = 10 kΩ, or analog signals 0/4 to 20 mA at a maximum of 200 Ω. Used for reference or feedback signals. A thermistor can be connected here.
55	Common for terminals 53 and 54.
61	RS-485 common.
68, 69	RS 485 interface and serial communication.

Term	18	19	27	29	32	33	37	53	54	42	1-3	4-6
Par.	E-01	E-02	E-03	E-04	E-05	E-06	E-07	AN-1#	AN-2#	AN-5#	E-24 [0]	E-24 [1]

Table 2.2: Control Terminals and Associated Parameter

Control terminals must be programmed. Each terminal has specific functions it is capable of performing and a numbered parameter associated with it. The setting selected in the parameter enables the function of the terminal. See the Operating Instructions for details.

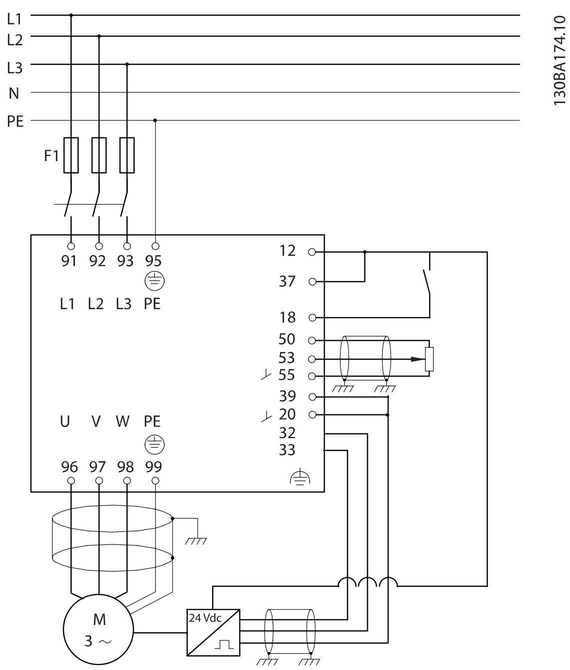


Illustration 2.4: Control Terminals Electrical Diagram

2.8 Earthing Screened Cables

It is recommended that screened control cables be connected with cable clamps at both ends to the metal cabinet of the frequency converter. The table below shows earth cabling for optimal results.

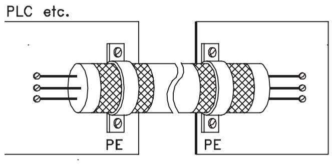
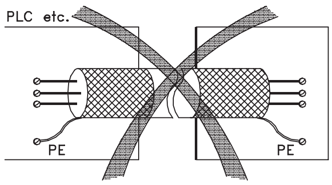
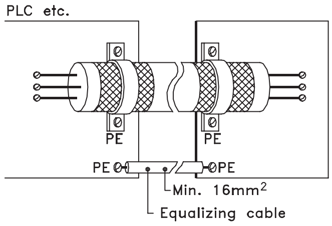
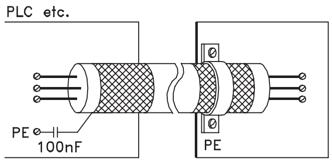
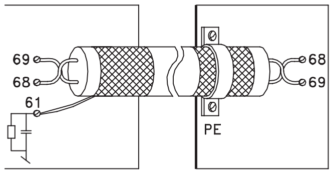
	**Correct earthing** Control cables and cables for serial communication must be fitted with cable clamps at both ends to ensure the best possible electrical connection.
	**Incorrect earthing** Do not use twisted cable ends (pigtails) since these increase screen impedance at high frequencies.
	**Earth potential protection** When the earth potential between the frequency converter and the PLC or other interface device is different, electrical noise may occur that can disturb 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 earth loops** When using very long control cables, 50/60 Hz earth loops may occur that can disturb the entire system. This can be resolved by connecting one end of the screen with a 100 nF capacitor and keeping the lead short.
 175ZA165.11	**Serial communication control cables** Low frequency noise currents between frequency converters can be eliminated by connecting one end of the screened cable to frequency converter terminal 61. This terminal connects to earth through an internal RC link. It is recommended to use twisted-pair cables to reduce the differential mode interference between conductors.

Table 2.3: Earthing Screened Cables

3 Internal Frequency Converter Operation

3.1 General

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

3.2 Description of Operation

A frequency converter is an electronic controller that supplies a regulated amount of AC power to a three phase induction motor in order to control the speed of the motor. By supplying variable frequency and voltage to the motor, the frequency converter controls the motor speed, or maintains a constant speed as the load on the motor changes. The frequency converter can also stop and start a motor without the mechanical stress associated with a line start.

In its basic form, the frequency converter can be divided into four main sections: rectifier, intermediate circuit, inverter, and control (see illustration below).

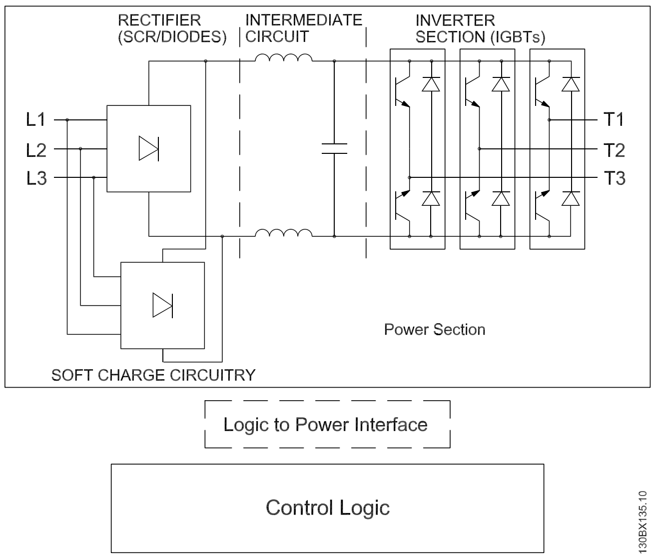


Illustration 3.1: Control Card Logic

To provide an overview, the main frequency converter components will be grouped into three categories consisting of the control logic section, logic to power interface, and power section. In the sequence of operation description, these three sections will be covered in greater detail while describing how power and control signals move throughout the frequency converter.

3

3.2.1 Logic Section

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

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

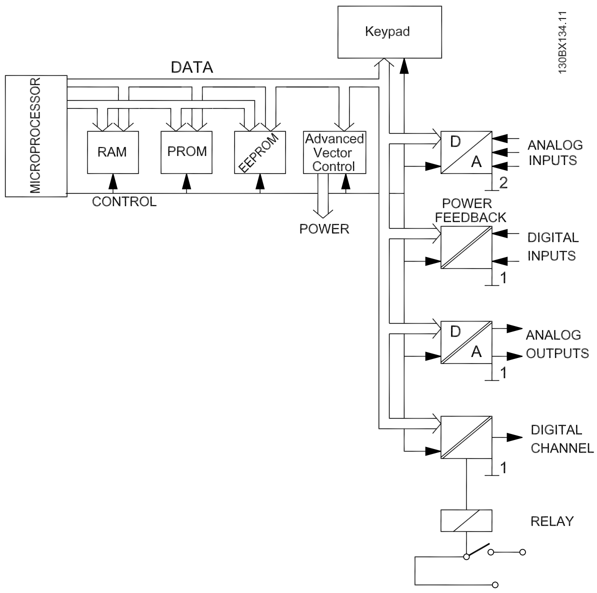


Illustration 3.2: Logic Section

The PWM waveform is created using a control scheme called Advanced Vector Control. Advanced Vector Control provides a variable frequency and voltage to the motor which matches the requirements of the motor. Also available is the continuous pulsing SFAVM PWM. Selection can be made in parameter F-26, F-27 and F-37, F-38. The dynamic response of the system changes to meet the variable requirements of the load.

Another part of the logic section is the Keypad. This is a removable keypad/display mounted on the front of the frequency converter. The Keypad provides the interface between the frequency converter's internal digital logic and the operator.

All the frequency converter's programmable parameter settings can be uploaded into the EEPROM of the Keypad. This function is useful for maintaining a backup frequency converter profile and parameter set. It can also be used, through its download function, in programming other frequency converters or to restore a program to a repaired unit. The Keypad is removable during operation to prevent undesired program changes. With the addition of a remote mounting kit, the Keypad can be mounted in a remote location of up to ten feet away.

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

The control card logic is capable of communicating via serial link with outside devices such as personal computers or programmable logic controllers (PLC).

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

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

Two relays for monitoring the status of the frequency converter are located on the power card. These are programmable through parameter group E-##. The relays are Form C, meaning it has one normally open contact and one normally closed contact on a single throw. The contacts of the relay are rated for a maximum load of 240 VAC at 2 Amps resistance.

The logic circuitry on the control card allow for the addition of option modules for synchronising control, serial communications, additional relays, the cascade pump controller, or custom operating software.

3.2.2 Logic to Power Interface

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

Much of the fault processing for output short circuit and earth fault conditions is handled by the control card. The power card provides conditioning of these signals. Scaling of current feedback and voltage feedback is accomplished by the control card.

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

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

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

3

3.2.3 Power Section

The high voltage power section consists of AC input terminals, AC and DC bus bars, fusing, harnessing, AC output, and optional components. The power section (see illustration below) also contains circuitry for the soft charge and SCR/diode modules in the rectifier; the DC bus filter circuitry containing the DC coils, often referred to as the intermediate or DC bus circuit; and the output IGBT modules which make up the inverter section.

In conjunction with the SCR/diode modules, the soft charge circuit limits the inrush current when power is first applied and the DC bus capacitors are charging. This is accomplished by the SCRs in the modules being held off while charging current passes through the soft charge resistors, thereby limiting the current. The DC bus circuitry smooths the pulsating DC voltage created by the conversion from the AC supply.

Each unit contains one DC coil per inverter module. Therefore the 61/63 units contain two DC coils and the 62/64 units contain three. The DC coil has two coils wound on a common core. One coil resides in the positive side of the DC bus and the other in the negative. The coil reduces mains harmonics.

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

The inverter section is made up of six IGBTs, commonly referred to as switches. Two switches are necessary for each phase of the three-phase power, for a total of six switches per IGBT module (half-phase per switch). Three IGBT modules run in parallel are contained in each inverter due to the high current handling requirements. Each inverter can be paralleled with one or two additional inverter modules to provide the required current for the power size.

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

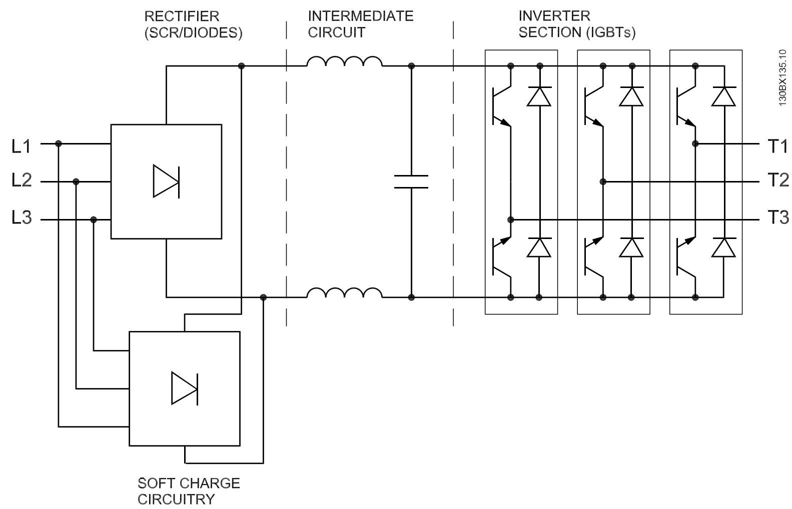


Illustration 3.3: Typical Power Section

3.3 Sequence of Operation

3.3.1 Rectifier and Option Cabinet

When input power is first applied to the frequency converter, it enters through the input terminals (L1, L2, L3) and on to the disconnect or/and RFI option, depending on the unit's configuration (see illustration 3-4). If equipped with optional fuses, these fuses (FU1, FU2, FU3) limit damage caused by a short circuit in the power section. The SCRs, in the combined SCR/diode modules, are not gated so current can travel to the rectifier on the soft charge card. The SCR and diode modules are separate. Additional fuses located on the soft charge card provide protection in the event of a short in the soft charge or fan circuits. Three phase power is also branched off and sent to the power card. It provides the power card with a reference of the main supply voltage and provides a supply voltage for the cooling fans.

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

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

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

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

As long as power is applied to the frequency converter, this voltage is present in the intermediate circuit and the inverter circuit. It is also fed to the Switch Mode Power Supply (SMPS) on the power card and is used for generating all other low voltage supplies.

During normal operation, the power card and control card are monitoring various functions within the frequency converter. The current sensors provide current feedback information. The DC bus voltage and mains voltage are monitored as well as the voltage delivered to the motor. A thermal sensor mounted on the heatsink for each rectifier module.

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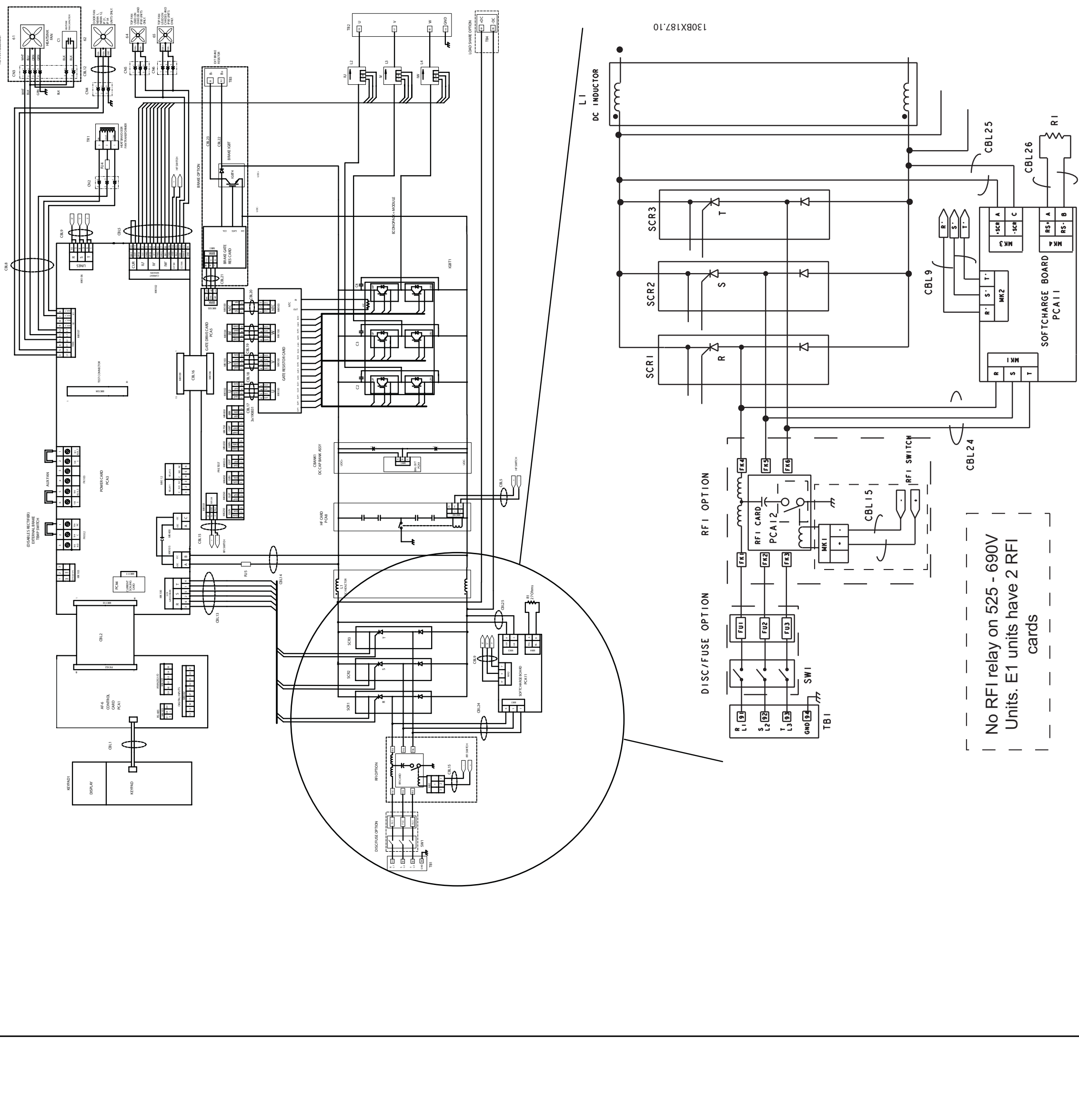

Illustration 3.4: Rectifier circuit

3.3.2 Intermediate Section

Following the rectifier section, voltage passes to the intermediate section. (See following illustration). This rectified voltage is smoothed by an LC filter circuit consisting of the DC bus inductor and the DC bus capacitor banks per each inverter module.

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

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

Also located in the intermediate section is the high frequency (HF) filter card for each inverter module. It contains a high frequency filter circuit to reduce naturally occurring currents in the HF range to prevent interference with other sensitive equipment in the area. The circuit, as with other RFI filter circuitry, can be sensitive to unbalanced phase-to-earth voltages in the three-phase AC input line. This can occasionally result in nuisance overvoltage alarms. For this reason, the high frequency filter card on 380–500 V range frequency converters, contains a set of relay contacts in the earth connection of the filter capacitors. The relay is tied into the RFI/HF switch, which can be switched on or off in par. SP-50 *RFI Filter*. This disconnects the earth references to all filters to eliminate nuisance overvoltage conditions created by an unbalanced phase-to-earth voltages.

For 525–690 V frequency converters, the customer may not open the relay contacts to disconnect the earthing via par. SP-50 *RFI Filter*, but the relay automatically opens based on the DC bus voltage to protect the drive.

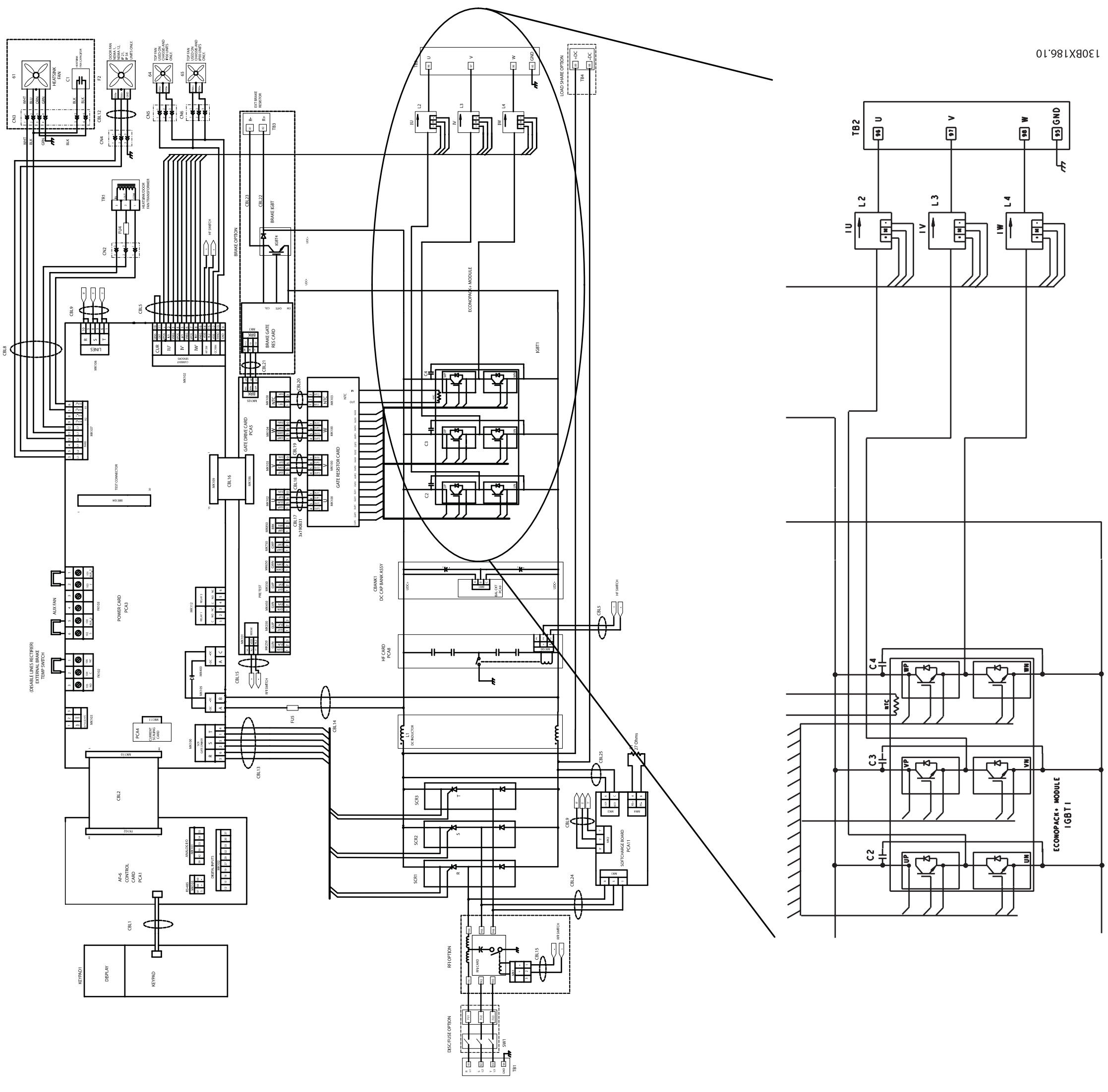

Illustration 3.5: Intermediate and inverter sections

3.3.3 Inverter Section

In the inverter section, gate signals are received from the control card (through the MDCIC), and sent to each inverter module's power card and the gate drive card to the IGBT gates. (See illustration titled*Intermediate and Inverter Sections).*The output of each IGBT, connected in series, first passes through the current sensors.

Once a run command and speed reference are present, the IGBTs begin switching to create the output waveform, as shown in the illustration below. Looking at the phase-to-phase voltage waveform with an oscilloscope, it can be seen that the Pulse Width Modulation (PWM) principal creates a series of pulses which vary in width. Basically, the pulses are narrower as zero crossing is approached and wider the farther from zero crossing. The width is controlled by the pulse duration of applied DC voltage. Although the voltage waveform is a consistent amplitude, the inductance within the motor windings will serve to average the voltage delivered and so, as the pulse width of the waveform varies, the average voltage seen by the motor varies as well. This then equates to the resultant current waveform which takes on the sine wave shape that we expect to see in an AC system. The frequency of the waveform is then determined by the rate at which the pulses occur. By employing a sophisticated control scheme, the frequency converter is capable of delivering a current waveform that nearly replicates a true AC sine wave.

This waveform, as generated by the GE Advanced Vector Control PWM principle at the control card, provides optimal performance and minimal losses in the motor.

Hall effect current sensors monitor the output current of each inverter module and deliver proportional signals via the power cards to the MDCIC where they are summed and buffered and delivered to the control card. These current signals are used by the control card logic to determine proper waveform compensations based on load conditions. They further serve to detect overcurrent conditions, including earth faults and phase-to-phase shorts on the output.

During normal operation, the power card and control card are monitoring various functions within the frequency converter. The current sensors provide current feedback information. The DC bus voltage and mains voltage are monitored as well as the voltage delivered to the motor. A thermal sensor mounted inside the middle IGBT module provides heatsink temperature feedback for each inverter module.

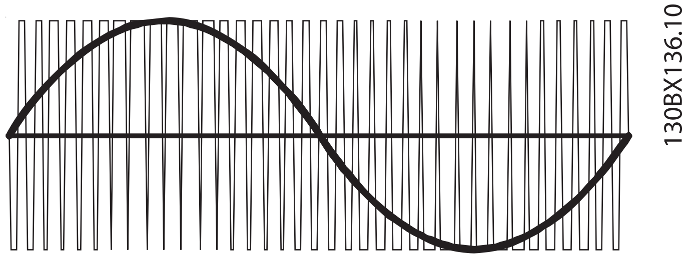

Illustration 3.6: Output Voltage and Current Waveforms

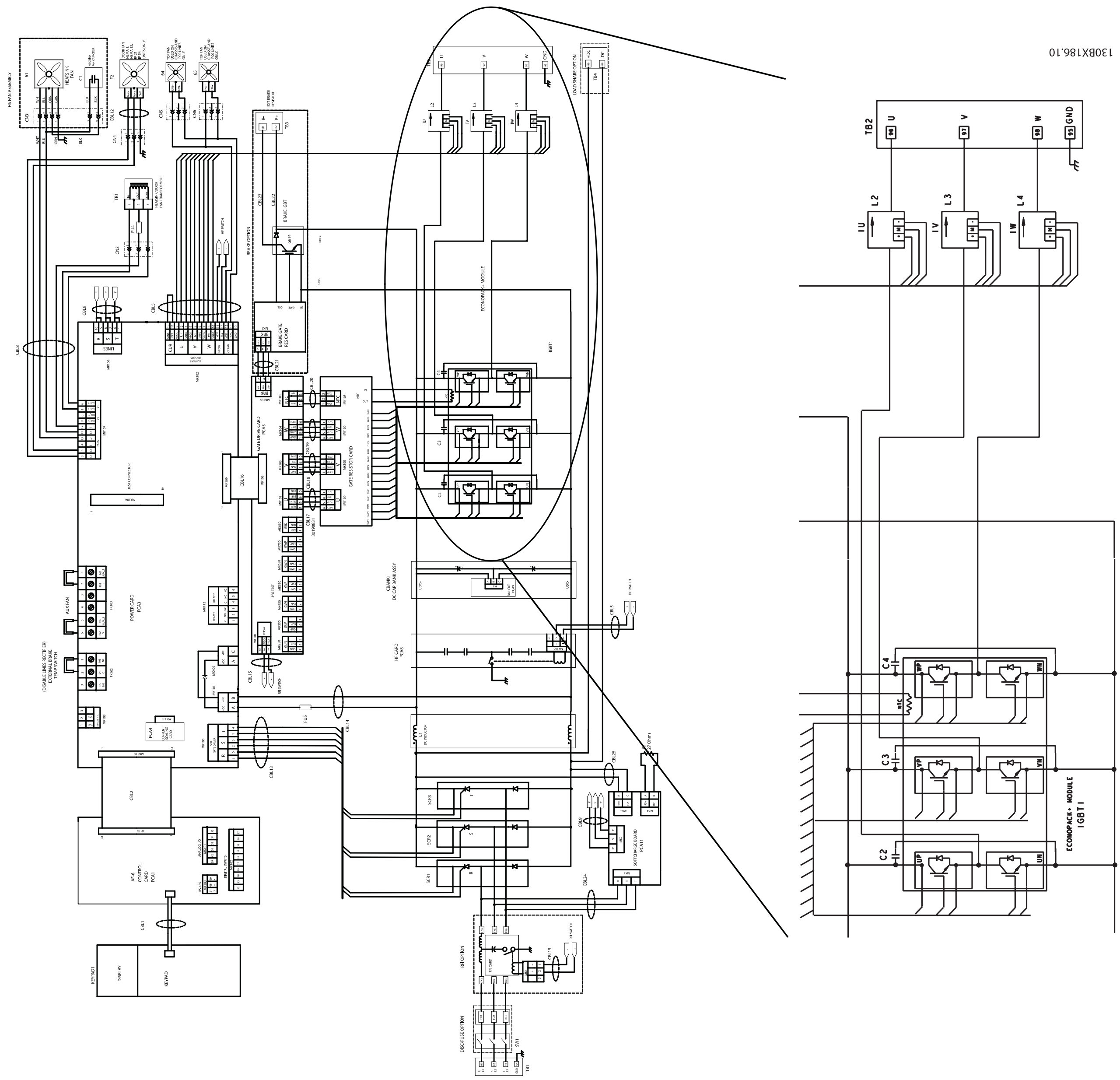

Illustration 3.7: Inverter section

3.3.4 Brake Option

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

The function of the brake IGBT (see Illustration *Brake Option*) is to limit the voltage in the intermediate circuit, whenever the maximum voltage limit is exceeded. It does this by switching the externally mounted resistor across the DC bus to remove excess DC voltage present on the bus capacitors. Excess DC bus voltage is generally a result of an overhauling load causing regenerative energy to be returned to the DC bus. This occurs, for example, when the load drives the motor causing the voltage to return to the DC bus circuit.

Placing the brake resistor externally has the advantages of selecting the resistor based on application need, dissipating the energy outside of the Keypad, and protecting the frequency converter from overheating if the brake resistor is overloaded.

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

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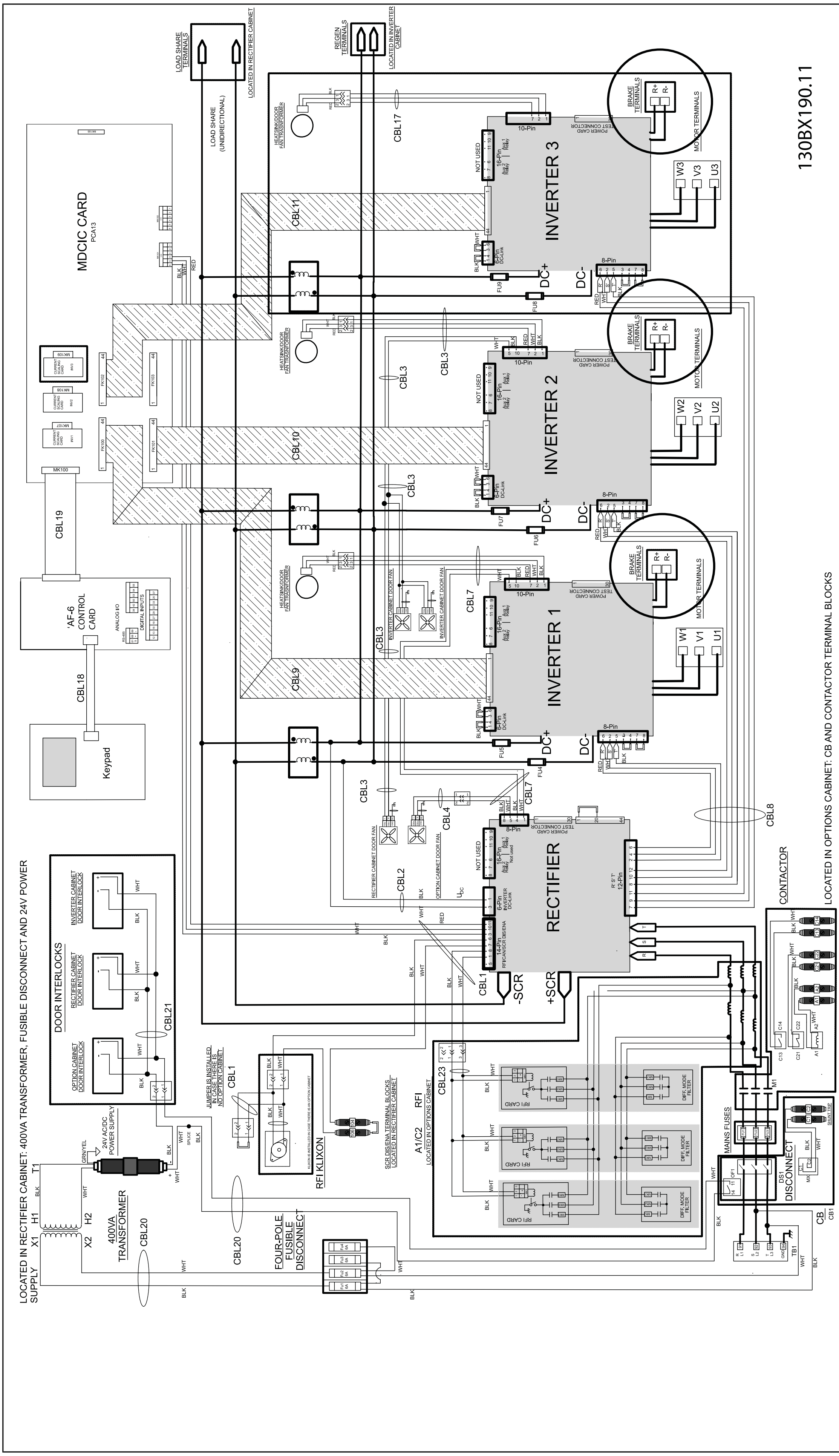

Illustration 3.8: Brake option

3.3.5 Cooling Fans

All frequency converters in this size range are equipped with cooling fans to provide airflow along the heatsinks and within the enclosures. All fans are powered by mains voltage which is stepped down by autotransformers and regulated to 200 or 230 VAC by circuitry provided on the power cards. On/off and high/low speed control of the fans is provided to reduce overall acoustical noise and extend the life of the fans.

Fans are activated by the following causes:

60% of nominal current exceeded

Specific heatsink temperature exceeded (power size dependent)

Specific power card ambient temperature exceeded

Specific control card ambient temperature exceeded

DC hold active

DC brake active

Pre-magnetization of the motor

Automatic motor adaptation in progress

Regardless of the heatsink temperature, the fans are started shortly after main input power is applied to the frequency converter.

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

3.3.6 Fan Speed Control

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

- 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	45° C
Fan low speed to high speed	50° C
Fan high speed to low speed	40° C
Fan turn OFF from low speed	30° C

Table 3.1: IGBT Thermal Sensor

- 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	45° C
Fan turn OFF from high speed	40° C
Fan turn ON to high speed	<10° C

Table 3.2: Power Card Ambient Temperature Sensor

- 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	55° C
Fan turn OFF from low speed	45° C

Table 3.3: Control Card Thermal Sensor

- Output current value. If the output current is greater than 60% of rated current, the fan will turn on low speed.

3.3.7 Load Sharing

Units with the built-in load sharing option contain terminals 89 (+) DC and 88 (-) DC. Within the frequency converter, these terminals connect to the DC bus in front of the DC link reactor and bus capacitors.

The use of the load sharing terminals can take on two different configurations.

In one method, the terminals are used to tie the DC bus circuits of multiple frequency converters together. This allows for the possibility of one frequency converter that is in a regenerative mode to share its excess bus voltage with another frequency converter that is in motoring mode. When applied correctly, this can reduce the need for external dynamic brake resistors while also saving energy. In theory, the number of frequency converters that can be connected in this way is infinite; however, the frequency converters must be of the same voltage rating. In addition, depending on the size and number of frequency converters, it may be necessary to install DC reactors and DC fuses are required in the DC link connections and AC reactors on the mains. Attempting such a configuration requires specific considerations .

In the second method, the frequency converter is powered exclusively from a DC source. This is a bit more complicated. First, a DC source is required. Second, a means to soft charge the DC bus at power up is required. Last, a mains voltage source is required to power the fans within the frequency converter.

3.3.8 Specific Card Connections

Connector FK102, terminals 104, 105 and 106 located on the power cards, provide for the connection of an external temperature switch. The input could be used to monitor the temperature of an external brake resistor. Two input configurations are possible. A normally closed switch may be connected between terminals 104 and 106 or a normally open switch between terminals 104 and 105. Should the input change states, the frequency converter would trip on an Alarm 27, *Brake IGBT Fault*. The input SCRs would also be disabled to prevent further energy from being supplied to the DC bus. If no such input is used, or the normally open configuration is selected, a jumper must be installed between terminals 104 and 106.

Connector FK103, terminals 100, 101, 102, and 103 located on the power cards, provide for the connection of mains voltage to allow powering the AC cooling fans from an external source. This is required when the frequency converter is used in a load sharing application where no AC power is provided to the main input terminals. To make use of this provision, the jumpers would be removed from terminals 100 and 102, 101 and 103. The auxiliary mains voltage power supply would be connected to terminals 100 and 101.

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

Terminal positions on the power card labelled MK400 and MK103 are reserved for future use.

4 Troubleshooting

4.1 Troubleshooting Tips

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

1. Ensure that no voltage is present on the frequency converter prior to troubleshooting. Check for the presence of AC input voltage and DC bus voltage and ensure there is none before working on the unit. **Remember that voltage may be present for as long as 40 minutes after removing power from the unit. See the label on the front of the frequency converter door for the specific discharge time.** Some points in the frequency converter are referenced to the negative DC bus and are at bus potential even though it may appear on diagrams to be a neutral reference.
2. If any of the DC bus fuses are blown, always ensure no DC bus voltage is present on either side of the DC fuses. When any DC bus fuse is blown, capacitor banks in the other inverter modules are no longer electrically connected. As a result, one inverter module may have stored voltage even when the rest of the unit has none.
3. Darkened LED lights on the Keypad does not mean that the drive has no dangerous internal voltage. Do not assume the unit contains no voltage when the indicator lights are off.
4. Never apply power to a unit that is suspected of being faulty. Many faulty components within the frequency converter can cause damage to other components when power is applied. Always perform the procedure for testing the unit after repair as described in Section *Test Procedures*.
5. With an external power supply and cable assembly, the logic section of the frequency converter can be powered without applying power to the rest of the unit. This method of power isolation is recommended for troubleshooting logic problems.
6. Never attempt to defeat any fault protection circuitry within the frequency converter. That will result in unnecessary component damage and may cause personal injury.
7. Always use factory approved replacement parts. The frequency converter has been designed to operate within certain specifications. Incorrect parts may affect tolerances and result in further damage to the unit.
8. Read the instruction and service manuals. A thorough understanding of the unit is the best approach. If ever in doubt, consult the factory or authorized repair centre for assistance.

4.2 Exterior Fault Troubleshooting

There may be slight differences in servicing a frequency converter that has been operational for some extended period of time compared to a new installation. When using proper troubleshooting procedures, make no assumptions. To assume a motor is wired properly because the frequency converter has been in service for some time may cause you to overlook loose connections, improper programming, or added equipment, for example. It is best to develop a detailed approach, beginning with a physical inspection of the system. See Table *Visual Inspection* for items to examine.

4.3 Fault Symptom Troubleshooting

This troubleshooting section is divided into sections based on the symptom being experienced. To start the following table provides a visual inspection check list. Many times the root cause of the problem may be due to the way the frequency converter has been installed or wired. The check list provides guidance through a variety of items to inspect during any frequency converter service process.

Next, symptoms are approached as the technician most commonly discovers them: reading an unrecognised frequency converter display, problems with motor operation, or a warning or alarm displayed by the frequency converter. Remember, the frequency converter processor monitors inputs and outputs as well as internal frequency converter functions, so an alarm or warning does not necessary indicate a problem within the frequency converter itself.

Each incident has further descriptions on how to troubleshoot that particular symptom. When necessary, further referrals are made to other parts of the manual for additional procedures. The section *Frequency Converter and Motor Applications* presents detailed discussions on areas of frequency converter and system troubleshooting that an experienced repair technician should understand in order to make effective diagnoses.

Finally, a list of tests called After Repair Tests is provided. These tests should always be performed when first starting a frequency converter, when approaching a frequency converter that is suspected of being faulty, or anytime following a repair to the frequency converter.

4.4 Visual Inspection

The table below lists a variety of conditions that require visual inspection as part of any initial troubleshooting procedure.

Inspect For	Description
Auxiliary equipment	Look for auxiliary equipment, switches, disconnects, or input fuses/circuit breakers that may reside on either the input power side of frequency converter or the output side to motor. Examine the operation and condition of these items for possible causes of operational faults. Check the function and installation of pressure sensors or encoders or other devises that provide feedback to the frequency converter.
Cable routing	Avoid routing motor wiring, mains wiring, and signal wiring in parallel. If parallel routing is unavoidable, try to maintain a separation of 150-200 mm (6–8 inches) between the cables or separate them with an earthed conductive partition. Avoid routing cables through free air. For unscreened cabling, run input power and motor power in separate conduit.
Control wiring	Check for broken or damaged wires and connections. Check the voltage source of the signals. The use of screened cable or a twisted pair is recommended. Ensure the screen is terminated correctly. For unscreened control wiring, run in separate conduit from power cabling.
Drive cooling	Check the operational status of all cooling fans. Check the door filters on NEMA 12 (IP54) units. Check for blockage or constrained air passages. Make sure the bottom gland plate is installed.
Drive display	Warnings, alarms, drive status, fault history and many other important items are available via the Keypad on the drive.
Drive interior	The frequency converter interior must be free of dirt, metal chips, moisture, and corrosion. Check for burnt or damaged power components or carbon deposits resulting from catastrophic component failure. Check for cracks or breaks in the housings of power semiconductors, or pieces of broken component housings loose inside the unit.
EMC considerations	Check for proper installation with regard to electromagnetic capability.
Environmental conditions	Under specific conditions, these units can be operated within a maximum ambient of 55° C (131° F). Humidity levels must be less than 95% noncondensing. Check for harmful airborne contaminates such as sulphur based compounds.
Earthing	The frequency converter requires a dedicated earth wire from its chassis to the building earth. It is also suggested that the motor be earthed to the frequency converter chassis as well. The use of a conduit or mounting the frequency converter onto a metal surface is not considered a suitable earth. Check for good earth connections that are tight and free of oxidation.
Input power wiring	Check for loose connections. Check for proper fusing. Check for blown fuses.
Motor	Check the nameplate ratings of the motor. Ensure that the motor ratings coincide with the frequency converters. Make sure that the frequency converter's motor parameters (P-##) are set according to the motor ratings.
Output to motor wiring	Check for loose connections. Check for switching components in the output circuit. Check for faulty contacts in the switch gear.
Programming	Make sure that the frequency converter parameter settings are correct according to motor, application, and I/O configuration.
Proper clearance	Frequency converters require adequate top and bottom clearance to ensure proper air flow for cooling.
Vibration	Look for any unusual amount of vibration that the frequency converter may be subjected to. The unit should be mounted solidly or the use of shock mounts employed.

Table 4.1: Visual Inspection

4.5 Fault Symptoms

4.5.1 No Display

To troubleshoot no display:

Check that power is supplied.

Cycle power to the unit.

Restore the drive. (See section *Tips and Tricks*.)

4.5.2 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 frequency converter 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 frequency converter). 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.

4.5.3 Motor Will not Run

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

Keypad Stop

The [Off] key has been pressed.

Press the [Auto] or [Hand] key.

Standby

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

Ensure that a start command is present at terminal 18. Refer to the *Input Terminal Signal Test*.

Run OK, 0 Hz

This indicates that a run command has been given to the frequency converter but the reference (speed command) is zero or missing.

Check the control wiring to ensure that the proper reference signal is present at the frequency converter input terminals and that the unit is properly programmed to accept the signal provided. Refer to the Input Terminal Signal Test.

Off 1 (2 or 3)

This indicates that bit #1 (or #2, or #3) in the PROFIdrive control word is logic “0”. This will only occur when the frequency converter is being controlled via the PROFIBBUS network.

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

STOP

One of the digital input terminals 18, 19, 27, 29, 32, or 33 (parameter E-0#) is programmed for *Stop Inverse* and the corresponding terminal is low (logic “0”).

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

4.5.4 Incorrect Motor Operation

Occasionally, a fault can occur where the motor will continue to run, but not in the correct manner. The symptoms and causes may vary considerably. Many of the possible problems are listed below by symptom along with recommended procedures for determining their causes.

Wrong speed/unit will not respond to command

Possible incorrect reference (speed command).

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

Motor speed unstable

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

Check the settings of all motor parameters, including all motor compensation settings (Slip Compensation, Load Compensation, etc.) For Closed Loop operation, check PID settings.

Motor runs rough

Possible over-magnetization (incorrect motor settings), or an IGBT misfiring. Note: Motor may also stall when loaded or the frequency converter may trip occasionally on Alarm 13.

Check setting of all motor parameters.

Motor draws high current but cannot start

Possible open winding in motor or open phase in connection to motor.

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

Motor will not brake

Possible fault in the brake circuit. Possible incorrect setting in the brake parameters. The decel time too short. Note: May be accompanied by an alarm or warning message.

Check all brake parameters and decel time (parameters B-0#).

4.6 Alarms and Warnings

A warning or an alarm is signalled by the relevant LED on the front of the frequency converter and indicated by a code on the display.

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

In the event of an alarm, the frequency converter will have tripped. Alarms must be reset to restart operation once their cause has been rectified. This may be done in four ways:

1. By using the [Reset] control button on the Keypad.
2. Via a digital input with the “Reset” function.
3. Via serial communication/optional network.
4. By resetting automatically using the [Auto Reset] function.

NB!
After a manual reset using the [RESET] button on the Keypad, the [Auto] button must be pressed to restart the motor.

If an alarm cannot be reset, the reason may be that its cause has not been rectified, or the alarm is trip-locked (see also table on following page).

Alarms that are trip-locked offer additional protection, since the mains supply must be switched off before the alarm can be reset. After being switched back on, the frequency converter is no longer blocked and may be reset as described above once the cause has been rectified.

Alarms that are not trip-locked can also be reset using the automatic reset function in par. H-04 *Auto-Reset (Times)* (Warning: automatic wake-up is possible!)

If a warning and alarm is marked against a code in the table on the following page, this means that either a warning occurs before an alarm, or it can be specified whether it is a warning or an alarm that is to be displayed for a given fault.

This is possible, for instance, in par. F-10 *Electronic Overload* After an alarm or trip, the motor carries on coasting, and the alarm and warning flash on the frequency converter. Once the problem has been rectified, only the alarm continues flashing.

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock	Parameter Reference
1	10 Volts low	X			
2	Live zero error	(X)	(X)		AN-01
3	No motor	(X)			H-80
4	Mains phase loss	(X)	(X)	(X)	SP-12
5	DC link voltage high	X			
6	DC link voltage low	X			
7	DC over voltage	X	X		
8	DC under voltage	X	X		
9	Inverter overloaded	X	X		
10	Motor Electronic Thermal Overload over temperature	(X)	(X)		F-10
11	Motor thermistor over temperature	(X)	(X)		F-10
12	Torque limit	X	X		
13	Over Current	X	X	X	
14	Earth fault	X	X	X	
15	Hardware mismatch		X	X	
16	Short Circuit		X	X	
17	Control word timeout	(X)	(X)		O-04
22	Hoist mechanical brake		X		
23	Internal fans	X			B-2#
24	External fans	X			SP-53
25	Brake resistor short-circuited	X			
26	Brake resistor power limit	(X)	(X)		B-13
27	Brake chopper short-circuited	X	X		
28	Brake check	(X)	(X)		B-15
29	Heatsink temp	X	X	X	
30	Motor phase U missing	(X)	(X)	(X)	H-78
31	Motor phase V missing	(X)	(X)	(X)	H-78
32	Motor phase W missing	(X)	(X)	(X)	H-78
33	Inrush fault		X	X	
34	Network communication fault	X	X		
36	Mains failure	X	X		
37	Phase imbalance		X		
38	Internal fault		X	X	
39	Heatsink sensor		X	X	
40	Overload of Digital Output Terminal 27	(X)			E-00 & E-51
41	Overload of Digital Output Terminal 29	(X)			E-00 & E-52
42	Overload of Digital Output on X30/6 or Overload of Digital Output on X30/7	(X)			E-56 & E-57
45	Earth fault 2	X	X	X	
46	Power card supply		X	X	
47	24 V supply low	X	X	X	
48	1.8 V supply low		X	X	
49	Speed limit	X	X		
50	Auto Tune calibration failed		X		
51	Auto Tune check U_{nom} and I_{nom}		X		
52	Auto Tune low I_{nom}		X		
53	Auto Tune motor too big		X		
54	Auto Tune motor too small		X		
55	Auto Tune parameter out of range		X		
56	Auto Tune interrupted by user		X		
57	Auto Tune timeout		X		
58	Auto Tune internal fault	X	X		
59	Current limit	X			
60	External interlock	X	X		
61	Tracking Error	(X)	(X)		H-20
62	Output Frequency at Maximum Limit	X			
63	Mechanical brake low		(X)		B-20

Table 4.2: Alarm/Warning code list

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock	Parameter Reference
64	Voltage Limit	X			
65	Control Board Over-temperature	X	X	X	
66	Heat sink Temperature Low	X			
67	Option Configuration has Changed		X		
68	Safe Stop Activated		X		E-07
69	Power card temperature		X	X	
70	Illegal Drive configuration				
71	PTC 1 safe stop	X	X	X	E-07
72	Dangerous failure	X	X	X	E-07
73	Safe stop auto restart	X			E-07
76	Power unit setup	X			
77	Reduced power mode	X			SP-59
78	Tracking error		X		H-24
79	Illegal PS config		X	X	
80	Drive Restored to Default Value		X		
81	CSIV corrupt		X		
82	CSIV parameter error		X		
90	Feedback Monitor	(X)	(X)		EC-61
91	Analog input 54 wrong settings			X	
92	No-Flow	X	X		AP-2#
93	Dry Pump	X	X		AP-2#
94	End of Curve	X	X		AP-5#
95	Broken Belt	X	X		AP-6#
96	Start Delayed	X			AP-7#
97	Stop Delayed	X			AP-7#
98	Clock Fault	X			K-7#
200	Fire mode	(X)			FB-00
201	Fire mode was active	(X)			
202	Fire mode limits exceeded	(X)			
243	Brake IGBT	X	X		
244	Heatsink temperature	X	X	X	
245	Heatsink sensor		X	X	
246	Power card supply		X	X	
247	Power card temperature		X	X	
248	Illegal PS config		X	X	
250	New spare part			X	
251	New model number		X	X	

Table 4.3: Alarm/Warning code list, continued..

(X) Dependent on parameter

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

Alarm Word and Extended Status Word

Bit	Hex	Dec	Alarm Word	Warning Word	Extended Status Word
0	00000001	1	Brake Check	Brake Check	Ramping
1	00000002	2	Pwr. Card Temp	Pwr. Card Temp	Auto Tune Running
2	00000004	4	Earth Fault	Earth Fault	Start CW/CCW
3	00000008	8	Ctrl.Card Temp	Ctrl.Card Temp	Slow Down
4	00000010	16	Ctrl. Word TO	Ctrl. Word TO	Catch Up
5	00000020	32	Over Current	Over Current	Feedback High
6	00000040	64	Torque Limit	Torque Limit	Feedback Low
7	00000080	128	Motor Th Over	Motor Th Over	Output Current High
8	00000100	256	Motor Electronic Thermal Overload Over	Motor Electronic Thermal Overload Over	Output Current Low
9	00000200	512	Inverter Overld.	Inverter Overld.	Output Freq High
10	00000400	1024	DC under Volt	DC under Volt	Output Freq Low
11	00000800	2048	DC over Volt	DC over Volt	Brake Check OK
12	00001000	4096	Short Circuit	DC Voltage Low	Braking Max
13	00002000	8192	Inrush Fault	DC Voltage High	Braking
14	00004000	16384	Mains ph. Loss	Mains ph. Loss	Out of Speed Range
15	00008000	32768	Auto Tune Not OK	No Motor	OVC Active
16	00010000	65536	Live Zero Error	Live Zero Error	
17	00020000	131072	Internal Fault	10V Low	
18	00040000	262144	Brake Overload	Brake Overload	
19	00080000	524288	U phase Loss	Brake Resistor	
20	00100000	1048576	V phase Loss	Brake IGBT	
21	00200000	2097152	W phase Loss	Speed Limit	
22	00400000	4194304	Network Fault	Network Fault	
23	00800000	8388608	24 V Supply Low	24V Supply Low	
24	01000000	16777216	Mains Failure	Mains Failure	
25	02000000	33554432	1.8V Supply Low	Current Limit	
26	04000000	67108864	Brake Resistor	Low Temp	
27	08000000	134217728	Brake IGBT	Voltage Limit	
28	10000000	268435456	Option Change	Unused	
29	20000000	536870912	Drive Restored	Unused	
30	40000000	1073741824	Safe Stop	Unused	

Table 4.4: Description of Alarm Word, Warning Word and Extended Status Word

The alarm words, warning words and extended status words can be read out via serial bus or optional network for diagnosis. See also par. DR-90 *Alarm Word*, par. DR-92 *Warning Word* and par. DR-94 *Ext. Status Word*.

4

4.6.1 Warning/Alarm List

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

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 2, Live zero error:
This warning or alarm will only appear if programmed by the user in par. AN-01 *Live Zero Timeout Function* . The signal on one of the analog inputs is less than 50% of the minimum value programmed for that input. This condition can be caused by broken wiring or faulty device sending the signal.

Troubleshooting: Check the connections on all the analog input terminals. Control card terminals 53 and 54 for signals, terminal 55 common. OPCGPIO General Purpose I/O Option Module terminals 11 and 12 for signals, terminal 10 common. OPCAIO analog I/O Option Module terminals 1, 3, 5 for signals, terminals 2, 4, 6 common). Make sure that the frequency converter programming and switch settings match the analog signal type.

WARNING/ALARM 3, No motor:
No motor has been connected to the output of the frequency converter.

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

WARNING/ALARM 4, Mains phase loss:
A phase is missing on the supply side, or the mains voltage imbalance is too high. This message also appears for a fault in the input rectifier on the frequency converter. Options are programmed at par. SP-12 *Function at Line Imbalance*.

Troubleshooting: Check the supply voltage and supply currents to the frequency converter.

WARNING 5, DC link voltage high:
The intermediate circuit voltage (DC) is higher than the overvoltage limit of the control system. The frequency converter is still active.

WARNING 6, DC link voltage low
The intermediate circuit voltage (DC) is below the undervoltage limit of the control system. The frequency converter is still active.

WARNING/ALARM 7, DC over voltage:
If the intermediate circuit voltage exceeds the limit, the frequency converter trips after a time.
Connect a brake resistor. Extend the ramp time

Troubleshooting:

- Connect a brake resistor
- Extend the ramp time
- Change the ramp type
- Activate functions in par. B-10 *Brake Function*
- Increase par. SP-26 *Trip Delay at Drive Fault*

Alarm/warning limits:

Voltage ranges	3 x 380 - 480/500 V	3 x 525 - 690 V
	[VDC]	[VDC]
Undervoltage	373	553
Voltage warning low	410	585
Voltage warning high (w/o brake - w/brake)	810/840	1099/1109
Overvoltage	855	1130

The voltages stated are the intermediate circuit voltage of the frequency converter with a tolerance of ± 5 %. The corresponding mains voltage is the intermediate circuit voltage (DC-link) divided by 1.35

WARNING/ALARM 8, DC under voltage:
If the intermediate circuit voltage (DC) drops below the "voltage warning low" limit, the frequency converter checks if 24 V backup supply is connected.
If no 24 V backup supply is connected, the frequency converter trips after a given time depending on the unit.
To check whether the supply voltage matches the frequency converter, see *Specifications*.

Troubleshooting: Make sure that the supply voltage matches the frequency converter voltage.

WARNING/ALARM 9, Inverter overloaded:
The frequency converter is about to cut out because of an overload (too high current for too long). The counter for electronic, thermal inverter protection gives a warning at 98% and trips at 100%, while giving an alarm. Reset cannot be performed before counter is below 90%.
The fault is that the frequency converter is overloaded by more than 100% for too long.

Troubleshooting:

- Compare the output current shown on the Keypad with the frequency converter rated current.
- Compare the output current shown on the Keypad with measured motor current.
- Display the Thermal Drive Load on the Keypad and monitor the value.
- When running above the frequency converter continuous current rating, the counter should increase.
- When running below the frequency converter continuous current rating, the counter should decrease.

WARNING/ALARM 10, Motor Electronic Thermal Overload over temperature:
According to the electronic thermal protection (Electronic Thermal Overload), the motor is too hot. It can be chosen if the frequency converter is to give a warning or an alarm when the counter reaches 100% in par. F-10 *Electronic Overload* . The fault is that the motor is overloaded by more than 100% for too long. Check that par. P-03 *Motor Current* is set correctly.

Troubleshooting:

- Check if motor is overheating.
- If the motor is mechanically overloaded.
- That the par. P-03 *Motor Current* is set correctly.
- Motor data in par. P-07 *Motor Power [kW]* through par. P-06 *Base Speed* are set correctly.
- The setting in par. F-11 *Motor External Fan*.
- Run Auto Tune in par. P-04 *Auto Tune*.

WARNING/ALARM 11, Motor thermistor over temp:
The thermistor or the thermistor connection is disconnected. Choose if the frequency converter is to give a warning or an alarm. Check that the thermistor is connected correctly between terminal 53 or 54 (analog voltage input) and terminal 50 (+ 10 Volts supply), or between terminal 18 or 19 (digital input PNP only) and terminal 50. If a KTY sensor is used, check for correct connection between terminal 54 and 55.

Troubleshooting:

- Check if motor is overheating.
- If the motor is mechanically overloaded.
- Check that the thermistor is connected correctly between terminal 53 or 54 (analog voltage input) and terminal 50 (+10 V supply), or between terminal 18 or 19 (digital input PNP only) and terminal 50.
- If a KTY sensor is used, check for correct connection between terminal 54 and 55.
- If using a thermal switch or thermistor, check the programming of par. F-12 *Motor Thermistor Input* matches sensor wiring.
- If using a KTY sensor, check the programming of par. H-95 *KTY Sensor Type*, par. H-96 *KTY Thermistor Input* and par. H-97 *KTY Threshold level* match sensor wiring.

WARNING/ALARM 12, Torque limit:
The torque is higher than the value in par. F-40 *Torque Limiter (Driving)* (in motor operation) or the torque is higher than the value in par. F-41 *Torque Limiter (Braking)* (in regenerative operation). Par. SP-25 *Trip Delay at Torque Limit* can be used to change this from a warning only condition to a warning followed by an alarm.

WARNING/ALARM 13, Over Current:
The inverter peak current limit (approx. 200% of the rated current) is exceeded. Turn off the frequency converter and check if the motor shaft can be turned and if the motor size matches the frequency converter.

Troubleshooting: This fault may be caused by shock loading or fast acceleration with high inertia loads. Turn off the frequency converter. Check if the motor shaft can be turned. Make sure that the motor size matches the frequency converter. Incorrect motor data in par. P-07 *Motor Power [kW]* through par. P-06 *Base Speed*.

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

Troubleshooting:

Turn off the frequency converter and remove the earth fault.

Measure the resistance to earth of the motor leads and the motor with a megohmmeter to check for earth faults in the motor.

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

Par. ID-40 *Drive Type*

Par. ID-41 *Power Section*

Par. ID-42 *Voltage*

Par. ID-43 *Software Version*

Par. ID-45 *Actual Typecode String*

Par. ID-49 *SW ID Control Card*

Par. ID-50 *SW ID Power Card*

Par. ID-60 *Option Mounted*

Par. ID-61 *Option SW Version*

ALARM 16, Short-circuit:
There is short-circuiting in the motor or on the motor terminals.
Turn off the frequency converter and remove the short-circuit.

WARNING/ALARM 17, Control word timeout:
There is no communication to the frequency converter.
The warning will only be active when par. O-04 *Control Word Timeout Function* is NOT set to *OFF*.
If par. O-04 *Control Word Timeout Function* is set to *Stop* and *Trip*, a warning appears and the frequency converter decels until it trips, while giving an alarm.
Par. O-03 *Control Word Timeout Time* could possibly be increased.

Troubleshooting:

Check connections on the serial communication cable.

Increase par. O-03 *Control Word Timeout Time*.

Check the operation of the communication equipment.

Verify a proper installation based on EMC requirements.

WARNING 22, Hoist mechanical brake
The report value will show what kind it is.
0 = The torque reference was not reached before time-out.
1 = There was no brake feedback before the time-out.

4

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 par. SP-53 *Fan Monitor* ([0] Disabled).
For the unit size 4x, 5x, and 6x frequency converters, the regulated voltage to the fans is monitored.

Troubleshooting:

Check fan resistance.

Check soft charge fuses.

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 par. SP-53 *Fan Monitor* ([0] Disabled).
For the unit size 4x, 5x, and 6x frequency converters, the regulated voltage to the fans is monitored.

Troubleshooting:

Check fan resistance.

Check soft charge fuses.

WARNING 25, Brake resistor short-circuited:

The brake resistor is monitored during operation. If it short-circuits, the brake function is disconnected and the warning appears. The frequency converter still works, but without the brake function. Turn off the frequency converter and replace the brake resistor (see par. B-15 *Brake Check*.

ALARM/WARNING 26, Brake resistor power limit:

The power transmitted to the brake resistor is calculated as a percentage, as a mean value over the last 120 s, on the basis of the resistance value of the brake resistor (par. B-11 *Brake Resistor (ohm)*) and the intermediate circuit voltage. The warning is active when the dissipated braking power is higher than 90%. If *Trip* [2] has been selected in par. B-13 *Braking Thermal Overload*, the frequency converter cuts out and issues this alarm, when the dissipated braking power is higher than 100%.

ALARM/WARNING 27, Brake chopper fault:

The brake transistor is monitored during operation and if it short-circuits, the brake function disconnects and the warning comes up. The frequency converter is still able to run, but since the brake transistor has short-circuited, substantial power is transmitted to the brake resistor, even if it is inactive. Turn off the frequency converter and remove the brake resistor.

This alarm/warning could also occur should the brake resistor overheat. Terminal 104 to 106 are available as brake resistor. Klixon inputs, see section Brake Resistor Temperature Switch.

Troubleshooting:

Warning: There is a risk of substantial power being transmitted to the brake resistor if the brake transistor is short-circuited.

ALARM/WARNING 28, Brake check failed:

Brake resistor fault: the brake resistor is not connected/working.

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 frequency converter power size.

Troubleshooting:

Ambient temperature too high.

Motor cable too long.

Incorrect clearance above and below the frequency converter.

Dirty heatsink.

Blocked air flow around the frequency converter.

Damaged heatsink fan.

For the unit size 4x, 5x, and 6x frequency converters, this alarm is based on the temperature measured by the heatsink sensor mounted inside the IGBT modules. For the unit size 6x frequency converters, this alarm can also be caused by the thermal sensor in the rectifier module.

Check fan resistance.

Check soft charge fuses.

IGBT thermal sensor.

ALARM 30, Motor phase U missing:

Motor phase U between the frequency converter and the the motor is missing. Turn off the frequency converter and check motor phase U.

ALARM 31, Motor phase V missing:

Motor phase V between the frequency converter and the motor is missing. Turn off the frequency converter and check motor phase V.

ALARM 32, Motor phase W missing:

Motor phase W between the frequency converter and the motor is missing. Turn off the frequency converter and check motor phase W.

ALARM 33, Inrush fault:

Too many power-ups have occurred within a short time period. Let the unit cool to operating temperature.
See the chapter *Specifications* for the allowed number of power-ups within one minute.

WARNING/ALARM 34, Network communication fault:

The network on the communication option card is not working.

WARNING 35, Out of frequency range:

This warning is active if the output frequency has reached par. H-72 *Warning Speed Low* or par. H-73 *Warning Speed High*. If the frequency converter is set to *closed loop [3]* in par. H-40 *Configuration Mode*, the warning is active in the display. If the frequency converter is not in this mode bit 008000 Out of *frequency range* in extended status word is active but there is no warning in the display.

WARNING/ALARM 36, Mains failure

This warning/alarm is only active if the supply voltage to the frequency converter is lost and par. SP-10 *Line failure* is NOT set to OFF. Check the fuses to the frequency converter

ALARM 37, Phase imbalance:

There is a current imbalance between the units.

ALARM 38, Internal fault:

Contact the local GE supplier.

0	Serial port cannot be restored. Serious hardware failure
256-258	Power EEPROM data is defect or too old
512	Control board EEPROM data is defect or too old
513	Communication time out reading EEPROM data
514	Communication time out reading EEPROM data
515	Application Orientated Control cannot recognize the EEPROM data
516	Cannot write to the EEPROM because a write command is on progress
517	Write command is under time out
518	Failure in the EEPROM
519	Missing or invalid Barcode data in EEPROM
783	Parameter value outside of min/max limits
1024-1279	A can message that has to be sent, couldn't be sent
1281	Digital Signal Processor flash timeout
1282	Power micro software version mismatch
1283	Power EEPROM data version mismatch
1284	Cannot read Digital Signal Processor software version
1299	Option SW in slot A is too old
1300	Option SW in slot B is too old
1301	Option SW in slot C0 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)
1317	Option SW in slot C0 is not supported (not allowed)
1318	Option SW in slot C1 is not supported (not allowed)
1379	Option A did not respond when calculating Platform Version.
1380	Option B did not respond when calculating Platform Version.
1381	Option C0 did not respond when calculating Platform Version.
1382	Option C1 did not respond when calculating Platform Version.
1536	An exception in the Application Orientated Control is registered. Debug information written in Keypad
1792	DSP watchdog is active. Debugging of power part data Motor Orientated Control data not transferred correctly
2049	Power data restarted
2064-2072	H081x: option in slot x has restarted
2080-2088	H082x: option in slot x has issued a powerup-wait
2096-2104	H083x: option in slot x has issued a legal powerup-wait
2304	Could not read any data from power EEPROM
2305	Missing SW version from power unit
2314	Missing power unit data from power unit
2315	Missing SW version from power unit
2316	Missing io_statepage from power unit
2324	Power card configuration is determined to be incorrect at power up
2325	A power card has stopped communicating while main power is applied
2326	Power card configuration is determined to be incorrect after the delay for power cards to register
2327	Too many power card locations have been registered as present
2330	Power size information between the power cards does not match
2561	No communication from DSP to ATACD
2562	No communication from ATACD to DSP (state running)
2816	Stack overflow Control board module
2817	Scheduler slow tasks
2818	Fast tasks
2819	Parameter thread
2820	Keypad Stack overflow
2821	Serial port overflow
2822	USB port overflow
2836	cfListMempool to small
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	Out of memory

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 the short-circuit connection. Check par. E-00 *Digital I/O Mode* and par. E-51 *Terminal 27 Mode*.

WARNING 41, Overload of Digital Output Terminal 29

Check the load connected to terminal 29 or remove the short-circuit connection. Check par. E-00 *Digital I/O Mode* and par. E-52 *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 par. E-56 *Term X30/6 Digi Out (OPCGPIO)*(OPCGPIO General Purpose I/O Option Module).

For X30/7, check the load connected to X30/7 or remove the short-circuit connection. Check par. E-57 *Term X30/7 Digi Out (OPCGPIO)* (OPCGPIO General Purpose I/O Option Module).

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, 5V, +/- 18V. When powered with 24 VDC with the OPC24VPS 24 V DC External Supply Module option, only the 24 V and 5 V supplies are monitored. When powered with three phase mains voltage, all three supplied are monitored.

WARNING 47, 24 V supply low:

The external 24 V DC backup power supply may be overloaded, otherwise contact the local GE supplier.

WARNING 48, 1.8 V supply low:

The 1.8 Volt DC supply used on the control card is outside of allowable limits. The power supply is measured on the control card.

ALARM 49, Speed Limit:

When the speed is not within the specified range in par. F-18 *Motor Speed Low Limit [RPM]* and par. F-17 *Motor Speed High Limit [RPM]* the drive will show a warning. When the speed is below the specified limit in par. H-36 *Trip Speed Low [RPM]* (except when starting or stopping) the drive will trip.

ALARM 50, Auto Tune calibration failed:

Contact the local GE supplier.

ALARM 51, Auto Tune check Unom and Inom:

The setting of motor voltage, motor current, and motor power is presumably wrong. Check the settings.

ALARM 52, Auto Tune low Inom:

The motor current is too low. Check the settings.

ALARM 53, Auto Tune motor too big:

The motor is too big for the Auto Tune to be carried out.

ALARM 54, Auto Tune motor too small:

The motor is too small for the Auto Tune to be carried out.

ALARM 55, Auto Tune parameter out of range:

The parameter values found from the motor are outside acceptable range.

ALARM 56, Auto Tune interrupted by user:

The Auto Tune has been interrupted by the user.

ALARM 57, Auto Tune timeout:

Try to start the Auto Tune again a number of times, until the Auto Tune is carried out. Please note that repeated runs may heat the motor to a level where the resistance Rs and Rr are increased. In most cases, however, this is not critical.

ALARM 58, Auto Tune internal fault:

Contact the local GE supplier.

WARNING 59, Current limit:

The current is higher than the value in par. F-43 *Current Limit*

WARNING 60, External interlock:

External interlock has been activated. To resume normal operation, apply 24 V DC to the terminal programmed for external interlock and reset the frequency converter (via serial communication, digital I/O, or by pressing reset button on keypad).

WARNING 61, Tracking error

An error has been detected between the calculated motor speed and the speed measurement from the feedback device. The function for Warning/ Alarm/ Disable is set in par. H-20 *Motor Feedback Loss Function*, error setting in par. H-21 *Motor Feedback Speed Error*, and the allowed error time in par. H-22 *Motor Feedback Loss Timeout*. During a commissioning procedure the function may be effective.

WARNING 62, Output Frequency at Maximum Limit:

The output frequency is higher than the value set in par. F-03 *Max Output Frequency 1*

ALARM 63, mechanical brake Low

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

WARNING 64, Voltage Limit:

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

WARNING/ALARM/TRIP 65, Control Card Over Temperature:

Control card over temperature: The cut-out temperature of the control card is 80° C.

WARNING 66, Heatsink Temperature Low:

This warning is based on the temperature sensor in the IGBT module. See section Ratings tables for the temperature reading that will trigger this warning.

Troubleshooting:

The heatsink temperature measured as 0° C could indicate that the temperature sensor is defective, thereby 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.

ALARM 67, Option Configuration has Changed:

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

ALARM 68, Safe Stop Activated:

Safe Stop has been activated. To resume normal operation, apply 24 V DC to terminal 37, then send a reset signal (via Bus, Digital I/O, or by pressing [RESET]). For correct and safe use of the Safe Stop function follow the related information and instructions in the Design Guide

ALARM 69, Power card temperature

The temperature sensor on the power card is either too hot or too cold. See the ratings table in Section 1.9 for the high and low temperatures that can cause this alarm.

Troubleshooting:

Check the operation of the door fans. Make sure that the filters for the door fans are not blocked. Make sure that the gland plate is properly installed on IP21 and IP54 (NEMA 1 and NEMA 12) frequency converters.

ALARM 70, Illegal Frequency Configuration:

Actual combination of control board and power board is illegal.

Warning 73, Safe stop auto restart:

Safe stopped. Note that with automatic restart enabled, the motor may start when the fault is cleared.

WARNING 76, Power Unit Setup

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

Troubleshooting:

When replacing a unit size 6X module this will occur if the power specific data in the module power card does not match the rest of the drive. Please confirm the spare part and its power card are the correct part number.

WARNING 77, Reduced power mode:

This warning indicates that the drive is operating in reduced power mode (i.e. less than the allowed number of inverter sections). This warning will be generated on power cycle when the drive is set to run with fewer inverters and will remain on.

ALARM 78, Tracking error:

The difference between set point value and actual value has exceeded the value in par. H-25 *Tracking Error*. Disable the function by par. H-24 *Tracking Error Function* or select an alarm/warning also in par. H-24 *Tracking Error Function*. Investigate the mechanics around the load and motor, Check feedback connections from motor – encoder – to drive. Select motor feedback function in par. H-20 *Motor Feedback Loss Function*. Adjust tracking error band in par. H-25 *Tracking Error* and par. H-27 *Tracking Error Ramping*.

ALARM 79, Illegal power section configuration:

The scaling card is the incorrect part number or not installed. Also, the MK102 connector on the power card is not installed.

ALARM 80, Restore to Default Value:

Parameter settings are restored to default setting after a manual (three-finger) reset.

WARNING 81, CSIV corrupt:

CSIV file has syntax errors.

WARNING 82, CSIV parameter error:

CSIV has failed to record a parameter.

ALARM 91, Analog input 54 wrong settings:

Switch S202 must be set in the position OFF (voltage input) when a KTY sensor is connected to analog input terminal 54.

ALARM 92, No flow:

A no-load situation has been detected in the system. See parameter group AP-2#.

ALARM 93, Dry pump:

A no-flow situation and high speed indicate that the pump has run dry. See parameter group AP-2#.

ALARM 94, End of curve:

Feedback stays lower than the setpoint which may indicate leakage in the pipe system. See parameter group AP-5#.

ALARM 95, Broken belt:

Torque is below the torque level set for no load, indicating a broken belt. See parameter group AP-6#.

Warning 96, Start Delayed:

A start signal is suppressed because the time that has passed since last accepted start is less than the minimum time programmed in par. AP-76 *Interval between Starts*.

Warning 97, Stop Delayed:

A stop signal is suppressed because the motor has been running less time than the minimum time programmed in par. AP-77 *Minimum Run Time*.

WARNING 98, Clock fault:

Clock Fault. The time is not set or the RTC clock (if mounted) has failed. See parameter group K-7#.

WARNING 200, Fire mode:

The input command fire mode is active. See parameter group FB-0#.

WARNING 201, Fire mode was active:

Fire mode has been active. See parameter group K-7#.

WARNING 202, Fire mode limits exceeded:

One or more warranty voiding alarms have been suppressed during fire mode operation. See parameter group K-7#.

ALARM 243, Brake IGBT:

This alarm is only for unit size 6x frequency converters. It is equivalent to Alarm 27. The report value in the alarm log indicates which power module generated the alarm:

1 = left most inverter module.
2 = middle inverter module in 62 or 64 drive.
2 = right inverter module in 61 or 63 drive.
3 = right inverter module in 62 or 64 drive.
5 = rectifier module.

ALARM 244, Heatsink temperature

This alarm is only for unit size 6x frequency converters. It is equivalent to Alarm 29. The report value in the alarm log indicates which power module generated the alarm:

1 = left most inverter module.
2 = middle inverter module in 62 or 64 drive.
2 = right inverter module in 61 or 63 drive.
3 = right inverter module in 62 or 64 drive.
5 = rectifier module.

ALARM 245, Heatsink sensor

This alarm is only for unit size 6x frequency converters. It is equivalent to Alarm 39. The report value in the alarm log indicates which power module generated the alarm:

1 = left most inverter module.
2 = middle inverter module in 62 or 64 drive.
2 = right inverter module in 61 or 63 drive.
3 = right inverter module in 62 or 64 drive.
5 = rectifier module.

ALARM 246, Power card supply

This alarm is only for unit size 6x frequency converters. It is equivalent to Alarm 46. The report value in the alarm log indicates which power module generated the alarm:

1 = left most inverter module.
2 = middle inverter module in 62 or 64 drive.
2 = right inverter module in 61 or 63 drive.
3 = right inverter module in 62 or 64 drive.
5 = rectifier module.

ALARM 247, Power card temperature

This alarm is only for unit size 6x frequency converters. It is equivalent to Alarm 69. The report value in the alarm log indicates which power module generated the alarm:

1 = left most inverter module.
2 = middle inverter module in 62 or 64 drive.
2 = right inverter module in 61 or 63 drive.
3 = right inverter module in 62 or 64 drive.
5 = rectifier module.

ALARM 248, Illegal power section configuration

This alarm is only for unit size 6x frequency converters. It is equivalent to Alarm 79. The report value in the alarm log indicates which power module generated the alarm:

1 = left most inverter module.
2 = middle inverter module in 62 or 64 drive.
2 = right inverter module in 61 or 63 drive.
3 = right inverter module in 62 or 64 drive.
5 = rectifier module.

ALARM 250, New spare part:

The power or switch mode power supply has been exchanged. The frequency converter model number must be restored in the EEPROM. Select the correct model number in par. SP-23 *Typecode Setting* according to the label on the unit. Remember to select 'Save to EEPROM' to complete.

ALARM 251, New model number:

The frequency converter has got a new model number.

4.7 After Repair Tests

Following any repair to a frequency converter or testing of a frequency converter suspected of being faulty, the following procedure must be followed to ensure that all circuitry in the frequency converter is functioning properly before putting the unit into operation.

1. Perform visual inspection procedures as described in the table *Visual Inspection*.
2. Perform static test on the drive as described in *Static Test Procedures.*
3. Remove the three output motor bus bars from each inverter module.
4. Connect a 610 – 800 VDC power supply to the switch mode power supply (SMPS) input to each module using the test cable 6KAF6H8766.
5. Apply power to the SMPS and observe that the display lights up properly. (The fans will not operate when powered in this manner.)
6. Give the frequency converter a run command (press Hand) and slowly increase the reference (speed command) to approximately 40 Hz.
7. Using the Signal Test Board 6KAF6H8437 and an oscilloscope, check the waveform at pins 25 - 30 with the scope referenced to pin 4. This procedure must be performed on each inverter module. Each waveform should approximate the illustration below.
8. Connect a 24 VDC power supply to the DC bus of the drive. This can be done on the DC bus output of the rectifier module or the bus bars connecting to the top side of the DC fuses on any of the inverter modules.
9. Observe the phase to phase waveform on the output bus bars of each phase of each inverter module. This waveform should appear the same as the normal output waveform of a properly operating drive, except that the amplitude will be 24 V instead of the full output voltage of a normal drive.
10. Press the OFF key of the frequency converter, disconnect power from both power supplies, and reinstall jumper connectors to the SMPS input plugs on all modules.
11. Reinstall the motor output bus bars on all inverter modules.
12. Apply AC power to the drive.
13. Apply a start command to the drive. Adjust the speed to a nominal level. Observe that the motor is running properly
14. Using a clamp-on style current meter, measure the output current on each phase. All currents should be balanced.

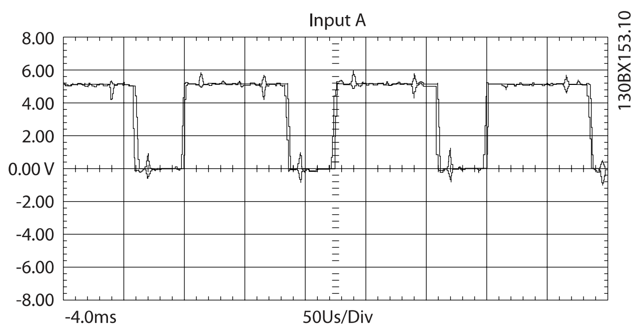

Illustration 4.1: After repair waveform: 2v/div 100us/div run at 10 Hz

5 Frequency Converter and Motor Applications

5.1 Torque Limit, Current Limit, and Unstable Motor Operation

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

Par. H-43 *Torque Characteristics* sets the mode in which the frequency converter will operate.

Parameters P-02 through P-08 match the frequency converter to the motor and adapt to the motor characteristics.

Parameters F-41 and SP-25 set the torque control features of the frequency converter for the application.

Par. H-40 *Configuration Mode* sets the frequency converter for open or closed loop operation or torque mode operation. In a closed loop configuration, a feedback signal controls the frequency converter speed. The settings for the PID controller play a key role for stable operation in closed loop, as described in the Operating Instructions. In open loop, the frequency converter calculates the torque requirement based on current measurements of the motor.

Par. H-43 *Torque Characteristics* sets the frequency converter for constant or variable torque operation. It is imperative that the correct torque characteristic is selected, based on the application. If, for example, the load type is constant torque, such as a conveyor, and variable torque is selected, the frequency converter may have great difficulty starting the load, if started at all. Consult the factory if uncertain about the torque characteristics of an application.

Parameters P-02 through P-07 configure the frequency converter for the connected motor. These are motor power, voltage, frequency, current, and rated motor speed. Accurate setting of these parameters is very important. Enter the motor data required as listed on the motor nameplate. For effective and efficient load control, the frequency converter relies on this information for calculating the output waveform in response to the changing demands of the application.

Par. P-04 *Auto Tune* activates the automatic motor adaptation (auto tune) function. When auto tune is performed, the frequency converter measures the electrical resistance of the motor stator windings, R1. Since Auto Tune in 6X drives can not calculate R2, X1, X2, and Xm (par. P-31 *Rotor Resistance (Rr)* to par. P-35 *Main Reactance (Xh)*) they must be requested from the motor manufacturer the optimal performance of the drive data. Par. P-31 *Rotor Resistance (Rr)* and par. P-35 *Main Reactance (Xh)*, as stated, should be set by the values supplied by the motor manufacturer, or left at the factory default values.

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

Par. F-41 *Torque Limiter (Braking)* sets the limit for frequency converter torque. The factory setting is 160% for AF-650 GP series and 110% for AF-600 FP series and will vary with motor power setting. For example, a frequency converter programmed to operate a smaller rated motor will yield a higher torque limit value than the same frequency converter programmed to operate a larger size motor. It is important that this value not be set too low for the requirements of the application. In some cases, it may be desirable to have a torque limit set at a lesser value. This offers protection for the application in that the frequency converter will limit the torque. It may, however, require higher torque at initial start up. Under these circumstances, nuisance tripping may occur.

Par. SP-25 *Trip Delay at Torque Limit* works in conjunction with torque limit. This parameter selects the length of time the frequency converter operates in torque limit prior to a trip. The factory default value is off. This means that the frequency converter will not trip on torque limit, but it does not mean it will never trip from an overload condition. Built into the frequency converter is an internal inverter thermal protection circuit. This circuit monitors the output load on the inverter. If the load exceeds 100% of the continuous rating of the frequency converter, a timer is activated. If the load remains excessive long enough, the frequency converter will trip on inverter time. Adjustments cannot be made to alter this circuit. Improper parameter settings effecting load current can result in premature trips of this type. The timer can be displayed.

5.1.1 Overvoltage Trips

This trip occurs when the DC bus voltage reaches its DC bus alarm voltage high (see ratings tables in introductory section). Prior to the trip, the frequency converter will display a high voltage warning. Most times an over voltage condition is due to fast deceleration ramps with respect to the inertia of the load. During deceleration of the load, inertia of the system acts to sustain the running speed. Once the motor frequency drops below the running speed, the load begins overhauling the motor. At this point the motor becomes a generator and starts returning energy to the frequency converter. This is called regenerative energy. Regeneration occurs when the speed of the load is greater than the commanded speed. This return voltage is rectified by the diodes in the IGBT modules and raises the DC bus. If the amount of returned voltage is too high, the frequency converter will trip.

There are a few ways to overcome this situation. One method is to reduce the deceleration rate so it takes longer for the frequency converter to decelerate. A general rule of thumb is that the frequency converter can only decelerate the load slightly faster than it would take for the load to naturally coast to a stop. A second method is to allow the overvoltage control circuit to take care of the deceleration ramp. When enabled the overvoltage control circuit regulates deceleration at a rate that maintains the DC bus voltage at an acceptable level. One caution with overvoltage control is that it will not make corrections to unrealistic ramp rates. For example, if the deceleration ramp needs to be 100 seconds due to the inertia, and the ramp rate is set at 3 seconds, overvoltage control will initially engage and then disengage and allow the frequency converter to trip. This is purposely done so the units operation is not misinterpreted. A third method in controlling regenerated energy is with a dynamic brake. The frequency converter monitors the level of the DC bus. Should the level become too high, the frequency converter switches the resistor across the DC bus and dissipates the unwanted energy into the external resistor bank mounted outside of the frequency converter. This will actually increase the rate of deceleration.

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Less often is the case that the overvoltage condition is caused by the load while it is running at speed. In this case the dynamic brake option can be used or the overvoltage control circuit. It works with the load in this way. As stated earlier, regeneration occurs when the speed of the load is greater than the commanded speed. Should the load become regenerative while the frequency converter is running at a steady state speed, the overvoltage circuit will increase the frequency to match the speed of the load. The same restriction on the amount of influence applies. The frequency converter will add about 10% to the base speed before a trip occurs. Otherwise, the speed could continue to rise to potentially unsafe levels.

5.1.2 Mains Phase Loss Trips

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

When the input voltage becomes unbalanced or a phase disappears completely, the ripple voltage increases causing the frequency converter to trip and issue an Alarm 4. In addition to missing phase voltage, increased bus ripple can be caused by a line disturbance or imbalance. Line disturbances may be caused by line notching, defective transformers or other loads that may be effecting the form factor of the AC waveform. Mains imbalances which exceed 3% cause sufficient DC bus ripple to initiate a trip.

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

Severe imbalance of supply voltage or phase loss can easily be detected with a voltmeter. Line disturbances most likely need to be viewed on an oscilloscope. Conduct tests for input imbalance of supply voltage, input waveform, and output imbalance of supply voltage as described in the chapter *Troubleshooting*.

5.1.3 Control Logic Problems

Problems with control logic can often be difficult to diagnose, since there is usually no associated fault indication. The typical complaint is simply that the frequency converter does not respond to a given command. There are two basic commands that must be given to any frequency converter in order to obtain an output. First, the frequency converter must be told to run (start command). Second, the frequency converter must be told how fast to run (reference or speed command).

The frequency converters are designed to accept a variety of signals. First determine what types of signals the frequency converter is receiving. There are six digital inputs (terminals 18, 19, 27, 29, 32, 33), two analog inputs (53 and 54), and the network (68, 69). The presence of a correct reading will indicate that the desired signal has been detected by the microprocessor of the frequency converter. See the chapter *Frequency Converter Inputs and Outputs*.

Using the status information displayed by the frequency converter is the best method of locating problems of this nature. By selecting within parameter group K-2# Keypad 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 of the frequency converter. This data also may be read in parameter group DR-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 frequency converter. This can be performed with a voltmeter or oscilloscope in accordance with the 6.3.16, Input Terminal Signal Test.

If the signal is present at the terminal, the control card is defective and must be replaced. If the signal is not present, the problem is external to the frequency converter. The circuitry providing the signal along with its associated wiring must then be checked.

5.1.4 Programming Problems

Difficulty with frequency converter operation can be a result of improper programming of the frequency converter parameters. Three areas where programming errors may affect drive and motor operation are motor settings, references and limits, and I/O configuration. See section *Frequency Converter Inputs and Outputs*.

The frequency converter must be set up correctly for the motor(s) connected to it. Parameters P-02 - P-07 must have data from the motor nameplate entered into the frequency converter. This enables the frequency converter processor to match the frequency converter to power characteristics of the motor. The most common result of inaccurate motor data is the motor drawing higher than normal amounts of current to perform the task expected of it. In such cases, setting the correct values for these parameters and performing the auto tune function will usually solve the problem.

Any references or limits set incorrectly will result in less than acceptable frequency converter performance. For instance, if maximum reference is set too low, the motor will be unable to reach full speed. These parameters must be set according to the requirements of the particular installation. References are set in the parameter group F-5#.

Incorrectly set I/O configuration usually results in the frequency converter not responding to the function as commanded. It must be remembered that for every control terminal input or output, there are corresponding parameters settings. These determine how the frequency converter responds to an input signal or the type of signal present at that output. Utilising 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 E-0# and AN-0# parameter groups.

5.1.5 Motor/Load Problems

Problems with the motor, motor wiring or mechanical load on the motor can develop in a number of ways. The motor or motor wiring can develop a phase-to-phase or phase-to-earth short resulting in an alarm indication. Checks must be made to determine whether the problem is in the motor wiring or the motor itself. Ensure that the motor wiring from the drive meets the unit size 6x requirements detailed in the high power operating instructions manual.

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

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

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

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

5.2 Internal Frequency Converter Problems

The vast majority of problems related to failed frequency converter 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 of these problems.

5.2.1 Overtemperature Faults

Overtemperature faults in the drive are typically the result of blocked airflow or a faulty cooling fan. The overtemperature alarm message displayed indicates where the fault exists.
Alarm 244, *Heatsink Overtemperature*. This normally indicates a heatsink fan not functioning. While an overtemperature alarm message is displayed, all cooling fans should be operating at full speed. Check the fans prior to resetting the drive to determine the fault location.
Alarm 247, *Power Card Overtemperature*. This normally indicates that the ambient temperature inside the drive enclosure is too high. Check all air passages to ensure that nothing is obstructing the air flow. Also check the filters for the door fans and clean or replace if necessary.
With either of these alarms, the report value in the Alarm Log displays which module experienced the overtemperature condition.

5.2.2 Open (Blown) Fuses

Open (Blown) Fuses

The drive contains fuses protecting internal circuits from excessive damage in the event of a component failure. It must be emphasized that an open fuse is an indication of a problem in that circuit. Do not replace an open fuse and apply power to the drive without checking for short circuits or component failures. See the following descriptions for details.

Mains Input Fuses

An open mains input fuse typically indicates that there is a shorted power component in either the rectifier or inverter circuits. Perform the static test procedures to locate the failed component(s).

Soft Charge Fuses

Each soft charge card contains three fuses which are in series with the AC input to the card. This AC input powers the soft charge circuit. It also connects to the power card in each inverter module to supply power for the fans.

An open soft charge fuse can indicate a short in either the soft charge rectifier or the fan transformer supplied by that soft charge card. To locate the source of the problem, perform the static test procedure for the soft charge rectifier and the fan continuity test.

Fan Fuse

The fan fuse on each inverter module protects the fan circuitry from excessive damage in the event of a failure in the heatsink or door fans. Perform the fan continuity test to determine the location of the defective fan.

DC Supply Fuse

The DC bus connection to each power card contains a fuse in the positive DC lead. This is to protect the logic circuitry from damage should a fault occur in the SMPS circuitry. It is not recommended to replace an open DC supply fuse without checking and possibly replacing the power card in that module.

DC Bus Fuses

The DC bus connection to each inverter module is fused to prevent excessive damage due to a shorted IGBT in the inverter section. Typically, an open fuse indicates a shorted or failed IGBT in the module.

Note, however, that an IGBT fault may fail the DC bus fuses in adjacent inverter modules due to the quick discharging of the DC capacitors through the shorted IGBT. Perform a static test on all inverter modules if one or more of these fuses are found to be open.

5.2.3 Current Sensor Faults

When a current sensor fails, it is indicated sometimes by an overcurrent alarm that cannot be reset, even with the motor leads disconnected. Most often, however, the frequency converter will experience frequent false earth fault trips. This is due to the DC offset failure mode of the sensors.

To explain this it is necessary to investigate the internal makeup of a Hall effect type current sensor. Included inside the device is an op-amp to amplify the signal to usable levels in the receiving circuitry. Like any op-amp, the output at zero input level (zero current flow being measured) should be zero volts, exactly halfway between the plus and minus power supply voltages. A tolerance of +/- 15mv is acceptable. In a three phase system that is operating correctly, the sum of the three output currents should always be zero.

When the sensor becomes defective, the output voltage level varies by more than the 15mv allowed. The defective current sensor in that phase indicates current flow when there is none. This results in the sum of the three output currents being a value other than zero, an indication of leakage current flowing. If the deviation from zero (current amplitude) approaches a specific level, the frequency converter assumes an earth fault and issues an alarm.

The simplest method of determining whether a current sensor is defective is to disconnect the motor from the frequency converter, then observe the current in the frequency converter display. With the motor disconnected, the current should be zero. A frequency converter with a defective current sensor will indicate some current flow. An indication of a fraction of an amp is tolerable. However, that value should be considerably less than one amp. If the display shows more than one amp of current, there is a defective current sensor.

To determine which current sensor is defective, measure the voltage offset at zero current for each current sensor. See the current sensor test procedure.

Check also that all current scaling cards are properly connected to the MDCIC boards. An incorrect or improperly connected scaling card can result in an incorrect current measurement. If a current scaling card is missing, the drive will trip on overcurrent or earth fault.

5.3 Electromagnetic Interference

5.3.1 Effect of EMI

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

While electromagnetic interference (EMI) related disturbances to frequency converter operation are uncommon, the following detrimental EMI effects may be seen:

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

A disturbance resulting from other nearby equipment is more common. Generally, other industrial control equipment has a high level of EMI immunity. However, non-industrial, commercial, and consumer equipment is often susceptible to lower levels of EMI. Detrimental effects to these systems may include the following:

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

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5.3.2 Sources of EMI

Modern frequency converters (see illustration below) utilise Insulated-Gate Bipolar Transistors (IGBTs) to provide an efficient and cost effective means to create the Pulse Width Modulated (PWM) output waveform necessary for accurate motor control. These devices rapidly switch the fixed DC bus voltage creating a variable frequency, variable voltage PWM waveform. This high rate of voltage change [dV/dt] is the primary source of the frequency converter generated EMI.

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

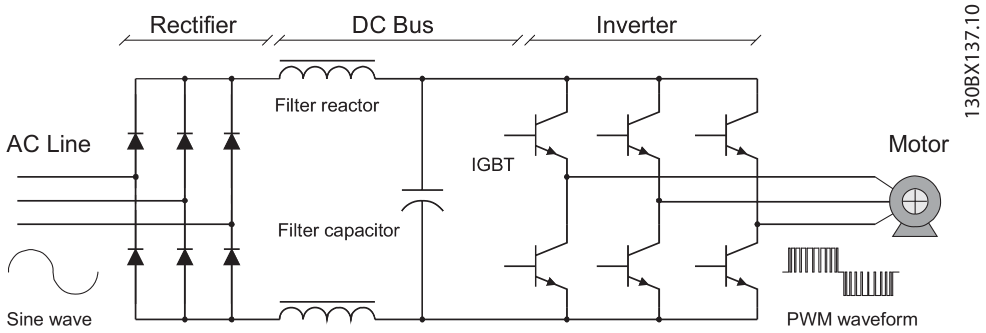


Illustration 5.1: Frequency Converter Functionality Diagram

5.3.3 EMI Propagation

Frequency converter generated EMI is both conducted to the mains and radiated to nearby conductors. See illustrations below.

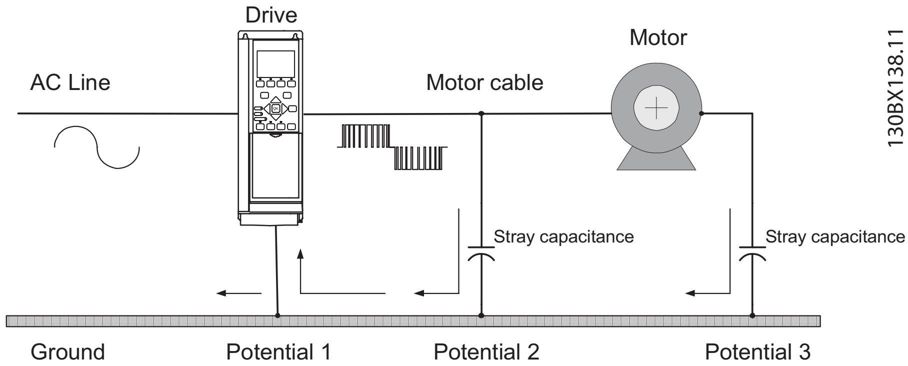


Illustration 5.2: Earth Currents

Stray capacitance between the motor conductors, equipment earth, and other nearby conductors results in induced high frequency currents.

High earth circuit impedance at high frequencies results in an instantaneous voltage at points reputed to be at *earth potential*. This voltage can appear throughout a system as a common mode signal that can interfere with control signals.

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

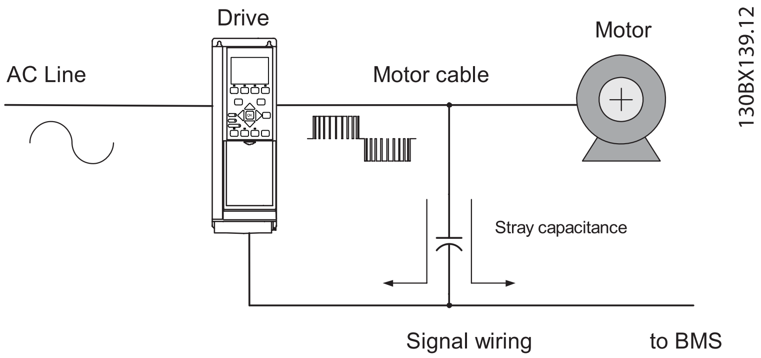


Illustration 5.3: Signal Conductor Currents

Unprotected or poorly routed signal conductors located close to or in parallel to motor and mains conductors are susceptible to EMI.

Signal conductors are especially vulnerable when they are run parallel to the power conductors for any distance. EMI coupled into these conductors can affect either the frequency converter or the interconnected control device. See the following illustration.

While these currents will tend to travel back to the frequency converter, imperfections in the system will cause some current to flow in undesirable paths thus exposing other locations to the EMI.

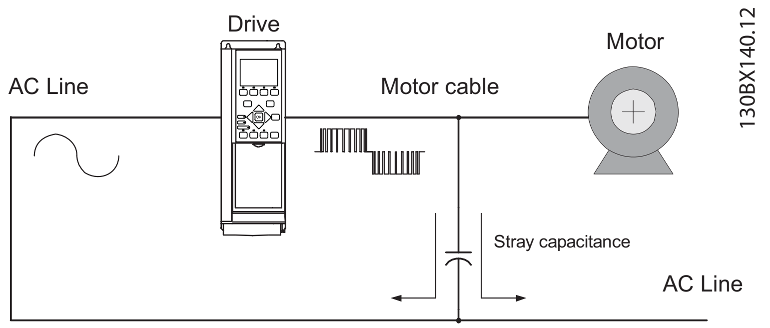


Illustration 5.4: Alternate Signal Conductor Currents

High frequency currents can be coupled into the mains supplying the frequency converter when the mains conductors are located close to the motor cables.

5.3.4 Preventive Measures

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

Earthing

The frequency converter and motor should be solidly earthed to the equipment frame. A good high frequency connection is necessary to allow the high frequency currents to return back to the frequency converter rather than to travel thorough the power network. The earth connection will be ineffective if it has high impedance to high frequency currents, therefore it should be as short and direct as practical. Flat braided cable has lower high frequency impedance than round cable. Simply mounting the frequency converter or motor onto a painted surface will not create an effective earth connection. In addition, running a separate earth conductor directly between the frequency converter and the running motor is recommended.

Cable routing

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

Signal cable selection

Signal cable selection. Single conductor 600 volt rated wires provide the least protection from EMI. Twisted-pair and screened twist-pair cables are available which are specifically designed to minimise the effects of EMI. While unscreened twisted-pair cables are often adequate, screened twisted-pair cables provide another degree of protection. The signal cable's screen should be terminated in a manner that is appropriate for the connected equipment. Avoid terminating the screen through a pigtail connection as this increases the high frequency impedance and spoils the effectiveness of the screen. Refer to Section *Earthing Screened Cables*.

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

Motor cable selection

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

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

If screened motor cable is not available, then 3 phase conductors plus earth in a conduit will provide some degree of protection. This technique will not be as effective as screened cable due to the unavoidable contact of the conduit with various points within the equipment.

Serial communications cable selection

There are various serial communication interfaces and protocols on the market. Each of these recommends one or more specific types of twisted-pair, screened twisted-pair, or proprietary cables. Refer to the manufacturer's documentation when selecting these cables. Similar recommendations apply to serial communication cables as to other signal cables. Using twisted-pair cables and routing them away from power conductors is encouraged. While screened cable provides additional EMI protection, the screen capacitance may reduce the maximum allowable cable length at high data rates.

5.3.5 Proper EMC Installation

Shown in the illustration below is a correct installation with EMC considerations in mind. Although most installations will not follow all the recommended practices the closer an installation resembles this example the better immunity the network will have against EMI. Should EMI problems arise in an installation, refer to this example. Attempt to replicate this installation recommendation as closely as possible to alleviate such problems.

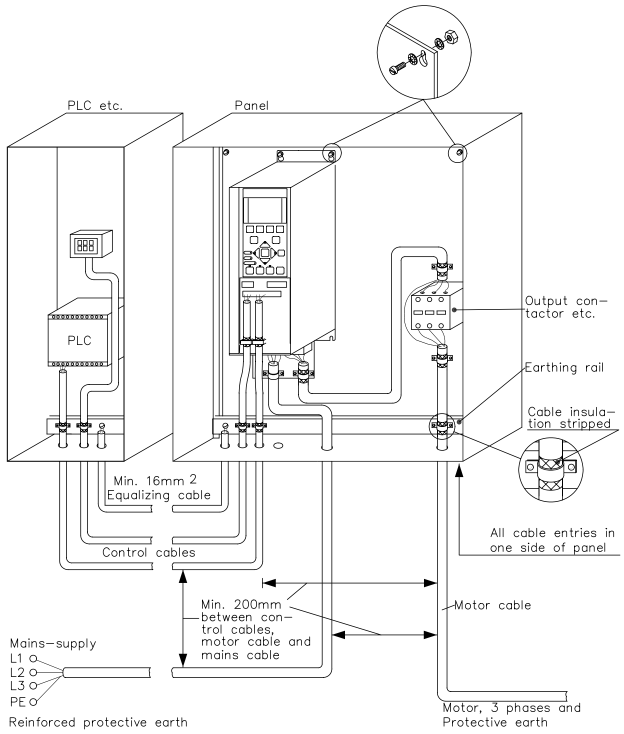


Illustration 5.5: Proper EMC Installation

6 Test Procedures

6.1 Introduction

Touching electrical parts of frequency converter may be fatal even after equipment has been disconnected from AC power. Wait 40 minutes after power has been removed before touching any internal components to ensure that capacitors have fully discharged.

This section contains detailed procedures for testing unit size 6x series frequency converters. Previous sections of this manual provide symptoms, alarms and other conditions which require additional test procedures to further diagnose the frequency converter. The results of these tests indicate the appropriate repair actions. Again, because the frequency converter monitors input and output signals, motor conditions, AC and DC power and other functions, the source of fault conditions may exist outside of the frequency converter itself. Testing described here will isolate many of these conditions as well. The Disassembly and Assembly Instructions describe detailed procedures for removing and replacing components, as required.

Frequency converter testing is divided into *Static Tests*, *Dynamic Tests*, and *Initial Start Up or After Repair Frequency Converter Tests*. Static tests are conducted without power applied to the frequency converter. The purpose of static testing is to check for shorted power components. Most frequency converter problems can be diagnosed simply with these tests. Static tests are performed with little or no disassembly. Perform these tests on any unit suspected of containing faulty power components prior to applying power.

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

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

Replace any defective component and retest the frequency converter with the new component before applying power to the frequency converter as described in *Initial Start Up or After Repair frequency converter Tests*.

6.1.1 Tools Required for Testing

Metric socket set	7–19 mm
Socket extensions	100 mm–150 mm (4 in and 6 in)
Torx driver set	T10 - T50
Torque wrench	0.675–19 Nm (6–170 in-lbs)
Needle nose pliers	
Magnetic sockets	
Ratchet	
Screwdrivers	Standard and Philips

Additional Tools Recommended for Testing

Digital volt/ohmmeter (must be rated for 1200 VDC for 690 V units)
Analog voltmeter
Oscilloscope
Clamp-on style ammeter
Test cable p/n 6KAF6H8439
Signal test board p/n 6KAF6H8437
Power supply: 610 - 800 VDC, 250 mA to supply external power to 4 power cards and the control card.
Power supply : 24 VDC, 2 A for external 24 V power supply.

6.1.2 Signal Test Board

The signal test board can be used to test circuitry within the frequency converter and provides easy access to test points. The test board plugs into the top of the modules. Its use is described in the procedures where called out. See Section 9, Signal Test Board, for detailed pin descriptions.

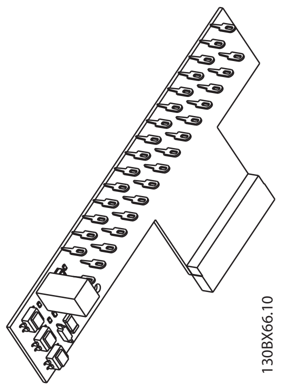


Illustration 6.1: Signal test board

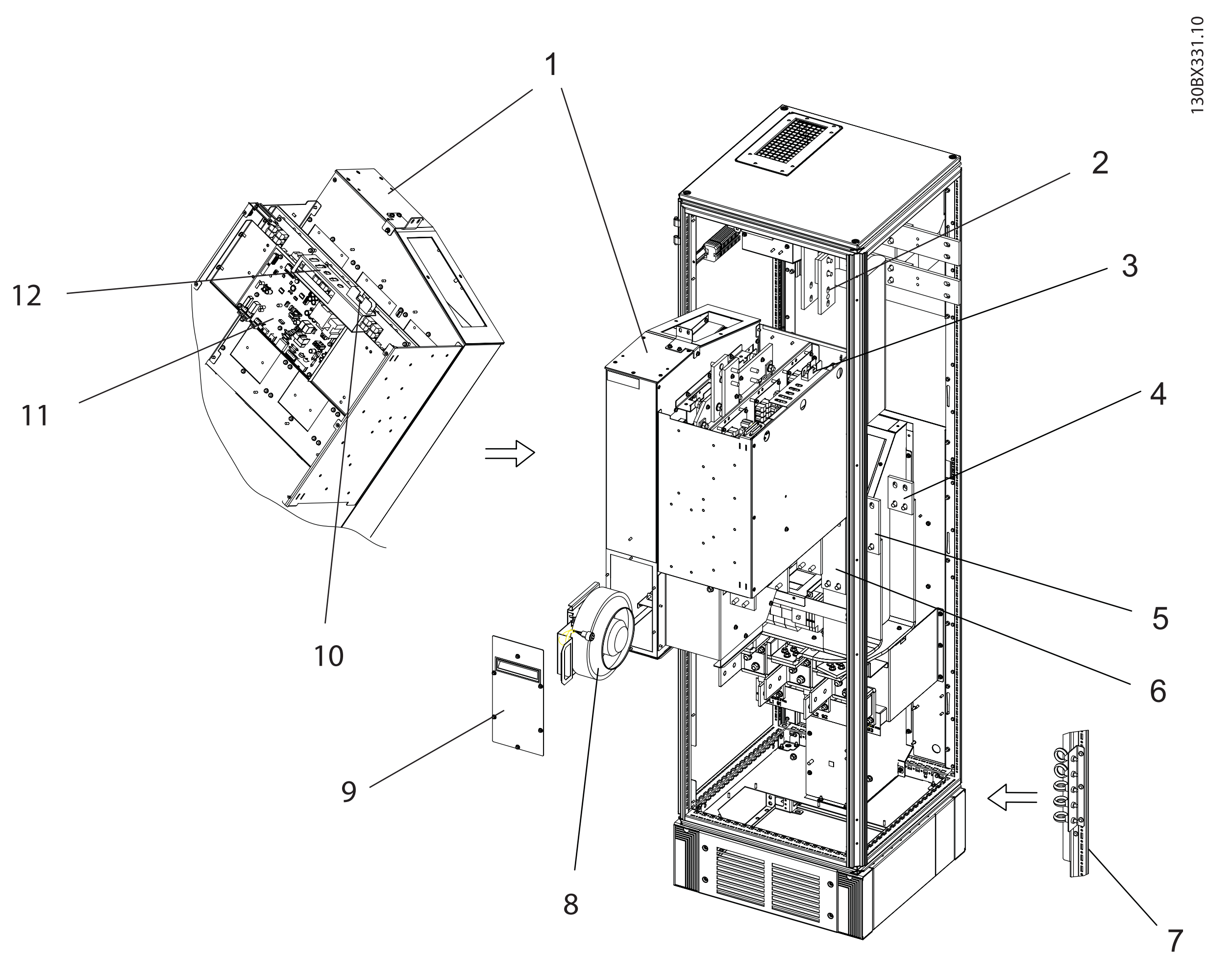
6.2 Static Test Procedures

All static tests should be made with a meter capable of testing diodes. Use a digital volt/ohm meter (VOM) set on the diode scale or an analog ohmmeter set on Rx100 scale. Before making any checks disconnect all input, motor and brake resistor connections.

NB!
Perform the static test procedures described in this section in the order presented for best troubleshooting results.

Diode Drop
A diode drop reading will vary depending on the model of ohmmeter. Whatever the ohmmeter displays as a typical forward bias diode is defined as a "diode drop" in these procedures. With a typical DVM, the voltage drop across most components will be around 0.300 to 0.500. The opposite reading is referred to as infinity and most DMVs will display the value OL for overload.

6.2.1 Rectifier Module Static Test



Rectifier module test points

1	Rectifier module	7	Module lifting eye bolts (mounted on vertical strut)
2	DC bus bar	8	Module heatsink fan
3	SMPS fuse	9	Fan door cover
4	(Optional) back AC fuse mounting bracket (T)	10	SMPS fuse
5	(Optional) middle AC fuse mounting bracket (S)	11	Power card
6	(Optional) front AC fuse mounting bracket (R)	12	Panel connectors

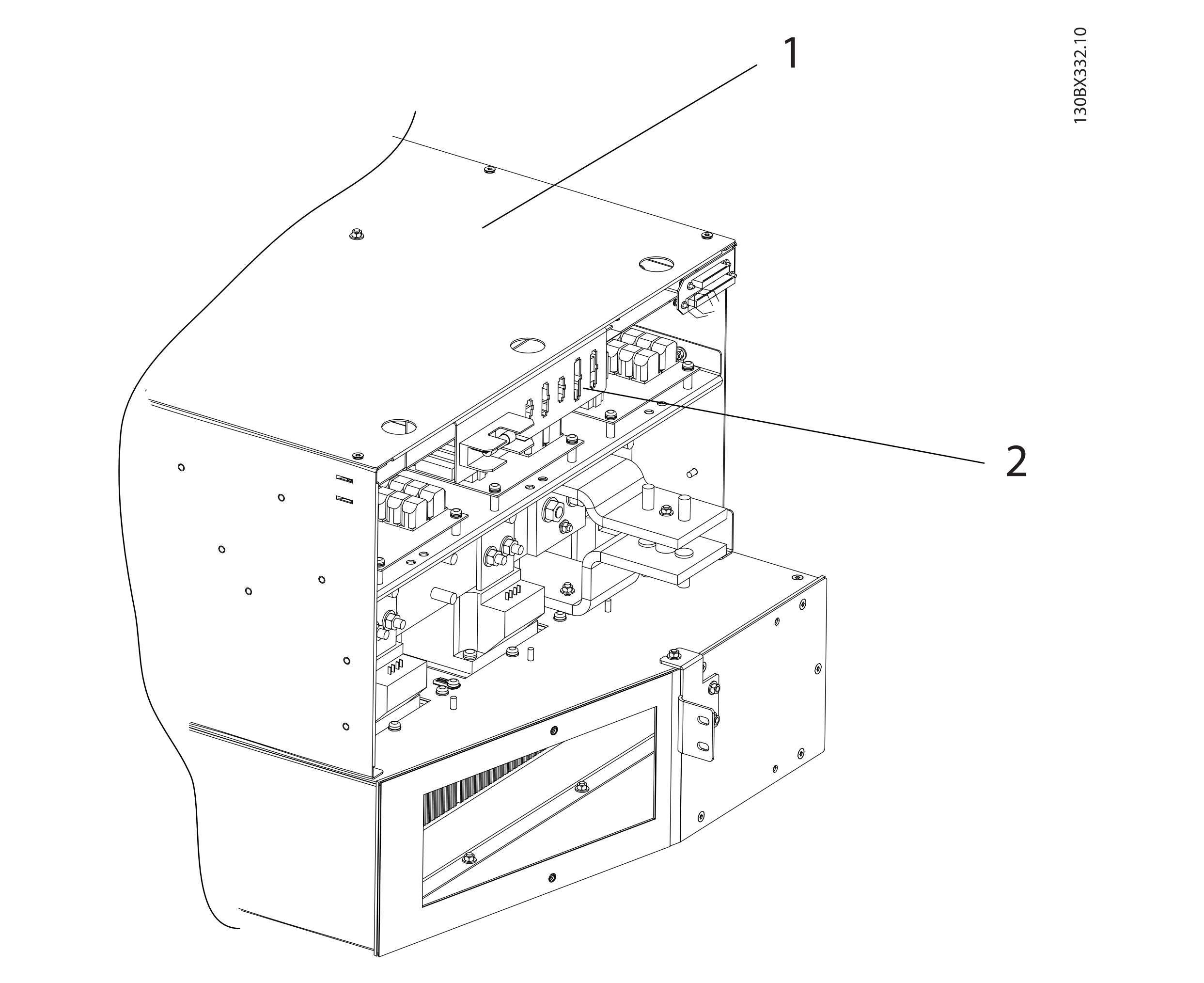
6.2.1.1 Soft Charge Fuse Test

This test is used to determine if any of the soft charge fuses are open.

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

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

A measurement of 0 Ω indicates good continuity. Replace any open fuses (infinite resistance). Note that the rectifier module must be removed to replace fuses.



1	Rectifier module	2	12-pin connector

6.2.1.2 Soft Charge and Rectifier Circuit Test

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

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

Remove the safety covers to access the unit.

Main rectifier circuit test part I

1. Connect positive (+) meter lead to positive (+) DC bus.
2. Connect negative (–) meter lead to terminals L1, L2, and L3 in turn.

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

Incorrect reading

With the Part I test connection, the SCRs in the SCR/Diode modules are reverse biased so they are blocking current flow. If a short circuit exists, it would be possible that either the SCRs or the diodes in the soft charge rectifier are shorted. To isolate between SCRs or the soft charge rectifier, internal module testing must be performed.

Main rectifier circuit test part II

1. Reverse meter leads by connecting negative (–) meter lead to positive (+) DC bus.
2. Connect positive (+) meter lead to L1, L2, and L3 in turn. Each reading should show a diode drop.

Incorrect reading

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

If an open reading were present, it would indicate the upper diodes in the soft charge rectifier are open. It could also indicate that one or more of the soft charge fuses are open. It could further indicate that the soft charge resistor is open. To isolate between the three possibilities, internal module testing must be performed.

A short circuit reading indicates either one or more of the upper soft charge rectifier diodes are shorted or the SCRs are shorted in the SCR/Diode module. To isolate between SCRs or the soft charge rectifier, internal module testing must be performed.

Main rectifier circuit test part III

1. Connect positive (+) meter lead to negative (-) DC bus.
2. Connect negative (–) meter lead to terminals L1, L2 and L3 in turn. Each reading should show a diode drop.

Incorrect reading With the Part III test connection, the diodes in the SCR/Diode modules are forward biased as well as the lower diodes in the soft charge rectifier. The meter reads the diode drops. If a short circuit exists it would be possible that either the diodes in the SCR/Diode modules or the lower diodes in the soft charge rectifier are shorted. To isolate between SCRs or the soft charge rectifier, internal module testing must be performed.

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

Main rectifier circuit test part IV

1. Reverse meter leads by connecting negative (–) meter lead to negative (-) DC bus.
2. Connect positive (+) meter lead to L1, L2 and L3 in turn. Each reading should show infinity.

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

Incorrect reading

With the Part IV test connection, the diodes in the SCR/Diode modules are reversed biased as well as the lower diodes in the soft charge rectifier. If a short circuit exists it would be possible that either the diodes in the SCR/Diode modules or the lower diodes in the soft charge rectifier are shorted. To isolate between SCRs or the soft charge rectifier, internal module testing must be performed.

6.2.2 Inverter Module Static Tests

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

Before testing the inverter module, ohm check the top and bottom of the DC fuses to ensure no voltage is present. Dangerous and even fatal voltage levels can be present if the capacitors are not fully discharged

Remove the safety covers to access the unit.

6.2.2.1 Test Point Access

To access test points in the module, remove the bus bars as follows.

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

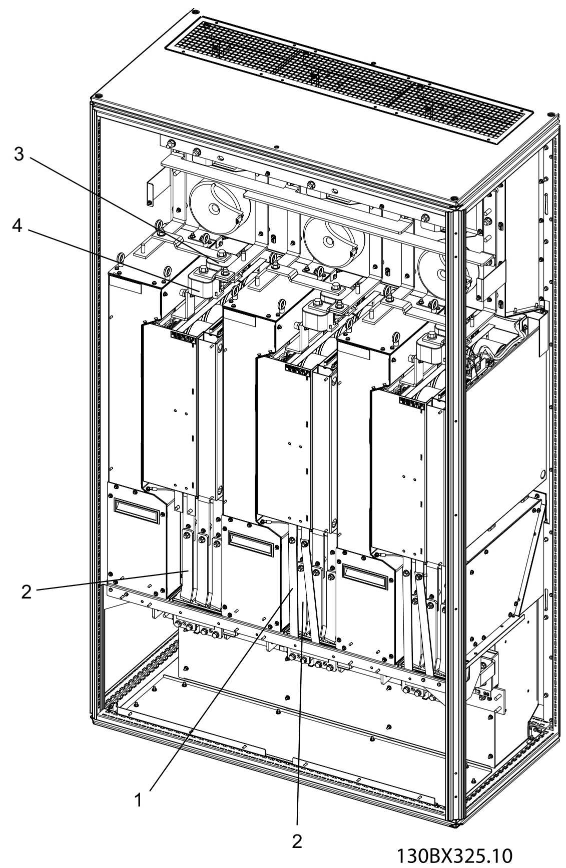


Illustration 6.2: Inverter module test points

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

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

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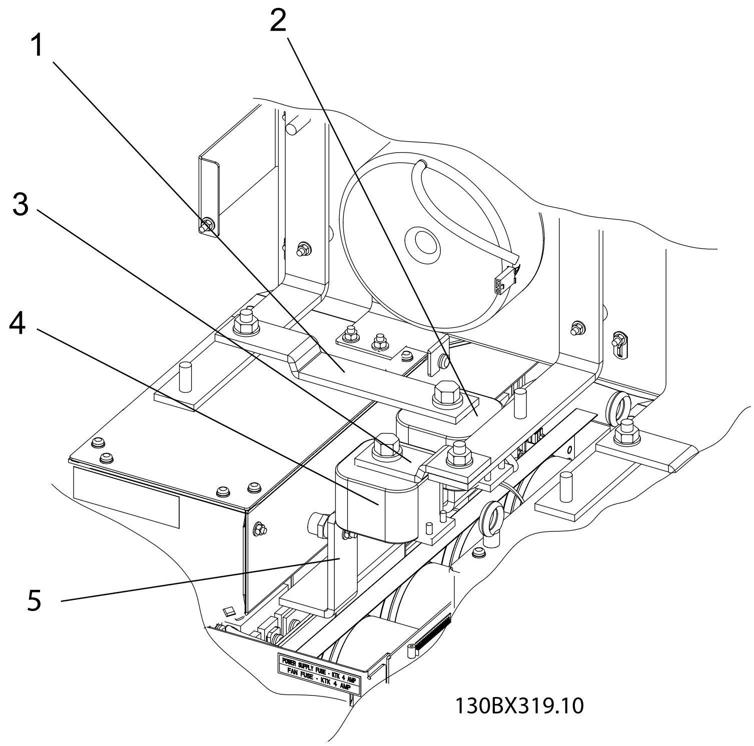
6.2.2.2 Inverter test part I

1. Connect the positive (+) meter lead to the (+) positive DC bus bar.
2. Connect the negative (–) meter lead to terminals U, V, and W in sequence.



1	Top (-)DC link fuse bus bar	4	(+)DC link fuse
2	(-)DC link fuse	5	Bottom (+)DC link fuse bus bar
3	Top (+)DC link fuse bus bar		

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

Inverter test part II

1. Reverse the meter leads by connecting the negative (–) meter lead to the positive (+) DC bus bar.
2. Connect the positive (+) meter lead to U, V, and W in sequence. Each reading should show a diode drop.

Incorrect reading

An incorrect reading in any inverter test indicates a failed IGBT in that inverter module. Replace the IGBT module according to the disassembly instructions. The inverter module must be removed to replace the IGBT module.

Inverter test part III

1. Connect the positive (+) meter lead to the negative (-) DC bus bar.
2. Connect the negative (–) meter lead to terminals U, V, and W in sequence. Each reading should show a diode drop.

Inverter test part IV

1. Reverse the meter leads by connecting the negative (–) meter lead to the negative (-) DC bus bar.
2. Connect the positive (+) meter lead to U, V, and W in sequence.

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

Incorrect reading

An incorrect reading in any inverter test indicates a failed module. Replace the IGBT module according to the disassembly instructions. The inverter module must be removed to replace the IGBT module.

6.2.3 Brake IGBT Test

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

1. Remove the safety covers to access the unit.
2. Note the position of the brake jumper bus bars prior to removal. The tops of the bus bars are connected to the motor lead bus bars as referred to in the following test procedures.
3. Remove the brake jumper bus bars

Brake IGBT test part I

1. Connect the positive (+) meter lead to the brake resistor terminal R+ (82).
2. Connect the negative (-) meter lead to the brake resistor terminal R- (81).

The reading should indicate infinity. The meter may start out at a value and climb toward infinity as capacitance is charged within the frequency converter.

Brake IGBT test part II

1. Connect the positive (+) meter lead to the brake resistor terminal R- (81).
2. Connect the negative (-) meter lead to the brake resistor terminal R+ (82).

The reading should indicate a diode drop.

Brake IGBT test part III

1. Connect the positive (+) meter lead to the brake resistor terminal R- (81).
2. Connect the negative (-) meter lead to the negative (-) DC bus.

The reading should indicate infinity. The meter may start out at a value and climb toward infinity as capacitance is charged within the frequency converter.

Incorrect reading

An incorrect reading on any of the above tests indicates the brake IGBT is defective. Replace the brake IGBT per the disassembly procedure. The inverter module must be removed to replace the IGBT brake.

6.2.4 Fan Continuity Test

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.

Control Source	Fan Location
Inverter module 2	Rectifier cabinet door
Inverter module 2	Inverter cabinet left door
Inverter module 2	Inverter cabinet right door
Inverter module 1	Rectifier heatsink
Inverter module 1	Inverter module 1 heatsink
Inverter module 2	Inverter module 2 heatsink
Inverter module 3 (if unit has 3 modules)	Inverter module 3 heatsink

Check 1: Fan Fuse Test

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

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

Check 2: Continuity from the AC Input Terminals to Each Inverter Module.

For the following tests, unplug the 10-pin connector on the top of each Inverter Module. Read the terminals on the Inverter Module side of the connector (female connector). The 8-pin connector must be plugged into the top of the Inverter Module. The 12-pin connector must be plugged into the top of the Rectifier Module.

1. Measure from L3 (T) to terminal 1. Reading of <1 Ohm should be indicated. This measurement should be made once for each Inverter Module.
2. Measure from L3 (S) to terminal 2. Reading of <1 Ohm should be indicated. This measurement should be made once for each Inverter Module.

Incorrect reading

An incorrect reading could indicate a number of different problems.

1. Perform the Rectifier Module Soft Charge Fuse Test. If any soft charge fuses are open, replace the fuse and retest the fan continuity.
2. Check the wire harness between the Rectifier Module and each Inverter Module. At the Rectifier Module this is the 12-pin connector. At each Inverter Module this is the 8-pin connector. If the wire harness is the problem, replace and retest the fan continuity.
3. If the above checks do not identify the problem, remove the faulty Inverter Module and check the connections between the connectors on the top of the module and the power card. If these connections are the problem, replace and retest the fan continuity.

After this check, plug in all connectors on top of the Rectifier Module and the Inverter Modules.

Check 3: Fan Transformer Ohm Test

For the following test, unplug the 10-pin connector on the top of each Inverter Module. Read the terminals on the connector end of the wire harness (male connector). Remember the same test should be performed for each fan transformer. There is one fan transformer for each Inverter Module installed in the drive.

Readings for 380 - 480V drives

1. Measure between pins 1 and 2. Should read approximately 4 Ω.
2. Measure between pins 1 and 7. Should read approximately 3 Ω.
3. Measure between pins 2 and 7. Should read approximately 1 Ω.

Readings for 525 - 690V drives

1. Measure between pins 1 and 2. Should read approximately 7.4 Ωs.
2. Measure between pins 1 and 7. Should read approximately 3.6 Ω.
3. Measure between pins 2 and 7. Should read approximately 3.2 Ω.

Incorrect reading

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

After this check, plug in the 10-pin connector on the top of each Inverter Module.

Check 4: Inverter Cabinet and Rectifier Cabinet Door Fans

This checks the wiring between the Inverter Module and the Cabinet Door Fans. All three door fans are controlled from Inverter Module number 2 (middle inverter module in 62/64 drive or right inverter module in 61/63 drive).

1. Unplug the 10-pin connector from the top of Inverter Module number 2. Read the terminals on the wire harness side of the connector (male connector).
2. Measure between pins 5 and 10. Should read approximately 16 Ω.

Incorrect reading

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

To check fans

1. Disconnect the wiring from the fan terminals.
2. Read across the fan terminals on each fan. A reading of approximately 47 Ω is expected.

Replace any defective fans and repeat the test.
Reconnect the 10-pin connector on top of Inverter Module number 2.

Check 5: Rectifier Heat Sink Fan and Option Cabinet Door Fan

1. Unplug the 10-pin connector from the top of Inverter Module number 1. Read the terminals on the wire harness side of the connector (male connector).
2. If unit size 61 or 62 Drive (no option cabinet), measure between pins 5 and 10. Should read approximately 21 Ω.
3. If unit size 63 or 64 Drive (with option cabinet), measure between pins 5 and 10. Should read approximately 15 Ω.

Incorrect Reading

In incorrect reading could indicate a failed fan or a bad wire harness.

1. Perform the Heat Sink Fan Ohm test on the Rectifier Module.
2. If unit size 63 or 64 (with option cabinet), perform the Option Cabinet Door Fan test.
3. If the above checks do not identify the problem, remove the faulty Rectifier Module and check the connections between the connectors on the top of the module and the power card. If these connections are the problem, replace and retest the fan continuity.

If the above checks do not identify the problem, replace the wire harness between Inverter Module number 1 and the Rectifier Module. Reconnect the 10-pin connector on top of Inverter Module number 1.

Check 6: Heat Sink Fan Ohm Test

Check the resistance of the heat sink fan on each module.

Rectifier Module

1. Unplug the 8-pin connector from the top of the Rectifier Module. Read the terminals on the Rectifier Module side of the connector (female connector).
2. Measure between pins 1 and 4. Should read approximately 21 Ω.

Inverter Module

1. Unplug the 10-pin connector from the top of each Inverter Module. Read the terminals on the Inverter Module side of the connector (female connector).
2. Measure between pins 5 and 10. Should read approximately 21 Ω.

Incorrect Reading

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

Follow the instructions for removing the heat sink fan. Make the following measurements on the connector leading to the fan

1. Measure between pins 1 and 2. Should read approximately 21 Ω.
2. Measure between pins 1 and 3. Should read approximately 45 Ω.
3. Measure between pins 2 and 3. Should read approximately 68 Ω.
4. Measure between pins 1 and 4. Should read open.
5. Measure between pins 2 and 4. Should read open.
6. Measure between pins 3 and 4. Should read open.

Incorrect reading

An incorrect reading indicates a failed fan. Replace the fan.

If the fan is OK, the problem is the wire harness inside the module. Remove the module in question and replace the fan wire harness.

Check 7: Option Cabinet Door Fan (only 63/64)

This checks the wiring between the Rectifier Module and the Option Cabinet Door Fan.

1. Unplug the 8-pin connector from the top of the Rectifier Module. Read the terminals on the wire harness side of the connector (male connector).
2. Measure between pins 5 and 8. Should read approximately 47 Ω.

Incorrect reading

In incorrect reading could indicate a failed fan or a bad wire harness. Measure the fan resistance at the Option Cabinet Door Fan. If bad, replace the door fan. If good, replace the wire harness.

Reconnect the 8-pin connector on top of the Rectifier Module.

6.3 Dynamic Test Procedures

6.3.1 Split Bus Mode

Powering the drive in the split bus mode allows dynamic testing on the drive in a safer manner.
In the split bus mode, the DC bus in each module is split into two portions. One connects to the DC bus and power card to provide low voltage power for the SMPS. By powering only the SMPS in each module, the various logic circuits can be tested without the danger of damaging the power components.
The other provides low voltage power to the DC capacitors and the output IGBTs for test purposes. A low voltage power supply connected to the DC bus allows testing the functionality of the output section safely.
The following procedure will be referred to throughout the dynamic test section.

Powering the Drive in Split Bus Mode

1. Ensure that AC power has been removed and that all DC capacitors are fully discharged.
2. Remove the top and bottom safety covers from each inverter module as well as the top safety cover from the rectifier module.
3. If a motor is connected to the drive, remove all output bus bars from each inverter module. Also remove the brake bus bars if the drive is equipped with the brake option.
4. Remove the plugs from the 6-pin sockets on each module.
5. Connect the power supply cable (p/n 6KAF6H8766) to the 6-pin sockets of each module.
6. Connect a 610 – 800VDC power supply to the input end of the power supply cable.
7. Apply power to the power supply. The Keypad should light up as if the drive were powered normally.
8. Warning 24, *External Fan Failure* will be displayed in the Keypad. This is because the fan circuitry is not powered in this mode. This will not affect the operation.

6.3.2 Warnings

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

Take all the necessary safety precautions for system start up prior to applying power to the frequency converter.

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

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

6.3.3 No Display Text

A frequency converter with no display can be the result of several causes.

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

First test for proper input voltage.

6.3.4 Input Voltage Test

1. Apply power to drive.
2. Use DVM to measure input line voltage between drive input terminals in turn:
   L1 to L2
   L1 to L3
   L2 to L3

For 380 - 480 V drives, all measurements must be within the range of 342 to 528 VAC. Readings of less than 342 VAC indicate problems with the input AC line voltage. For 525 - 690 V drives, all measurements must be within the range of 446 to 759 VAC. Readings of less than 446 VAC 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 drive can operate within specifications as long as the phase imbalance is not more than 3%.

The line imbalance is calculated per an IEC specification.

Imbalance = 0.67 X (Vmax – Vmin) / Vavg

For example, if three phase readings were taken and the results were 500 VAC, 478.5 VAC, and 478.5 VAC; then 500 VAC is Vmax, 478.5 VAC is Vmin, and 485.7 VAC is Vavg, resulting in an imbalance of 3%.

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

Incorrect reading

An incorrect reading here requires that the main supply be investigated further. 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

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

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

6.3.5 Basic Control Card Voltage Test

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

If an external 24 VDC supply is used for control voltage, it would be likely for switch 4 on the control card to be open. This opens the common connection to terminal 20. If this is the case, measure terminal 12 with respect to terminal 39.

An incorrect reading here could indicate the supply is being 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 out the customer connections.

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

An incorrect reading here could indicate the supply is being loaded down by a fault in the customer connections. Unplug the terminal strip and repeat the test. If this test is successful than continue. Remember to check out the customer connections.

A correct reading of both control card voltages would indicate the Keypad or the control card is defective. Replace the Keypad with a known good one. If the problem persists replace the control card.

6.3.6 DC Undervoltage Test

The initial charge of the DC bus is accomplished by the soft charge circuit. If the DC bus voltage is below normal it would indicate that either the line voltage is out of tolerance or the soft charge circuit is restricting the DC bus from charging. Conduct the input voltage test to ensure the line voltage is correct.

If excessive input power cycling has occurred, the PTC resistors on the soft charge card may be restricting the bus from charging. If this is the case, expect to read a DC bus voltage in the area of 50 VDC.

6.3.7 Input Imbalance of Supply Voltage Test

Theoretically, the current drawn on all three input phases should be equal. Some imbalance may be seen, however, due to variations in the phase to phase input voltage and, to some degree, single phase loads within the frequency converter itself.

A current measurement of each phase will reveal the balanced condition of the line. To obtain an accurate reading, it will be necessary for the frequency converter to run at its rated load or or at a load of not less than 40%.

1. Perform the input voltage test prior to checking the current, in accordance with procedure. Voltage imbalances will automatically result in a corresponding current imbalance.
2. Apply power to the frequency converter and place it in run.
3. Using a clamp-on amp meter (analog preferred), read the current on each of three input lines at L1(R), L2(S), and L3(T).
   Typically, the current should not vary from phase to phase by more than 5%. Should a greater current variation exist, it would indicate a possible problem with the mains supply to the frequency converter or a problem within the frequency converter itself.
   One way to determine if the mains supply is at fault is to swap two of the incoming phases. This assumes that two phases read one current while the third deviates by more than 5%. If all three phases are different from one another, swap the phase with the highest current with the phase with the lowest current.
4. Remove power to frequency converter.
5. Swap the phase that appears to be incorrect with one of other two phases.
6. Reapply power to the frequency converter and place it in run.
7. Repeat the current measurements.

If the imbalance of supply voltage moves with swapping the leads, then the mains supply is suspect. Otherwise, it may indicate a problem with the gating of the SCR. This may be due to a defective SCR or in the gate signals from the power card to the module, including the possibility of the wire harness from the power card to the SCR gates. Further tests on the proper gating of the SCRs require an oscilloscope equipped with current probes. Proceed to testing the input waveform.

6.3.8 Input Waveform Test

Testing the current waveform on the input of the frequency converter can assist in troubleshooting mains phase loss conditions or suspected problems with the SCR/diode modules. Phase loss caused by the mains supply can be easily detected. In addition, the rectifier section is controlled by SCR/diode modules. Should one of the SCR/diode modules become defective or the gate signal to the SCR lost, the frequency converter will respond the same as loss of one of the phases.

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

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

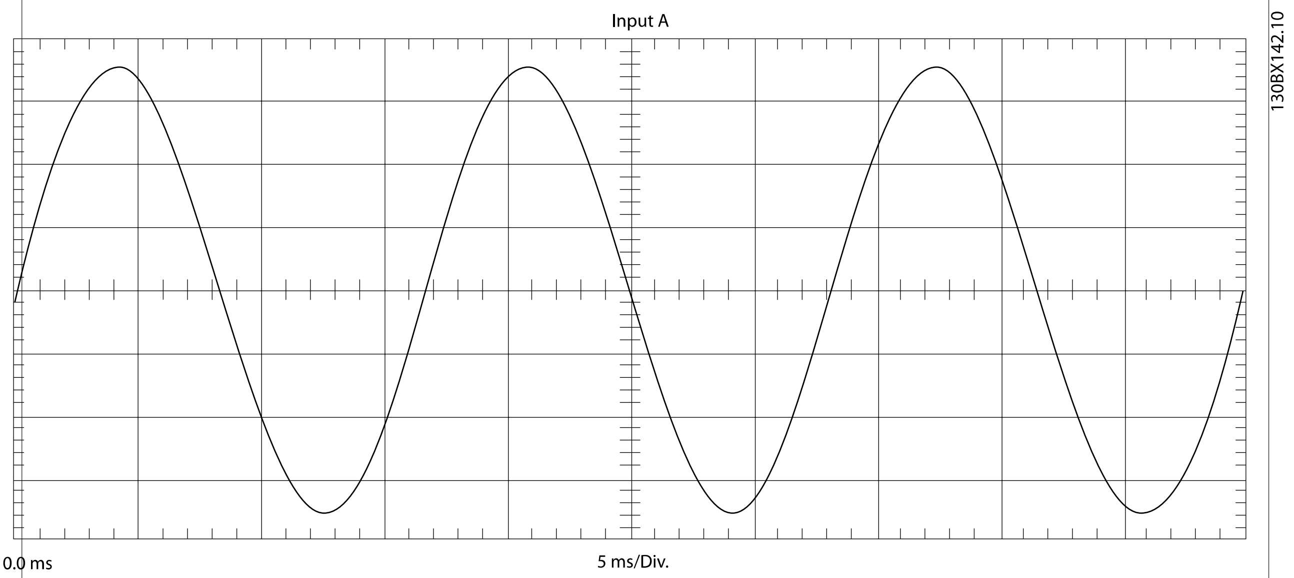


Illustration 6.3: Normal AC Input Voltage Waveform

The waveform shown in the illustration below represents the input current waveform for the same phase as in the Illustration above while the frequency converter is running at 40% load. The two positive and two negative jumps are typical of any 6 diode bridge. It is the same for frequency converters with SCR/diode modules.

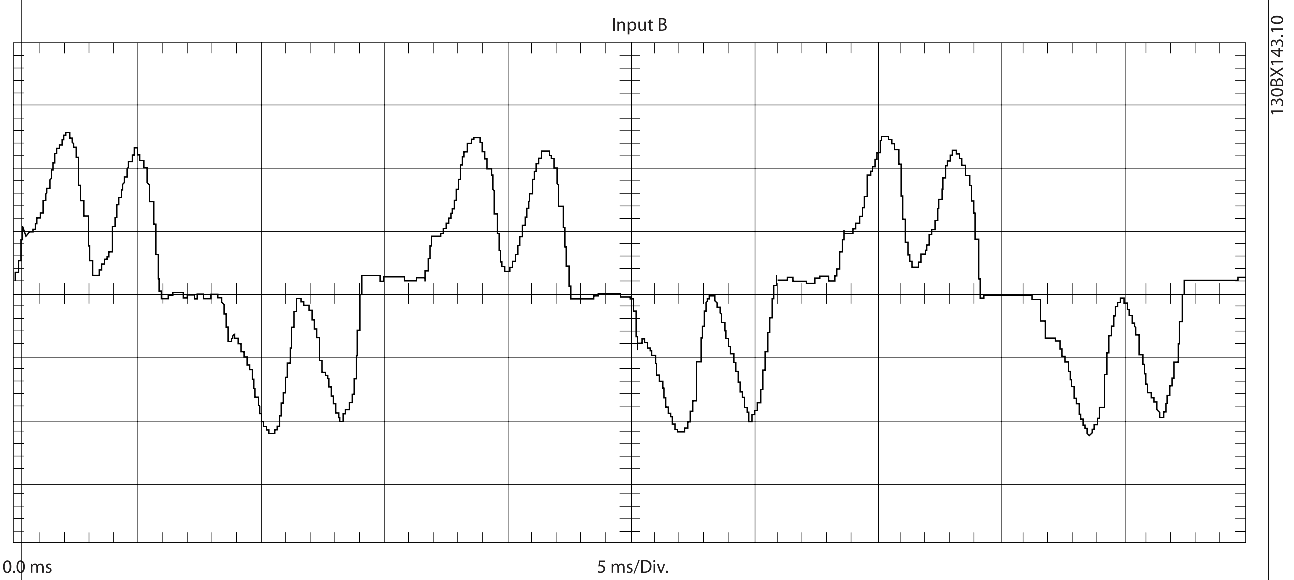


Illustration 6.4: AC Input Current Waveform with Diode Bridge

With a phase loss, the current waveform of the remaining phases would take on the appearance shown below.

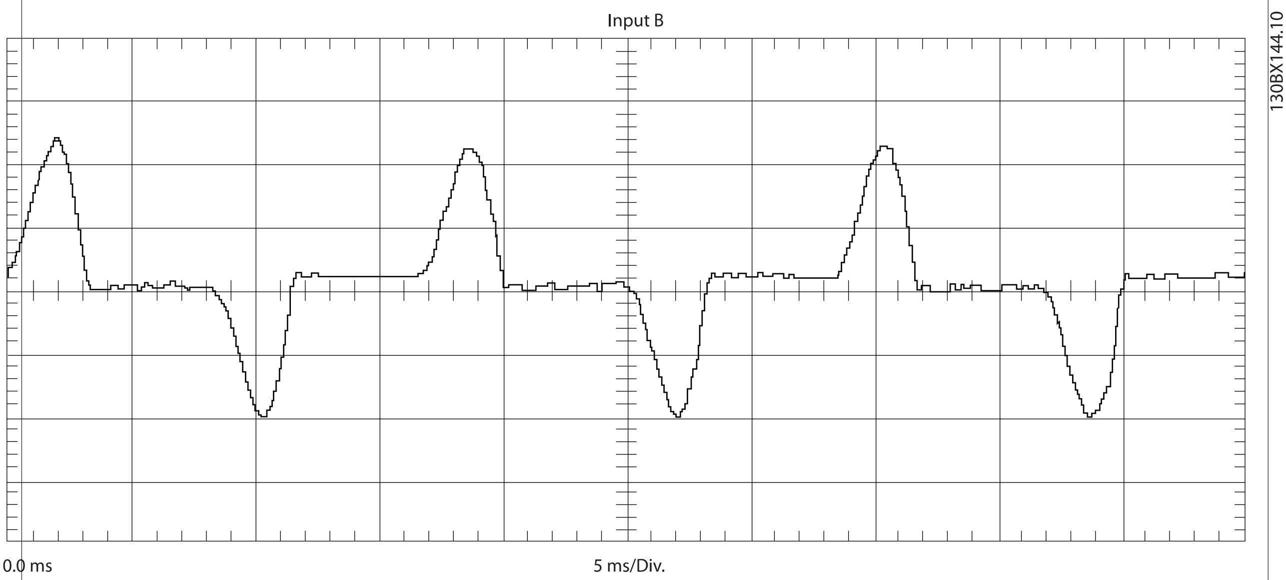
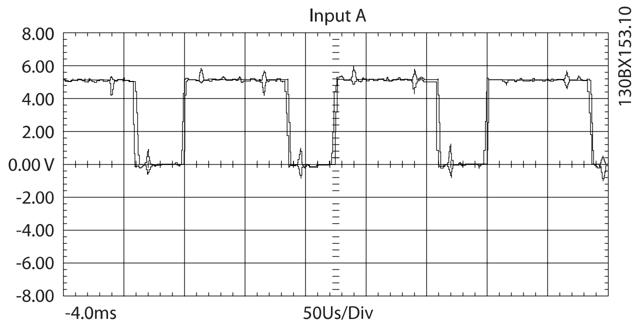


Illustration 6.5: Input Current Waveform with Phase Loss.

Always verify the condition of the input voltage waveform before forming a conclusion. The current waveform will follow the voltage waveform. If the voltage waveform is incorrect proceed to investigate the reason for the AC supply problem. If the voltage waveform on all three phases is correct but the current waveform is not then the input rectifier circuit in the frequency converter is suspect. Perform the static soft charge and rectifier tests.

6.3.9 Gate Signal Test

1. Remove the output bus bars from all inverter modules.
2. Power drive in split bus mode. (See split bus powering).
3. Connect a 24VDC power supply to the (+) and (-) DC bus bars.
4. Connect the signal test board (p/n 6KAF6H8437) to the 30 pin connector at the top of the inverter module.
5. Apply a run command and a speed command above 0 RPM. (Hand Start mode is sufficient).
6. Connect the common lead of an oscilloscope to terminal 4 of the signal test board. Observe the waveform on terminals 25 – 30 in turn. Each reading should appear similar to the figure shown.
7. Repeat this procedure for each inverter module.



Incorrect reading

If one or more of the IGBT gate signals is missing, this indicates a faulty connection in the ribbon cable from the control card to the MDCIC or from the MDCIC to the inverter module. Check the cables and replaced if necessary. If all six signals are missing, the control card is likely defective and needs to be replaced.

Conduct the IGBT Switching Test with the frequency converter powered as in this procedure.

6.3.10 IGBT Switching Test

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

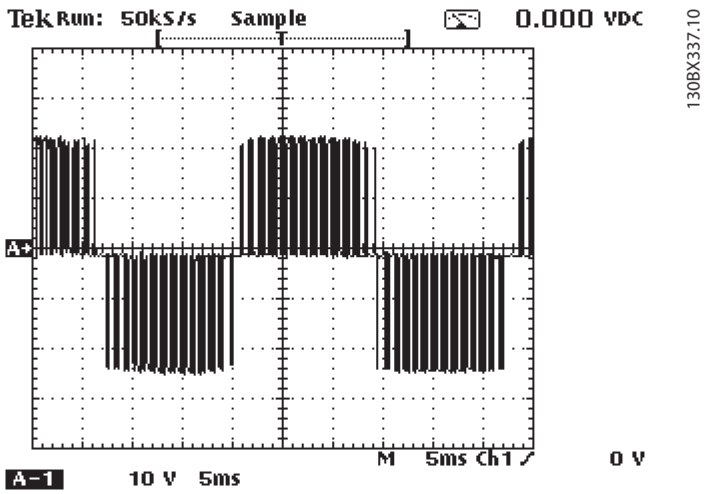


Illustration 6.6: Output waveform graphic

Incorrect reading

Indicates that an IGBT or gate driver card is defective. Check all IGBT modules for signs of damage. If no damage is found, replace gate driver card.

6.3.11 Current Sensor Test

1. Apply power to the unit.
2. Ensure that motor check, pre-magnetizing, DC hold, DC brake, or other parameter setups are disabled that create a holding torque while at zero speed. Current displayed will exceed 1 to 2 amps if such parameters are not disabled.
3. Run drive with a zero speed reference.
4. Read the output current in the display. It should indicate approximately 1 to 2 amps.

Incorrect reading

If the current is greater than 1 to 2 amps and a current producing parameter is not active, test the current sensor with the motor leads disconnected as described next.

1. Remove power from drive.
2. Ensure the DC bus is fully discharged.
3. Remove output motor bus bars from each inverter module.
4. Apply power to drive.
5. Run drive with a zero speed reference.
6. Read the output current in the display. The display should indicate less than 1 amp.

Incorrect reading

If an incorrect reading was obtained from the above tests, further tests of the current feedback signals are required using the signal test board. See Testing Current Feedback with the Signal Test Board.

6.3.12 Testing Current Feedback with the Signal Test Board

If the control card parameters are setup to provide holding torque while at zero speed, the current displayed will be greater than expected. To make this test, disable such parameters.

1. Remove power to drive.
2. Ensure DC bus is fully discharged.
3. Install signal test board into the 30 pin test connector socket in inverter one.
4. Apply power to the drive.
5. Using a DVM, connect negative (-) meter lead to terminal 4 (common) of signal test board.
6. Run drive with a zero speed reference.
7. In turn measure AC voltage at terminals 1, 2, and 3 of signal test board. These terminals correspond with current sensor outputs U, V, and W, respectively. Expect a reading near zero volts but no greater than 15mv.
8. Repeat the procedure for each inverter module in the drive.

Incorrect reading

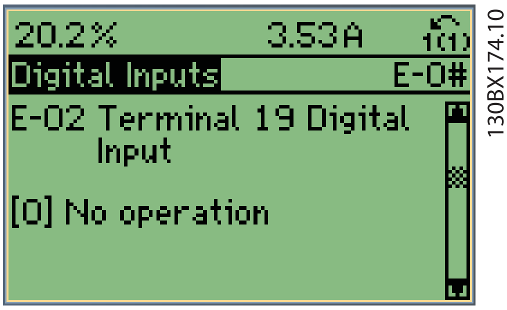
A current sensor feedback signal at this point in the circuit should read approximately 400mv at 100% drive load. Therefore, any reading above 15mv while the drive is at zero speed has a negative effect on the way the drive interprets the feedback signal. Replace the corresponding current sensor if the reading is greater than 15mv. See the disassembly instructions.

6.3.13 Input Terminal Signal Test

The presence of signals on either the digital or analog input terminals of the drive can be verified on the drive display. Digital or analog input status can be selected in the display using the [DISPLAY MODE] key and the [+] and [-] keys on the keypad.

Digital inputs

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



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If the desired signal is not present in the display, the problem may be either in the external control wiring to the drive or a faulty control card. To determine the fault location, use a volt meter 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. Meter should read between 21 and 27 VDC.

If the 24 V supply voltage is not present, conduct the Control Card Test (6.3.17) later in this section.

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

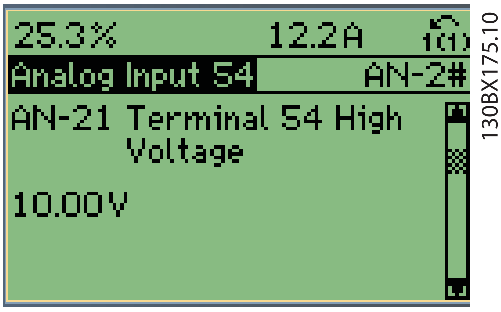
2. Connect (-) negative meter lead to reference terminal 20.
3. Connect (+) positive meter lead to terminals 18, 19, 27, 29, 32, and 33 in turn.

Presence of a signal at the desired terminal should correspond to the digital input display reading. A reading of 24 VDC indicates the presence of a signal. A reading of 0 VDC indicates no signal is present.

Analog inputs

The value of signals on analog input terminals 53, 54, and 60 can also be displayed.

The voltage on terminals 53 and 54, or the current in milliamps for terminal 60 is shown in line 2 of the display.



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

Verify the reference voltage power supply is correct as follows.

1. With a voltmeter measure voltage at control card terminal 50 with respect to terminal 55. Meter should read between 9.2 and 11.2 VDC.

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

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

2. Connect (-) negative meter lead to reference terminal 55.
3. Connect (+) positive meter lead to desired terminal 53, 54 or 60.

For analog input terminals 53 and 54, a DC voltage between 0 and +10 VDC should be read to match the analog signal being sent to the drive.

For analog input terminal 60, a reading of 0.9 to 4.8 VDC corresponds to a 4 to 20ma signal.

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

6.4 Module-level Static Test Procedures

6.4.1 Inverter Module

Heatsink Temperature Sensor Test

Remove the inverter module from the drive in accordance with disassembly procedures.

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. The centre IGBT 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 undertemperature conditions.

1. Use ohmmeter set to read Ω.
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 25°C, the resistance will be approximately 5k Ω. At 0° C, the resistance will be approximately 13.7k Ω. At 60° C, the resistance will be approximately 1.5k Ω. The higher the temperature, the lower the resistance.

6.4.2 Rectifier Module

Heatsink Temperature Sensor Test

Remove the rectifier module from the drive in accordance with disassembly procedures.

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

1. Use ohmmeter set to read Ω.
2. Unplug connector MK103 on power card and measure across cable leads.

The full range of the sensor is 787 Ω to 10K Ω where 10K Ω equals 25°C and 787 Ω equals 95°C. The higher the temperature, the lower the resistance.

Soft Charge Rectifier Test

1. Remove the rectifier module from the drive in accordance with disassembly procedures.
2. Remove the power card mounting plate in accordance with disassembly procedures.
3. Disconnect the connector MK3 from each soft charge card.

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

1. Measure the resistance between pins A and B of connector MK4 on the soft charge card. It should read 27 Ω (±10%) for 380–480 V frequency converters or 68 Ω (±10%) for 525–690 V frequency converters. A reading outside this range indicates a defective soft charge resistor. Replace the resistor according to the disassembly procedures. Continue tests.

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

2. Connect the negative (-) meter lead to the positive (+) MK3 (A) (DC output to DC bus), and connect the positive (+) meter lead to MK1 terminals R, S, and T in sequence. Each reading should show a diode drop.
3. Reverse meter leads with the positive (+) meter lead to the positive (+) MK3 (A). Connect the negative (-) lead to MK1 terminals R, S, and T in sequence. Each reading should show open.

4. Connect the positive (+) meter lead to the negative (-) MK3 (C). Connect the negative (-) meter lead to MK1 terminals R, S, and T in sequence. Each reading should show a diode drop.
5. Reverse the meter leads with the negative (-) meter lead to the negative (-) MK3 (C). Connect the positive (+) meter lead to MK1 terminals R, S, and T in sequence. Each reading should show open.

Incorrect Reading

An incorrect reading here indicates the soft charge rectifier is faulty. The rectifier is not serviced as a component. Replace the entire soft charge card in accordance with the disassembly procedures. Reconnect the MK3 on the soft charge card after these tests.

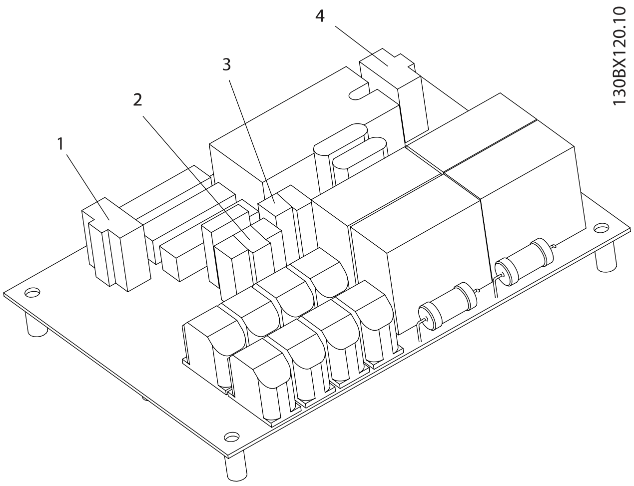


Illustration 6.7: Soft Charge Card Connectors

380-480/500V: Blue MOV and 8 PTCs. 525-690V: Red MOV and 6 PTCs

1	MK1	3	MK4
2	MK3	4	MK2

6.5 After Repair Drive Test

6.5.1 Procedure

Following any repair to a frequency converter or testing of a frequency converter suspected of being faulty, the following procedure must be followed to ensure that all circuitry in the frequency converter is functioning properly before putting the unit into operation.

1. Perform visual inspection procedures as described in the table *Visual Inspection*.
2. Perform static test on the drive as described in *Static Test Procedures.*
3. Remove the three output motor bus bars from each inverter module.
4. Connect a 610 – 800 VDC power supply to the switch mode power supply (SMPS) input to each module using the test cable 6KAF6H8766.
5. Apply power to the SMPS and observe that the display lights up properly. (The fans will not operate when powered in this manner.)
6. Give the frequency converter a run command (press [Hand]) and slowly increase the reference (speed command) to approximately 40 Hz.
7. Using the Signal Test Board 6KAF6H8437 and an oscilloscope, check the waveform at pins 25 - 30 with the scope referenced to pin 4. This procedure must be performed on each inverter module. Each waveform should approximate the illustration below.
8. Connect a 24 VDC power supply to the DC bus of the drive. This can be done on the DC bus output of the rectifier module or the bus bars connecting to the top side of the DC fuses on any of the inverter modules.
9. Observe the phase to phase waveform on the output bus bars of each phase of each inverter module. This waveform should appear the same as the normal output waveform of a properly operating drive, except that the amplitude will be 24 V instead of the full output voltage of a normal drive.
10. Press the OFF key of the frequency converter, disconnect power from both power supplies, and reinstall jumper connectors to the SMPS input plugs on all modules.
11. Reinstall the motor output bus bars on all inverter modules.
12. Apply AC power to the drive.
13. Apply a start command to the drive. Adjust the speed to a nominal level. Observe that the motor is running properly
14. Using a clamp-on style current meter, measure the output current on each phase. All currents should be balanced.

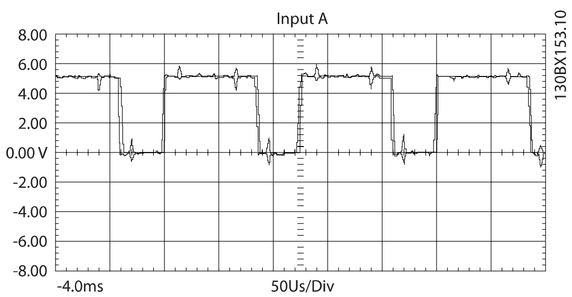


Illustration 6.8: After repair waveform: 2v/div 100us/div run at 10 Hz

7 Top Level Module Removal Instructions

7.1 Before Proceeding

7.1.1 High Voltage Warning

Frequency converters contain dangerous voltages when connected to mains voltage. No disassembly should be attempted with power applied. Remove power to the frequency converter and wait at least 40 minutes to let the frequency converter capacitors fully discharge. Only a competent technician should carry out service. Failure to fully discharge capacitors could result in serious injury or death.

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

7.1.3 Optional Circuit Breaker or Disconnect Switch

Supplied with a circuit breaker or disconnect switch, the cabinet doors are interlocked. To open the cabinet doors, the circuit breaker and disconnect switch must be in the OFF position.

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

7.1.4 Tools Required

Operating Instructions for the Drives Series Frequency Converter

Metric socket set	7–19 mm
Socket extensions	100 mm–150 mm (4 in and 6 in)
Torx driver set	T10 - T50
Torque wrench	0.675–19 Nm (6–170 in-lbs)
Needle nose pliers	
Magnetic sockets	
Ratchet	
Hex wrench set	
Screwdrivers	Standard and Philips

Additional Tools Recommended for Testing

Digital volt/ohmmeter (must be rated for 1200 VDC for 690 V units)
Analog voltmeter
Oscilloscope
Clamp-on style ammeter
Test cable p/n 6KAF6H8439
Signal test board p/n 6KAF6H8437
Power supply: 610 - 800 VDC, 250 mA to supply external power to 4 power cards and the control card.
Power supply : 24 VDC, 2 A for external 24 V power supply.

7.1.5 Unit Size 6x Service Shelf

The rectifier and inverter modules weigh up to 136 kg/300 lbs each and require special handling. An easy to assemble service shelf, part number 6KAF6H8835, is available from GE to provide support of the modules for removal from the units. This shelf, or other suitable support equipment, is recommended.

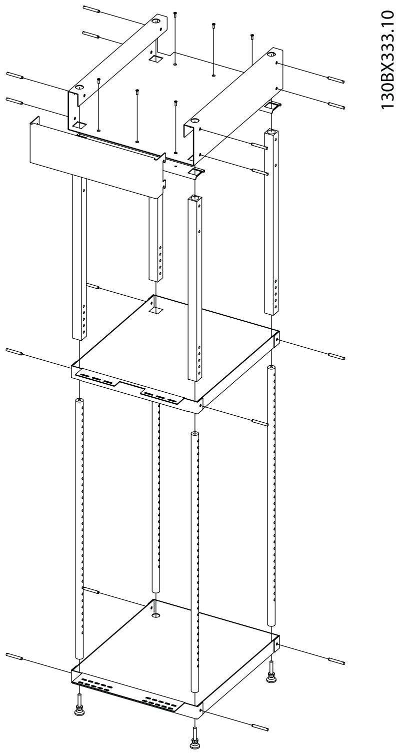


Illustration 7.1: Unit size 6x Service Shelf Assembly Drawing

7.2 Instructions

7.2.1 AC Line Input Fuses

AC Fuse Location

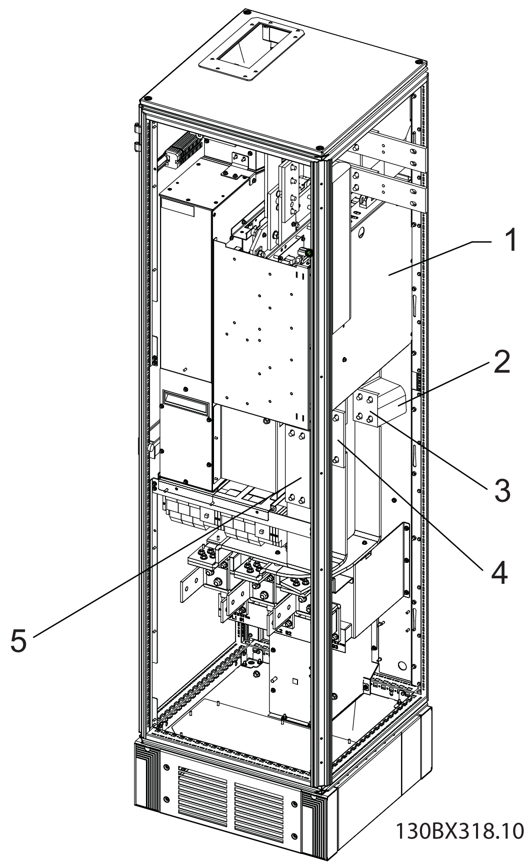
AC line fuses are optional. AC fuses are located in the rectifier cabinet if they are the only power option added to the frequency converter. If additional power options are present, the AC fuses will be located in the options cabinet.

AC Fuses Located in the Rectifier Cabinet

1. Remove bottom safety cover from rectifier cabinet.
   Note: Fuses must be removed sequentially, front to back. If only the fuse located in the back needs to be replaced, remove front and middle fuses to gain access to the back fuse. If additional access is necessary, the left-most inverter module can be removed from the inverter cabinet. Refer to inverter removal instructions.
2. Remove bolts (8mm) securing fuses in place.

AC Fuses Located in Options Cabinet

1. Remove covers from options cabinet to access fuses.
2. Remove bolts (8mm) securing fuses in place.



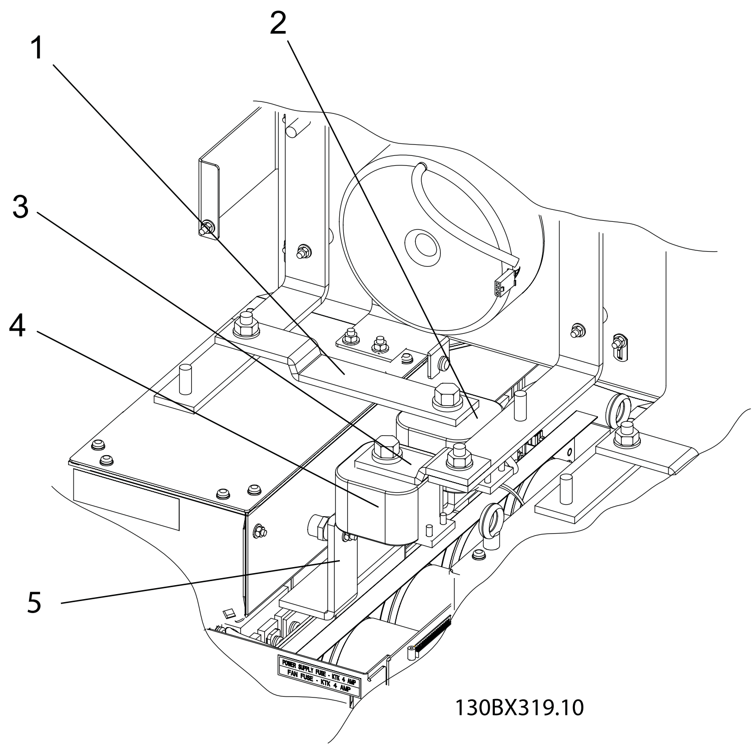
AC Fuses Located in the Rectifier Cabinet

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

7.2.2 DC Link Fuses

There are two DC link fuses for each inverter located on top of the inverter.

1. Remove covers from inverter cabinet to gain access.
2. Remove bus bars securing top of fuses by removing attaching bolts (8mm).
3. Remove bolts securing bottom of fuses (8mm).



1	Top (-)DC link fuse bus bar	4	(+)DC link fuse
2	(-)DC link fuse	5	Bottom (+)DC link fuse bus bar
3	Top (+)DC link fuse bus bar		

7.2.3 Door Fans

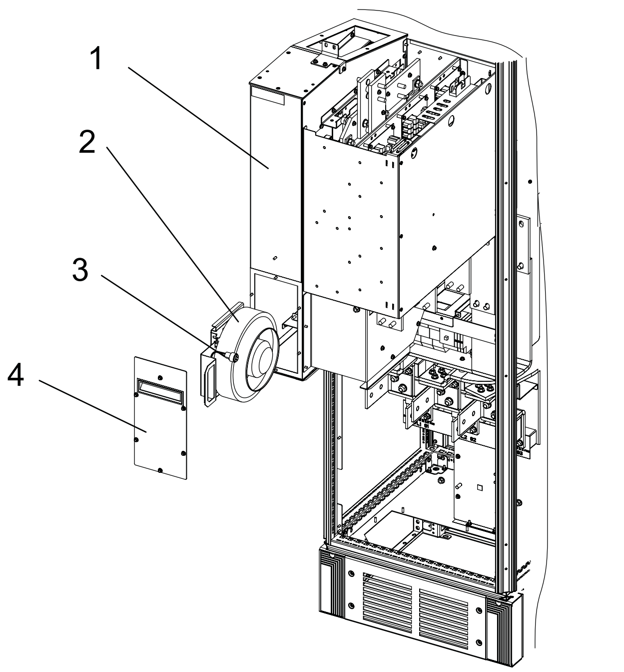
1. Disconnect the leads from the terminal strip on the fan, noting the correct terminal that each wire is connected to for reassembly.
2. Remove the four (8mm) mounting nuts from each corner of the fan assembly.
3. Remove fan assembly from mounting/filter housing assembly in door.
4. Reassemble in reverse order. Note that Unit size 6x drives are designed for fan airflow into the cabinets. For this reason, ensure that the fan is installed with the printed arrow on the fan pointing inward. Incorrect installation can cause excess heating and an overtemperature fault. Tighten nuts to 20 in/lbs (2.3 Nm).

7.2.4 Heatsink Fans

1. Remove panel to access fan by removing six nuts (M5) securing panel in place.
2. Unplug fan electrical connector and remove two nuts (M6) securing fan in place.

Reinstall in reverse order of disassembly.

NB!
The plug for the fan is keyed to only fit one way. However, if too much force is used, the plug can be forced the wrong way.

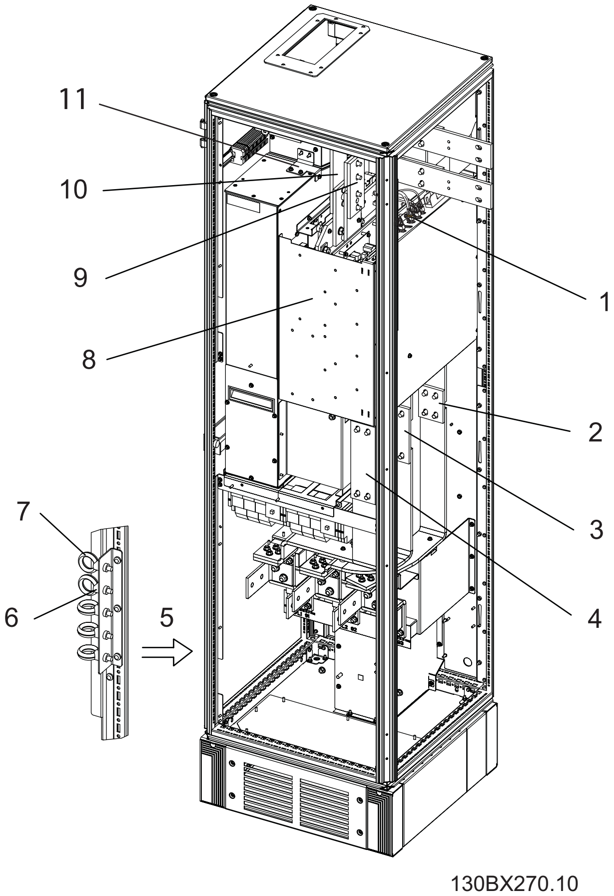


1	Heatsink	3	Plug
2	Heatsink fan	4	Cover

7.2.5 Rectifier Module

1. Remove center mounted safety cover from rectifier module by removing screws (8mm).
2. Remove top mounted safety cover from rectifier module by removing screws (8mm).
3. Remove two DC bus bars from top of rectifier by removing four nuts (8mm) securing each bus bar (two on each end of bus bar).
4. Remove three AC input power bus bars in order to free module for removal. Bus bars are stacked one behind the other. Each is retained by four nuts (17mm) .
5. Disconnect four white connectors from top of rectifier module.
   NOTE: For reinstallation, note that each connector is a different size.
6. Disconnect connector located on bottom of MDCIC board mounted to back panel above rectifier unit (not shown).
7. Remove two nuts (M6) from bracket at back of rectifier securing module to cabinet.
   NOTE: Four eye bolts and washers are stored at left bottom side of rectifier cabinet for use in lifting rectifier. If desired, attach washers and bolts to lifting holes provided at top of module. Module weighs approx. 136 kg / 300 lbs.
8. Provide sufficient mechanical support to withstand weight of rectifier. Withdraw rectifier from cabinet.

Reinstall rectifier module in reverse order of this procedure.

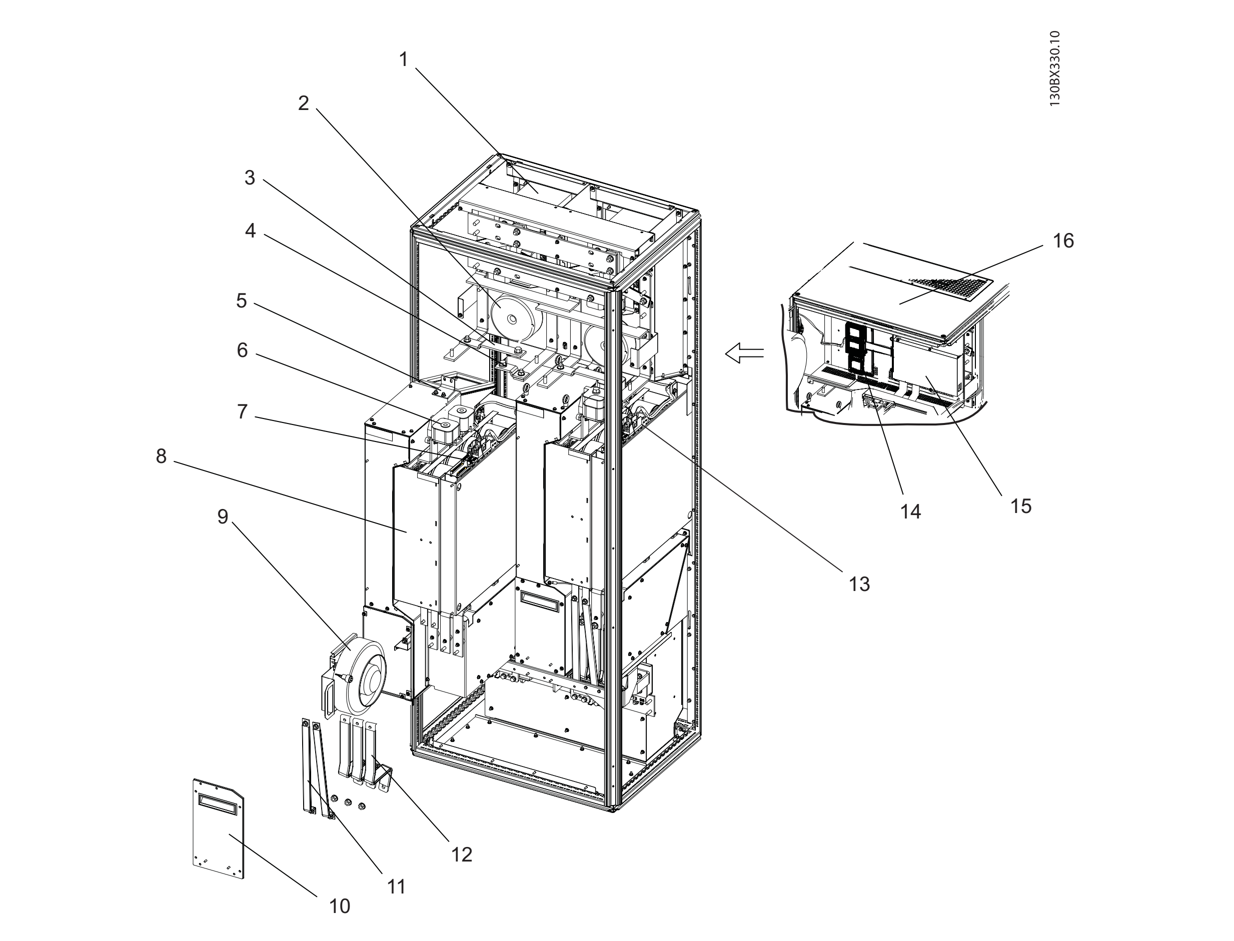


1	Connectors (step 5)	7	Eye bolt
2	Back AC input power bus bar (step 4)	8	Rectifier module
3	Middle AC input power bus bar (step 4)	9	DC bus bar (step 3)
4	Front AC input power bus bar (step 4)	10	DC bus bar (step 3)
5	Eye bolt location in rectifier cabinet	11	Mounting bracket
6	Eye-bolt washer		

7.2.6 Inverter Module

1. Remove safety covers from front of inverter module by removing attaching screws.
2. If present, remove two (optional) brake bus bars by removing four screws (M8), one on each end of both bus bars.
3. Remove three output motor bus bars by removing six screws (M8), one on each end of each bus bars.
4. Disconnect ribbon cable from top of inverter module.
5. Unplug connectors (two or three, depending upon unit) from top of inverter module.
   NOTE: For reinstallation, note that each connector is a different size.
6. Remove DC bus bars from top of both fuses by removing bolt (8mm) at top of fuse. (Fuse may remain connected to inverter module.)
   NOTE: Four eye bolts and washers are stored at left bottom side or inverter cabinet for use in lifting inverter. If desired, attach bolts to holes provided at top of inverter module. Module weighs approx. 136 kg / 300 lbs.
7. Remove 2 nuts (M6) from bracket at back of inverter securing module to cabinet.
8. Provide sufficient mechanical support to withstand weight of inverter module. Withdraw inverter from cabinet.

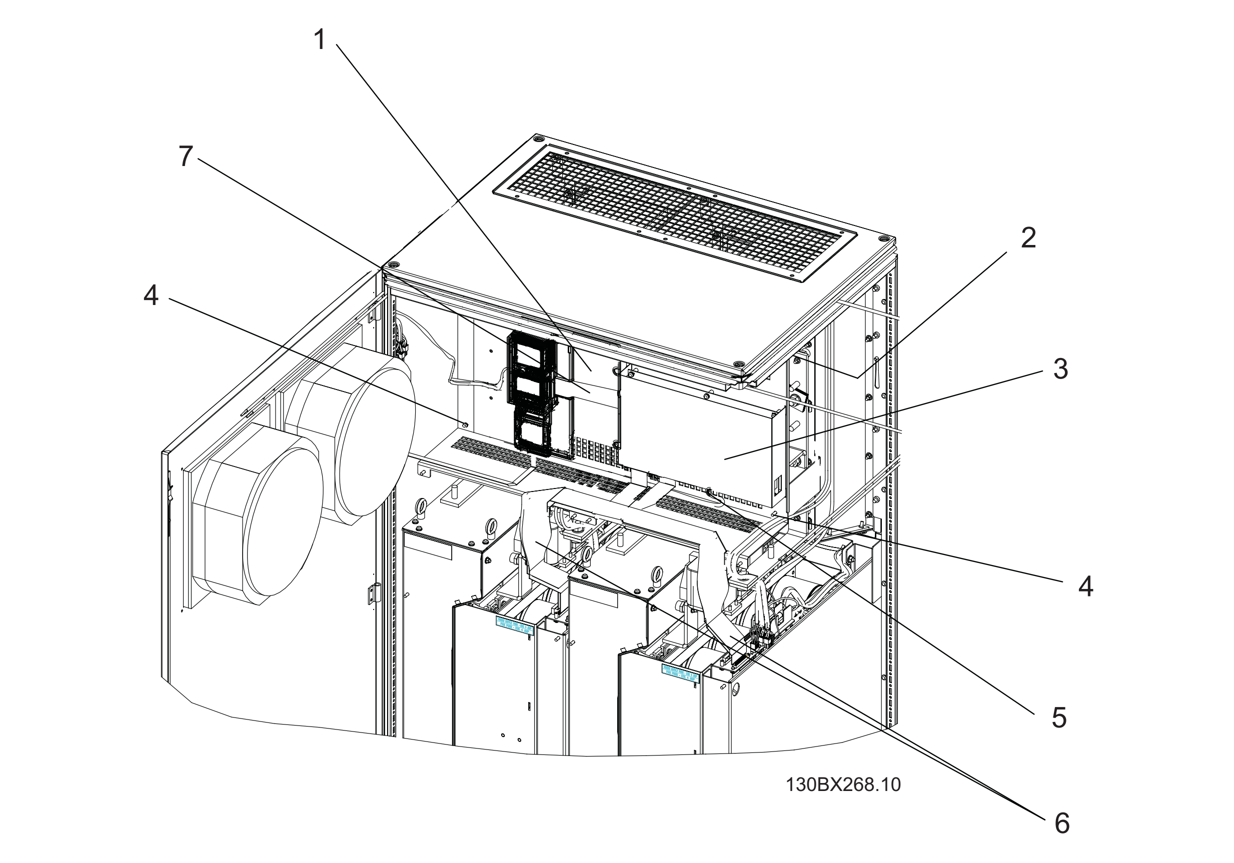
Reinstall inverter module in reverse order of these instructions.



1	DC link inductor	9	Module heatsink fan
2	Fan transformer	10	Fan door cover
3	(-)DC bus bar	11	(Optional) brake output bus bar (Step 2)
4	(+)DC bus bar	12	Motor output bus bar (Step 3)
5	Mounting bracket (Step 7)	13	SMPS fuse and fan fuse
6	DC Fuse (Step 6)	14	Control card
7	Panel connectors (Steps 4 and 5)	15	MDCIC board
8	Inverter module	16	Top cover plate

7.2.7 MDCIC Mounting Panel

1. Remove top mounted safety cover from inverter module by removing attaching screws (8mm).
2. Disconnect ribbon cable from control card.
3. Before removing MDCIC ribbon cable from each inverter module, note which cable connects to each module for reassembly. Remove MDCIC ribbon cable from each inverter module.
4. Before removing rectifier control cable MK101 of MDCIC board, note for reinstallation that MK101 is left most 6-pin connector on MDCIC board. Remove rectifier control cable from MDCIC board.
5. Remove relay connector from MDCIC panel.
6. Remove any customer interconnect wiring.
7. Remove MDCIC panel by removing four screws (M5) attaching panel to inverter cabinet (one in each corner of panel).



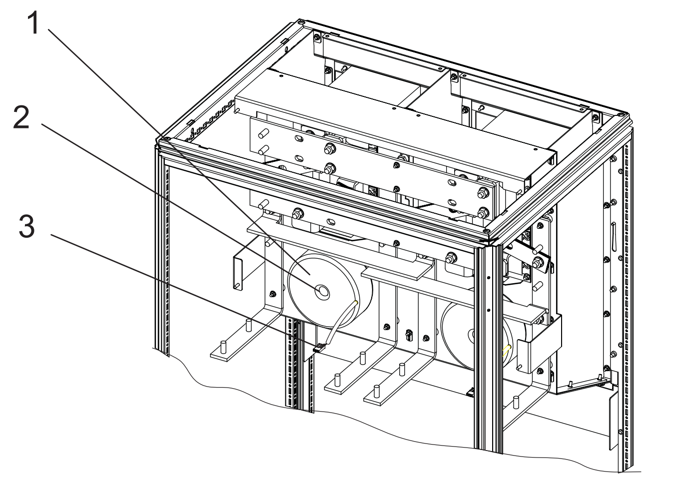
1	MDCIC mounting panel	5	Rectifier control cable MK101 (step 4)
2	Relay connector (not shown) (step 5)	6	MDCIC ribbon cable (step 3)
3	MDCIC board cover plate	7	Control card to MDCIC ribbon cable (step 2)
4	Attaching screw (step 7)		

Reinstall in reverse order of this procedure.

7.2.8 Fan Transformers

1. Remove MDCIC panel in accordance with instructions.
2. Disconnect electrical connector from fan transformer.
3. Remove nut (M8) from center of fan transformer securing transformer to panel.

Reinstall fan transformer in reverse order of this procedure.

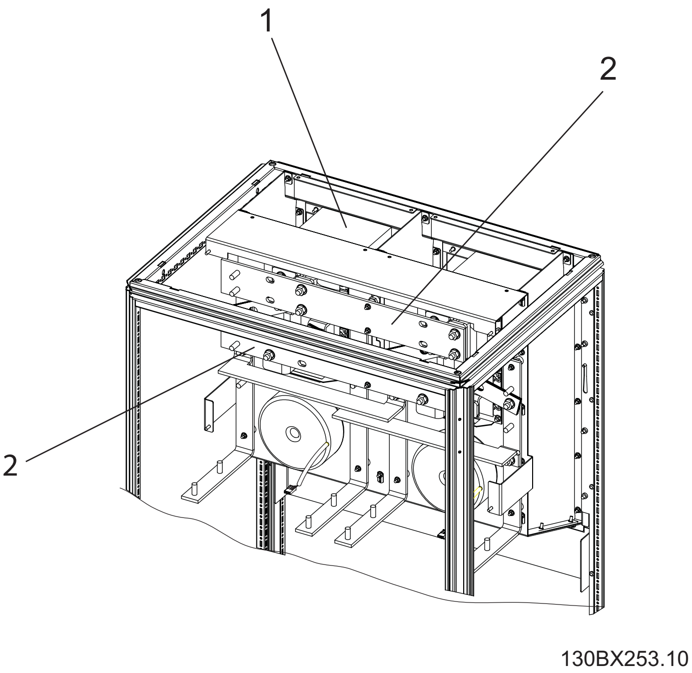


1	Fan transformer	3	Fan transformer connector (step 2)
2	Nut (M8) (step 3)		

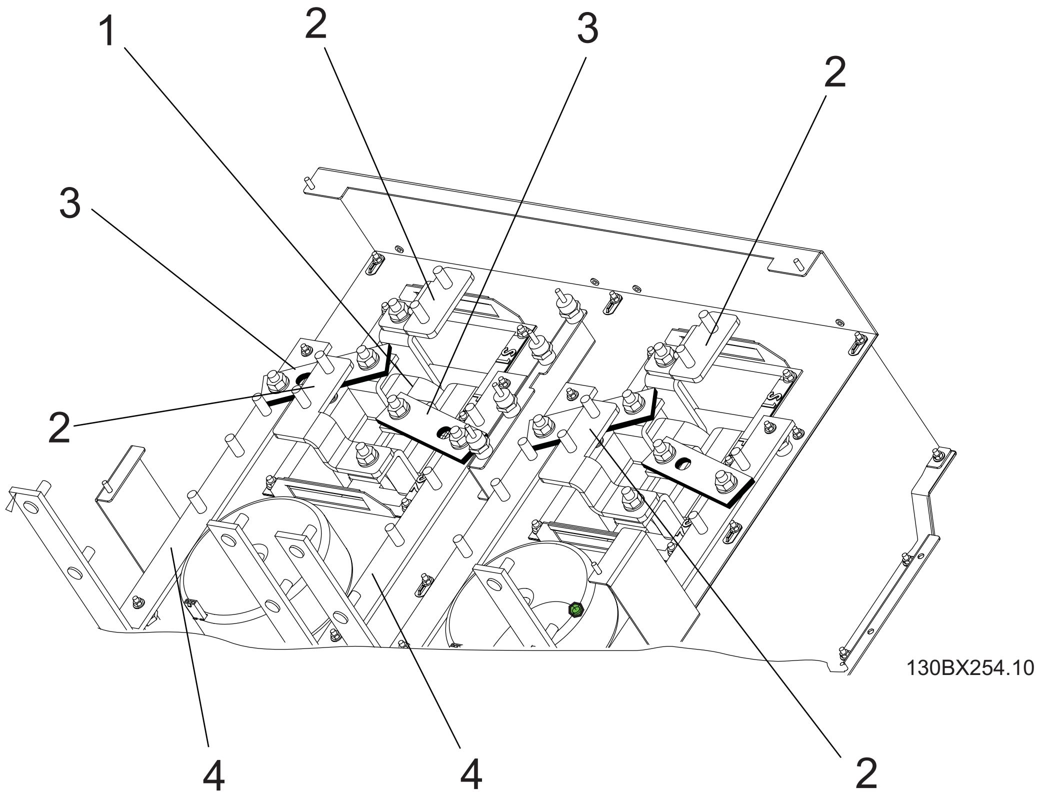
7.2.9 DC Link Inductor

1. Remove MDCIC panel in accordance with instructions. (Fan transformers do not need to be removed.)
2. Remove 2 bus bars covering inductor by removing four screws (8mm) on each bus bar.
3. Remove 4 mounting bracket bus bars that bus bars removed previously in Step 2 were mounted to by removing screw (8mm) from each mounting bracket.
4. Remove remaining short bus bars attached to angle bracket bus bars by removing two 8mm screws from each bus bar.
5. Note that DC link reactors weigh 25 kg / 55 lbs. Provide sufficient support and remove DC link inductor by removing M6 nuts securing inductor to cabinet.

Reinstall DC link reactors in reverse order of this procedure.



1	DC link inductor	2	Bus bars (step 2)

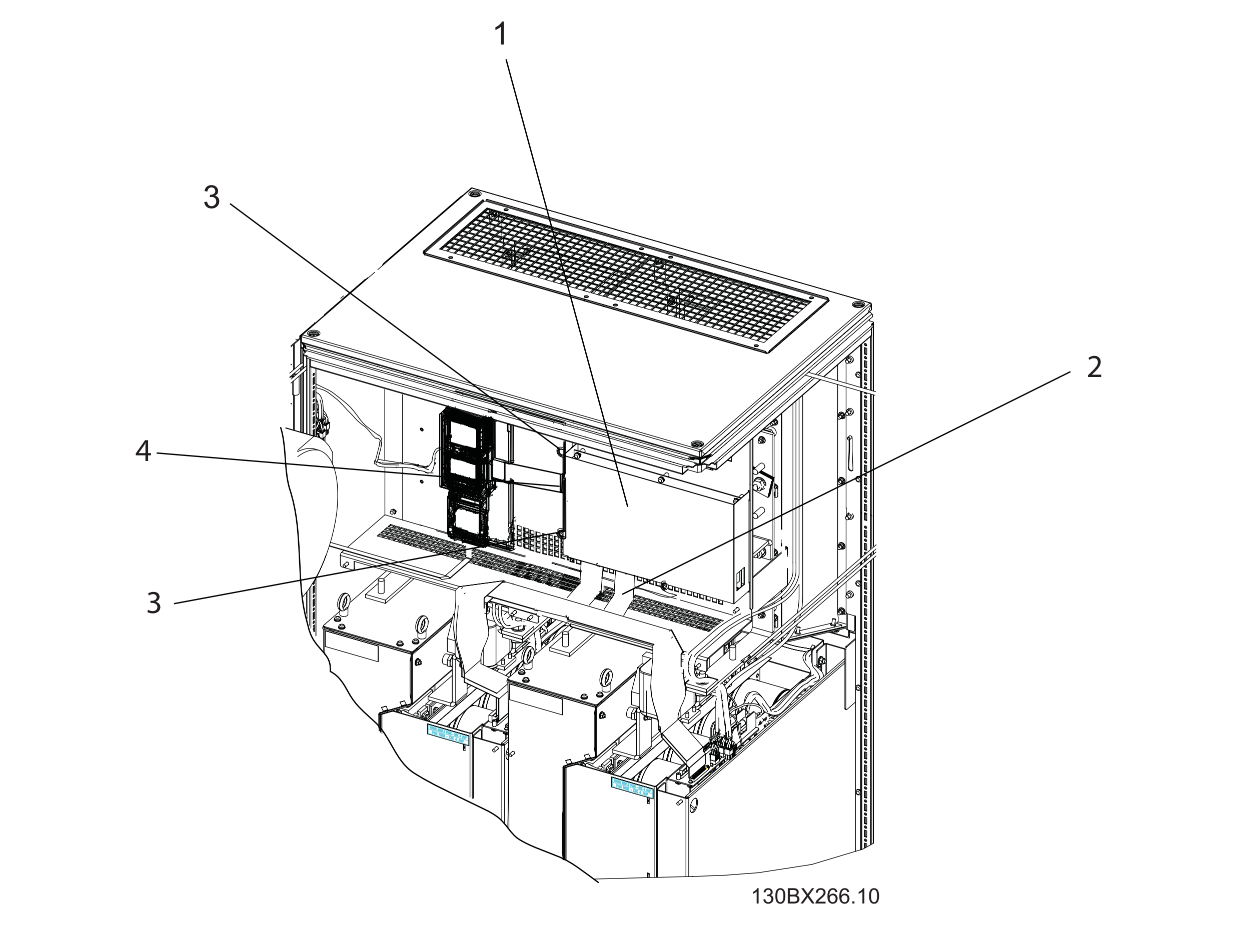


1	DC link inductor (step 5)	3	Short bus bars (step 4)
2	Mounting bracket bus bar (step 3)	4	Angle bracket bus bar (not removed)

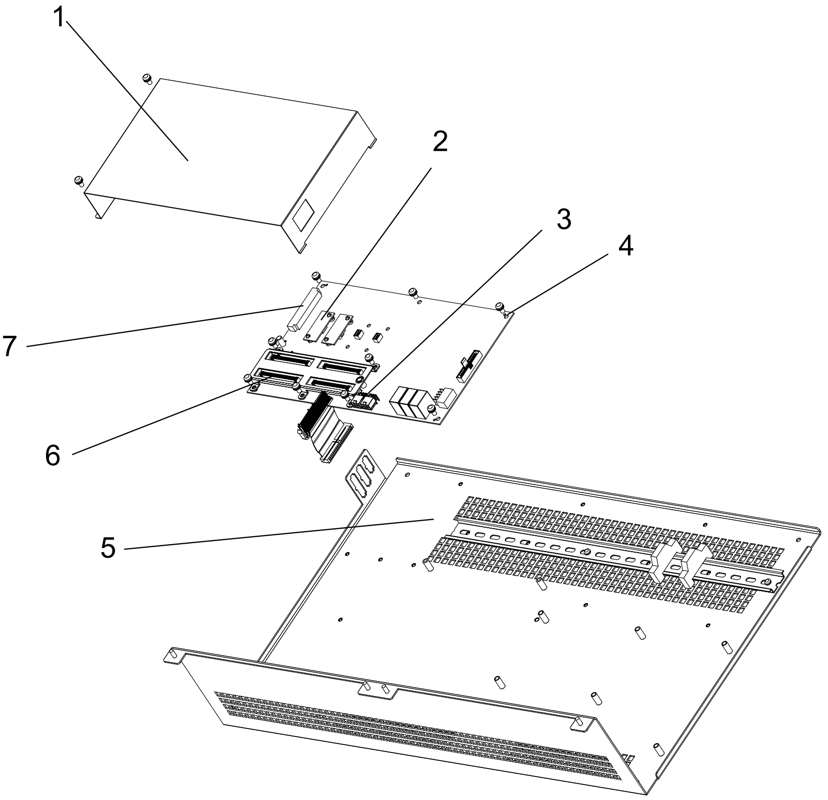
7

7.2.10 MDCIC Board

1. Remove two screws from left side of MDCIC cover.
2. Disconnect ribbon cable from left side of MDCIC board by gently pulling connector to left (as opposed to pulling connector out toward you).
3. Swing cover door open to access MDCIC board. Cover can be removed.
4. Note position of ribbon cables before removing for reinstallation. Remove ribbon cables.
5. Note position of rectifier control cable (MK101) connected to left 6-pin connector for reassembly. Disconnect rectifier control cable.
   NOTE: Scaling card (one on each module) must be retained to reinstall on replacement MDCIC board. A replacement scaling card is not included with replacement MDCIC board.
6. Remove MDCIC board by removing 9 screws securing board to panel standoffs.



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



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

8 Disassembly/Assembly - Inverter Module

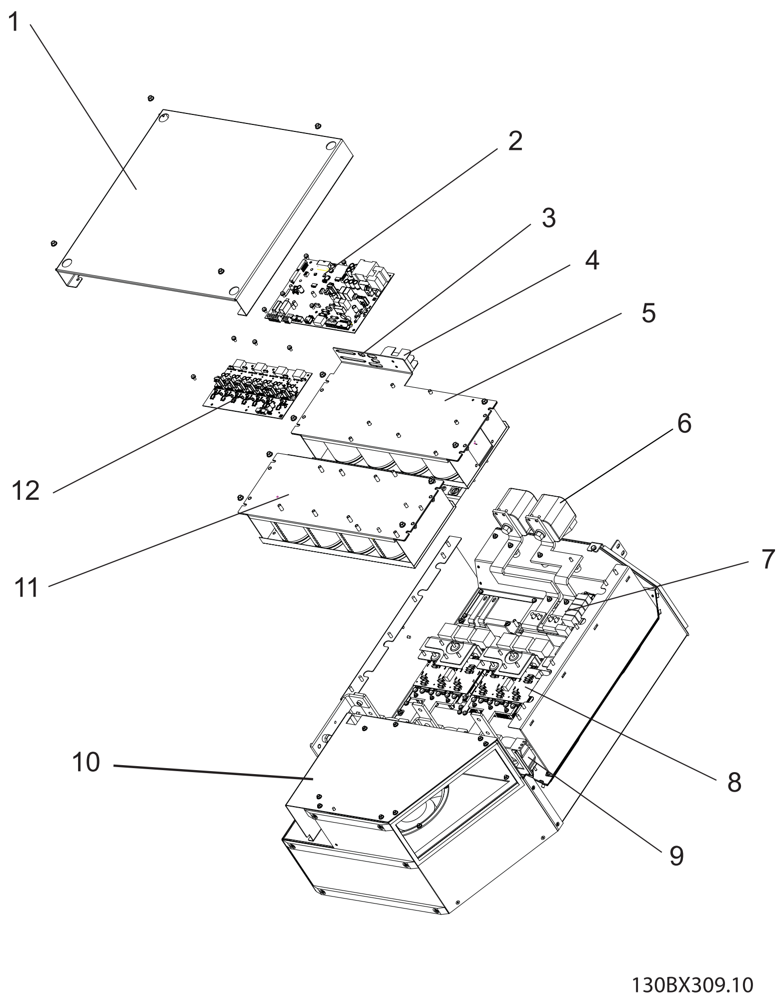
8.1 For Your Safety

8.1.1 GE Training Required

Only GE trained and certified technicians are permitted to test and repair components within the unit modules. The procedures described in this section are intended for GE qualified technicians. Repair work conducted by non-certified technicians can result in personal injury or equipment damage.

8.2 Inverter Module

8.2.1 Inverter Module, Exploded View



1	Right side cover plate	7	High frequency board
2	Inverter power card	8	IGBT module
3	Panel connectors	9	Current sensor
4	SMPS fuse and fan fuse	10	Fan assembly
5	Upper capacitor bank assembly	11	Lower capacitor bank assembly
6	DC bus fuses	12	Gate driver card

8.2.2 Internal Access

1. Remove inverter module from frequency converter in accordance with instruction in section *Inverter Module*.
2. Remove right side panel from inverter module by removing four nuts (10 mm). Note for reassembly 2 studs on panel edge. This side mounts to front of unit for reassembly.

8.2.3 Power Card

1. Unplug cables from all power card connectors: MK112, MK109, MK106, FK103, MK107, MK105, MK104, MK102, and MK110.
2. Remove power card by removing seven screws (T25) and detach plastic standoff at top right corner of power card.

Reinstall in reverse order of this procedure. Tighten mounting screws to 2.3 Nm (20 in-lbs).

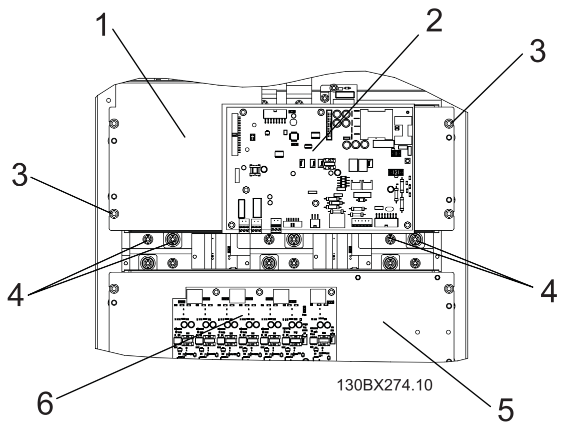
8.2.4 Upper Capacitor Bank Assembly (without removing power card)

NOTE: The power card may remain attached to the capacitor bank cover during removal. If desired, remove the power card in accordance with instructions provided. See exploded view illustration for further detail.

1. Disconnect cables from MK109 and MK105 on power card.
2. Disconnect cable from MK107 on power card.
3. Remove two red wires from 15A fuse block attached to cover plate flange.
4. Free cable entirely with the 2 red wires attached to it by disconnecting 10-pin connector next to fuse block on cover plate flange.
5. Disconnect 2 white wires from 4A fuse block attached to cover plate flange and free cable by disconnecting 6-pin connector on opposite end of cable.
6. Remove MK102 from power card and ground lug. Power card may now remain fastened to cap bank assembly.
7. Remove six electrical connection nuts (8mm) securing capacitor bank assembly. These nuts are recessed in the gap between the upper and lower capacitor banks.
8. Remove four retaining nuts (10mm) securing cap bank assembly.
9. **NOTE**: Capacitor bank assembly may weigh up to 9 kg (20 lbs). Remove capacitor bank assembly.

Reassembly is done in reverse order.

8

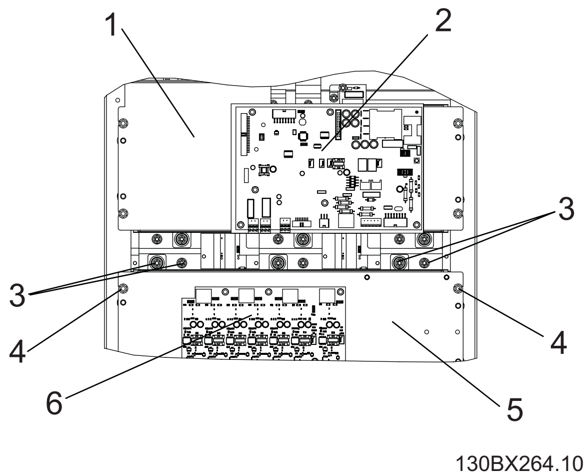


1	Upper capacitor bank assembly	4	8mm electrical connection nut (step 7)
2	Inverter power card	5	Lower capacitor bank assembly
3	10mm retaining nut (step 8)	6	IGBT gate driver card

8.2.5 Lower Capacitor Bank Assembly

1. Disconnect cables from gate drive card connectors MK100, MK102, MK103, MK104, MK106, and, if unit has a brake option MK105.
2. Remove six electrical connection nuts (8mm) securing capacitor bank assembly. These nuts are recessed in the gap between the upper and lower capacitor banks.
3. Remove four retaining nuts (10mm) securing capacitor bank assembly.
4. **NOTE**: Capacitor bank assembly may weigh up to 9 kg (20 lbs). Remove capacitor bank assembly.

Reassembly is done in reverse order.

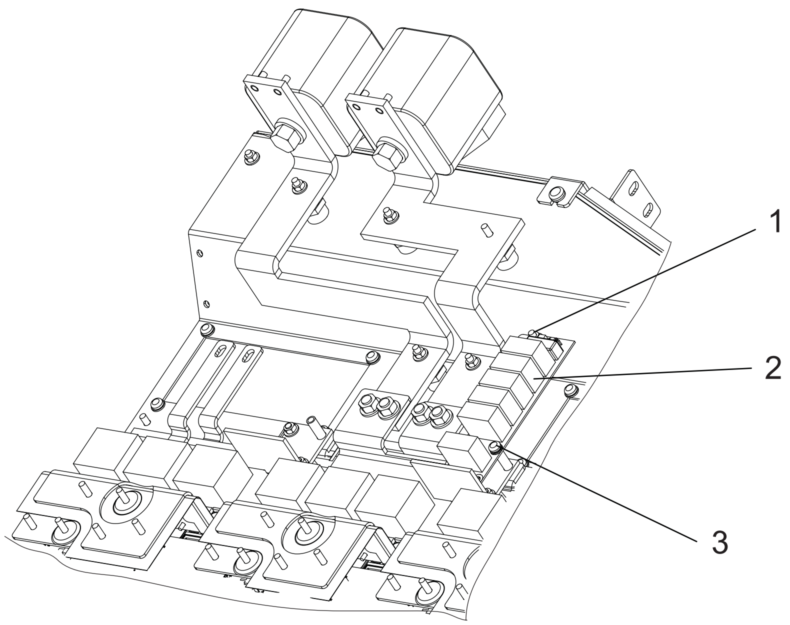


1	Upper capacitor bank assembly	4	10mm retaining nut (step 3)
2	Inverter power card	5	Lower capacitor bank assembly
3	8mm electrical connection nut (step 2)	6	IGBT gate driver card (step 1)

8.2.6 High Frequency Board

1. Remove upper capacitor bank assembly in accordance with instructions.
2. Disconnect cable from connector MK100 on high frequency board.
3. Remove two screws (T25) from high frequency board.
4. Remove one nut (8mm) from high frequency board standoff and remove board.

Reassembly is done in reverse order.

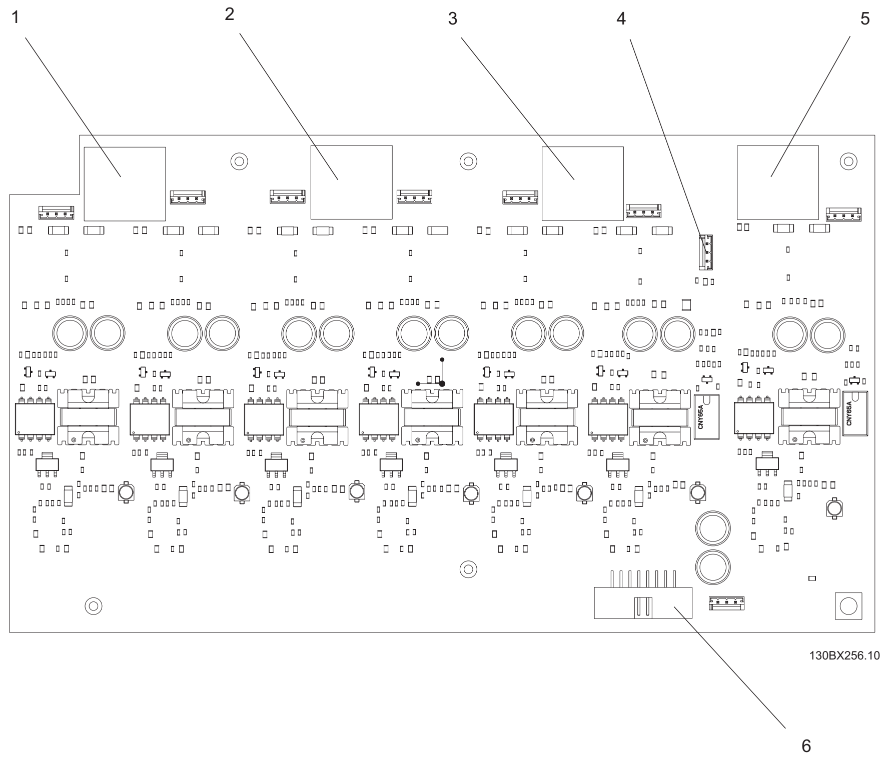


1	T25 screw (step 3)	3	8mm retaining nut (step 4)
2	High frequency board		

8.2.7 Gate Drive Card

1. Disconnect cables from gate drive card connectors MK100, MK102, MK103, MK104, MK106, and, if unit has a brake option MK105.
2. Remove gate drive card by removing 6 mounting screws (T25) from standoffs.

Reinstall in reverse order of this procedure. Tighten mounting screws to 2.3 Nm (20 in-lbs).



1	MK104 (W)	4	MK100
2	MK103 (V)	5	MK105 (brake option)
3	MK102 (U)	6	MK106

8

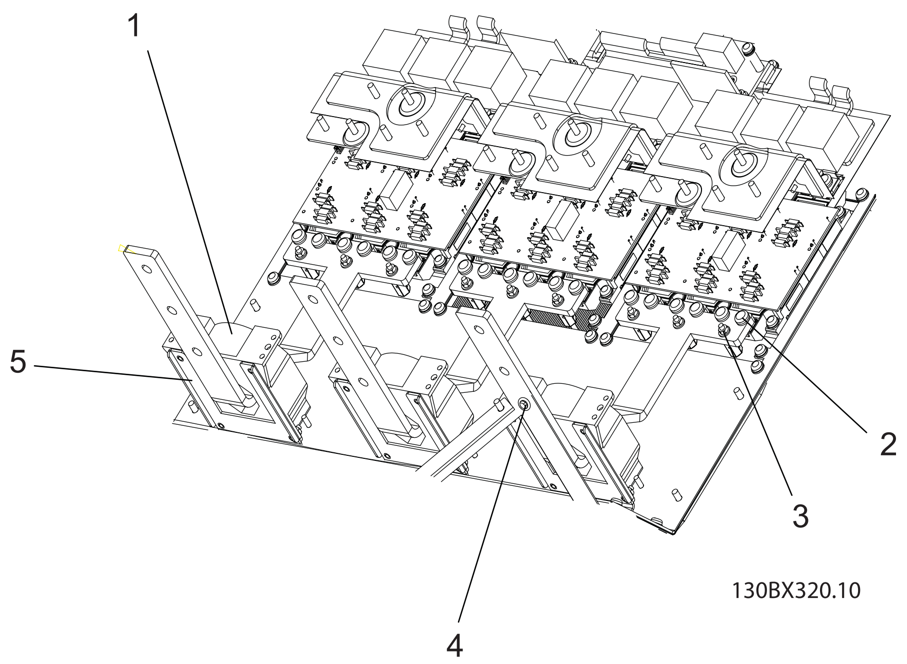
8.2.8 Current Sensor

NOTE: There are two types of current sensors, 500A or 1000A, depending on the size of the unit. Removal for both are the same except for an additional final step for the 1000A sensor.

1. Remove lower capacitor bank assembly in accordance with procedure.
2. Remove six screws (T30) connecting the bus bar to the IGBT module at IGBT end of bus bar.
3. Remove three screws (7mm) on standoffs from IGBT end of bus bar.
4. Remove one screw (T40) from opposite end of bus bar attached to output bus bar.
5. Unplug wire from current sensor (not shown).
6. Remove two screws (7mm) attaching base of current sensor to back panel.
7. Remove bus bar and slide current sensor free from bus bar.
8. For 1000A units, remove mounting bracket from back of current sensor by removing four screws (8mm). **NOTE**: Retain mounting bracket and screws for reassembly of replacement part.

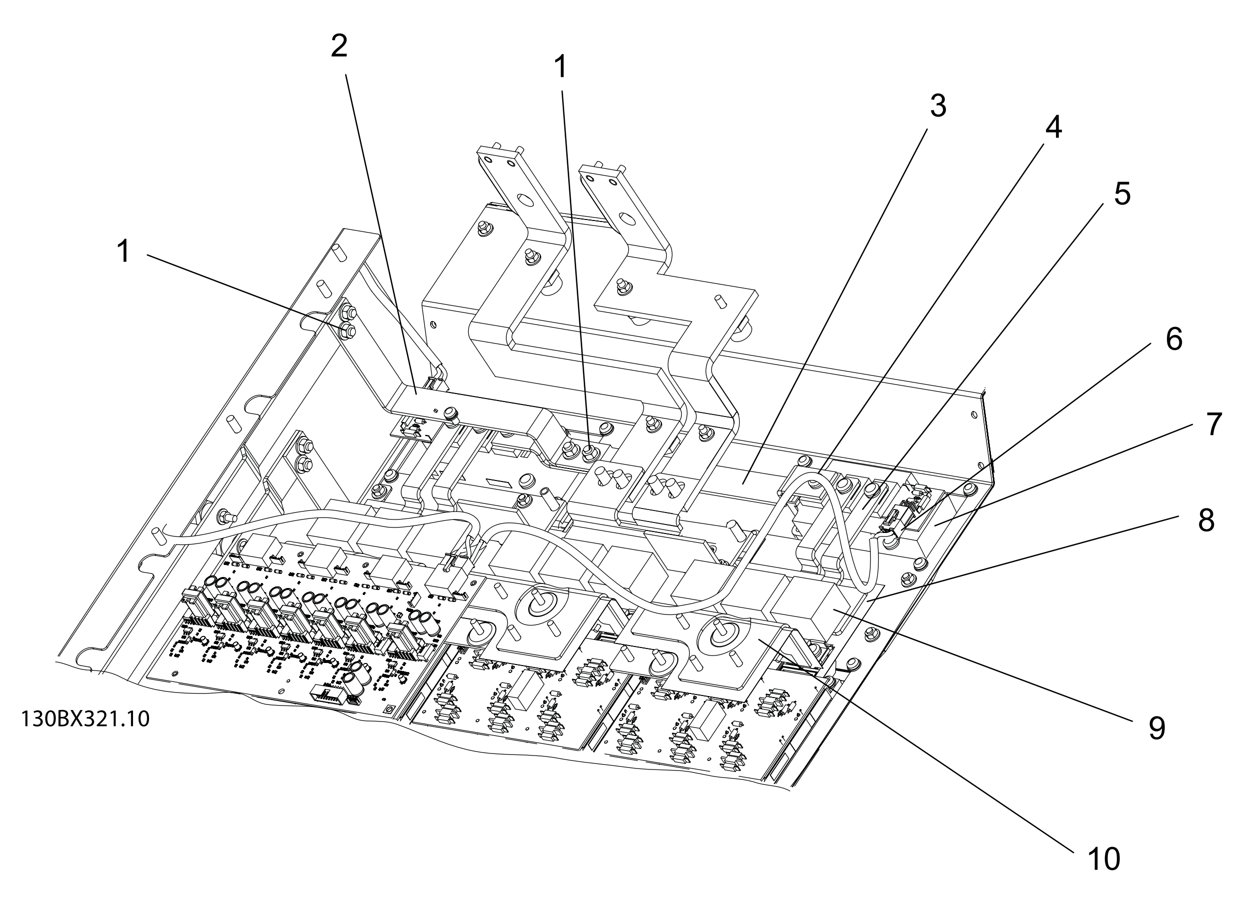
Reassembly is done in reverse order.

NB!
The six screws (T30) connecting the bus bar to the IGBT module should be tightened to 4 Nm (35 in lbs).



1	Current sensor	4	T40 screw (step 4)
2	T30 screw (step 2)	5	Mounting bracket (1000A sensor) (step 8)
3	7mm screw (step 3)		

8.2.9 Brake IGBT Module (Optional)



1	Attaching nut (step 4)	6	Brake IGBT cable (step 3)
2	Left attached bus bar (step 4)	7	Brake IGBT module
3	Jumper bus bar between brakes (step 5)	8	IGBT-Ind bus bar assembly (steps 9 and 10)
4	Attaching nut (step 5)	9	Snubber capacitor (step 7)
5	IGBT-Ind bus bar assembly (step 6)	10	IGBT capacitor bus bar (step 8)

NOTE: The brake IGBT is an option and may not be present on all units.

1. Remove both upper and lower capacitor bank assemblies in accordance with instructions.
2. Remove high frequency board in accordance with instructions.
3. Unplug brake IGBT cable from connector on each of the two brake IGBT modules.
4. Remove bus bar attached to left side of panel and to left most brake IGBT by removing two nuts at each end of bus bar.
5. Remove jumper bus bar between two brake IGBTs by removing retaining nut on each end of jumper bus bar.
6. Remove the two screws (T30) connecting the IGBT-Ind bus bar assembly to each brake IGBT module.
7. Remove nine snubber capacitors by removing two screws (T30) from each capacitor.
8. Remove the three IGBT bus bars freed by removing screws in step 7.
9. Remove four retaining nuts (13mm) connecting IGBT-Ind base bar assembly to two DC bus bars from inductor.
10. Remove IGBT-Ind bus bar assembly.
11. Remove brake IGBT by removing four mounting screws attaching each brake IGBT to back panel.

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Reassembly

1. Replace IGBT brake module in accordance with instructions included with replacement module.
2. Reassemble in reverse order of this procedure.

> **NB!**
> The special torque requirements on the instructions included with the replacement module.

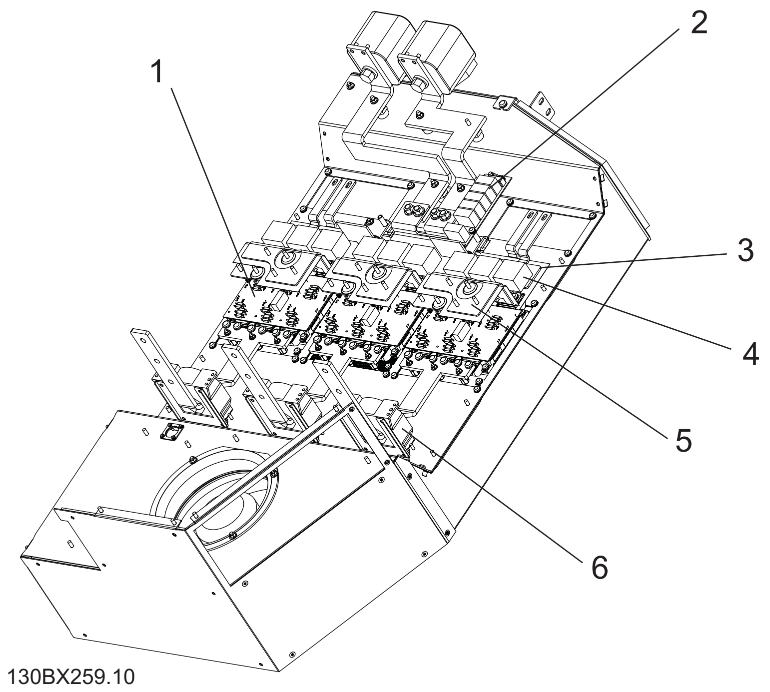
8.2.10 IGBT Module

1. Remove both upper and lower capacitor bank assemblies in accordance with instructions.
2. Remove high frequency board in accordance with instructions.
3. Remove three current sensors in accordance with instructions.
4. If optional brake IGBT is present, remove bus bar attached to left side of panel and to left most brake IGBT by removing two nuts at each end of bus bar. (See *Brake IGBT Module*.) Otherwise go to step 6.
5. If optional brake IGBT is present, remove the two screws (T30) connecting the IGBT-Ind bus bar assembly to each brake IGBT module.
6. Remove nine snubber capacitors by removing two screws (T30) for from each capacitor.
7. Remove the three IGBT capacitor bus bars freed by removing screws in step 6.
8. Remove four retaining nuts (13mm) connecting IGBT-Ind bus bar assembly to two DC bus bars from inductor.
9. Remove IGBT-Ind bus bar assembly.
10. Remove IGBT module by removing 8 retaining screws (T25) mounting IGBTmodule to back panel.

Reassembly

1. Replace IGBT brake module in accordance with instructions included with replacement module.
2. Reassemble in reverse order of this procedure.
3. **NOTE**: Connect temperature sensor cable from gate drive card MK100 to center IGBT module connector MK103.

> **NB!**
> The special torque requirements on the instructions included with the replacement module.



1	IGBT module (step 10)	4	Snubber capacitor (step 6)
2	High frequency board (step 2)	5	IGBT capacitor bus bar (step 7)
3	IGBT-Ind bus bar assembly (steps 5 and 9)	6	Current sensor (step 3)

9 Disassembly/Assembly - Rectifier Module

9.1 For Your Safety

9.1.1 GE Training Required

Only GE trained and certified technicians are permitted to test and repair components within the unit modules. The procedures described in this section are intended for GE qualified technicians. Repair work conducted by non-certified technicians can result in personal injury or equipment damage.

9.2 Rectifier Module

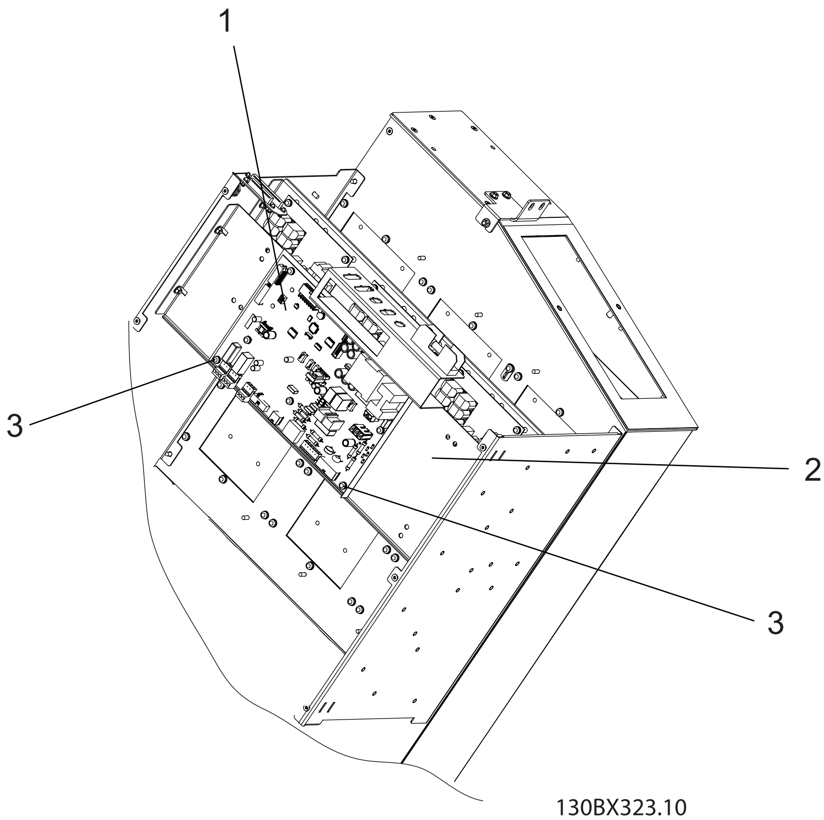
9.2.1 Internal Access

1. Remove rectifier module from frequency converter in accordance with instruction in section *Rectifier Module*.
2. Remove right side panel from rectifier module by removing six nuts (T25) and one nut (8mm).

9.2.2 Power Card

1. Disconnect cabling from power card: MK100, MK102, MK103, MK104, MK105, MK106, MK108, MK110, Mk112, and FK102.
2. Remove power card by removing seven screws (T25) and detach plastic standoff at top right corner of power card.
3. Insulation sheet behind power card can be left in place. Ensure its is in place for reassembly.
   NOTE: Power card may remain installed if power card mounting plate is being removed to access soft charge boards. Disconnect cabling.

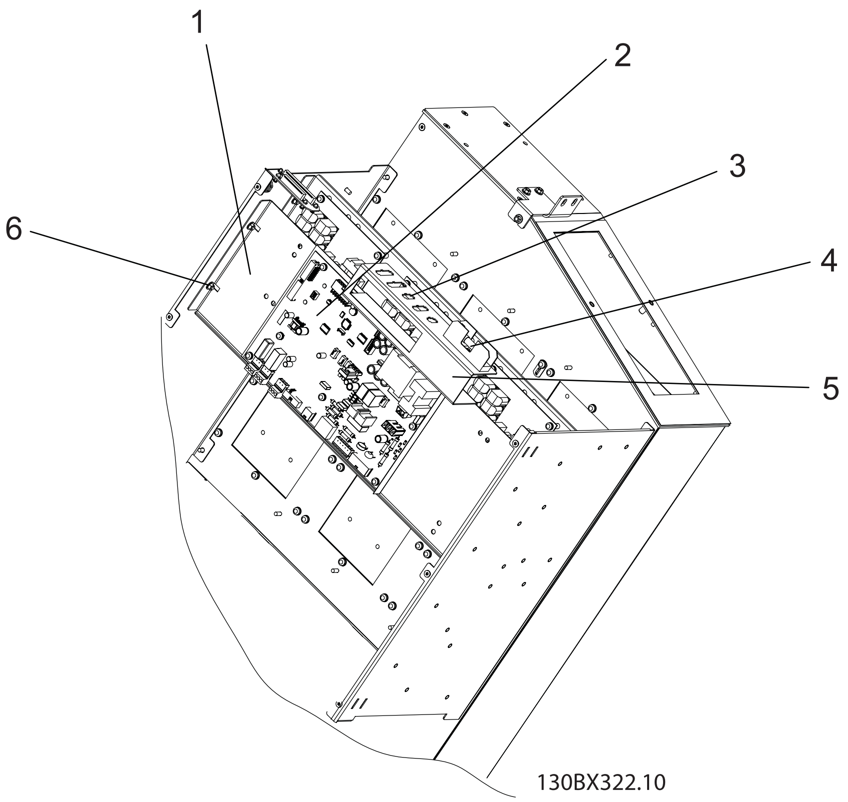
Reinstall in reverse order of this procedure. Tighten mounting screws to 2.3 Nm (20 in-lbs).



1	Power card (step 1)	3	Power card attaching screw (step 2)
2	Power card mounting plate		

9.2.3 Power Card Mounting Plate

1. Disconnect two fast-on connectors from fuse block attached to power card mounting plate flange.
2. Disconnect from power card connectors MK100, MK103, MK104, MK105, MK106, and MK110.
3. Disconnect three cable connectors (6-pin, 8-pin, and 12-pin) from power card mounting panel flange. Cable connectors disconnect from back side of flange.
4. Remove power card mounting plate by removing four retaining nuts (8mm) securing plate.
   NOTE: At this point soft charge cards are accessible for changing fuses. Two soft charge cards are present for units with two inverter modules, three soft charge cards for units with three inverter modules.



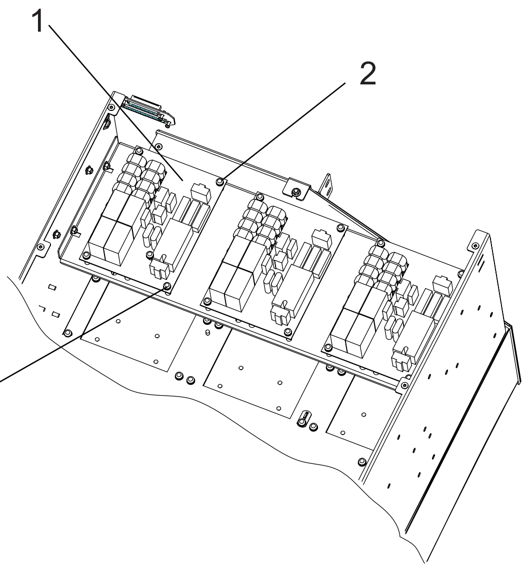
1	Power card mounting plate (step 4)	4	Fuse block (step 1)
2	Power card (step 2)	5	Power card mounting plate flange
3	Cable connectors (step 3)	6	Attaching screw (step 4)

9

9.2.4 Soft Charge Card

1. Remove power card mounting plate in accordance with instructions.
2. From soft charge card, disconnect connectors MK1, MK2, Mk3, and MK4.
3. Remove soft charge card from mounting plate by removing four screws (T25) fastening card to mounting plate. Note insulation sheet below soft charge card. Remove and keep the insulation sheet for reinstallation.

Reinstall in reverse order of this procedure. Tighten mounting screws to 2.3 Nm (20 in-lbs).

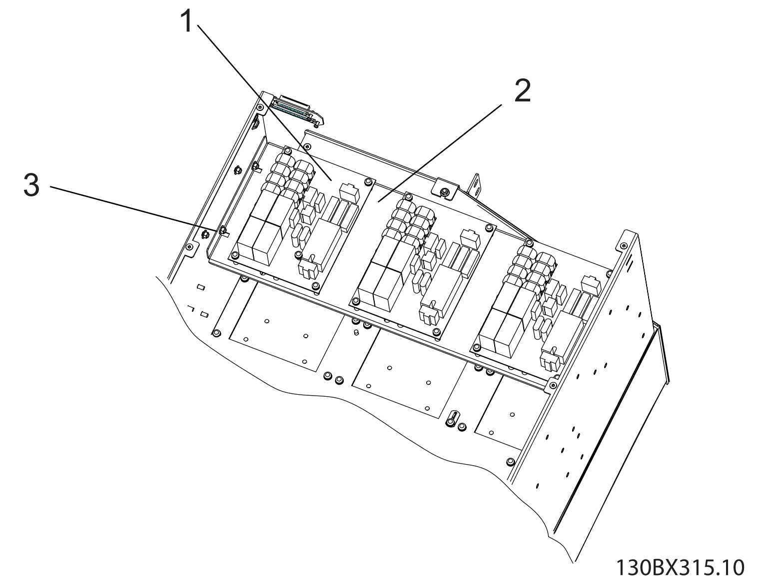


1	Soft charge card	2	Attaching screw (step 3)

9.2.5 Soft Charge Card Mounting Plate

1. Remove power card mounting plate in accordance with instructions.
2. Remove R (red), S (white), and T (black) ring lugs from input power bus bar. Two soft charge cards are present for units with two inverter modules, three soft charge cards for units with three inverter modules.
3. Disconnect MK3 and MK4 from each soft charge card.
4. Remove soft charge card mounting plate by removing four nuts (8mm) attaching mounting plate. (Soft charge cards can remain attached to mounting plate.)

Reinstall in reverse order of this procedure. Tighten 8mm nuts to 2.3 Nm (20 in-lbs).

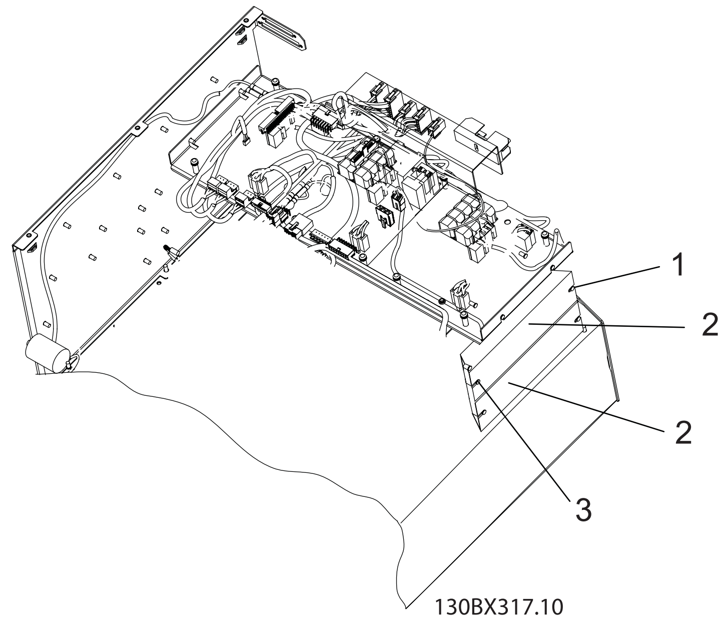


1	Soft charge card	3	Attaching nut (step 4)
2	Soft charge card mounting plate		

9.2.6 Soft Charge Resistor

1. Remove power card mounting plate in accordance with instructions.
2. Remove soft charge mounting plate in accordance with instructions.
3. **Note**: soft charge resistors are mounted on side panel; one on each side for units with two inductors, an additional one for units with three inverters.
4. Loosen bottom 8mm nut.
5. Remove top 8mm nut to remove soft charge resistor.

Reinstall in reverse order of this procedure. Tighten 8mm nuts to 2.3 Nm (20 in-lbs).



1	Top 8mm nut (step 5)	3	Bottom 8mm nut (step 4)
2	Soft charge resistor		

9.2.7 Heatsink Thermal Sensor

1. Remove power card mounting plate in accordance with instructions.
2. Remove soft charge mounting plate in accordance with instructions.
3. Remove heatsink thermal sensor by removing screw fastener (T20) mounting sensor to heatsink.

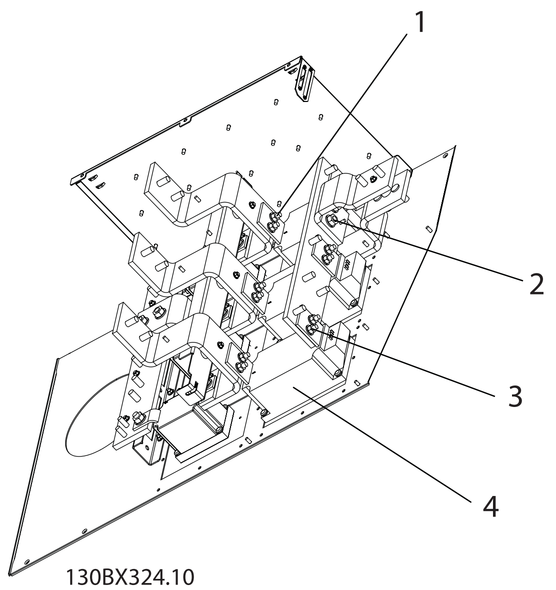
Reinstall in reverse order of this procedure. Tighten T20 screws to 1.0 Nm (20 in-lbs).

9.2.8 SCR Modules

1. Remove power card mounting plate in accordance with instructions.
2. Remove soft charge mounting plate in accordance with instructions.
3. Remove six nuts (13mm), two from each SCR module, on (+)DC bus bar.
4. Remove two nuts (17mm) (+)DC bus bar and remove (+)DC bus bar.
5. Remove six nuts (13mm), two from each SCR module, from AC input bus bar.
6. If removing more than one SCR module, note which gate lead attaches to which module. Unplug gate lead from SCR module.
7. Remove four mounting screws (T30) and washers attaching SCR module to heatsink back panel.

Reassembly

1. Replace SCR module in accordance with instructions included with replacement module.
2. Reassemble in reverse order of this procedure.



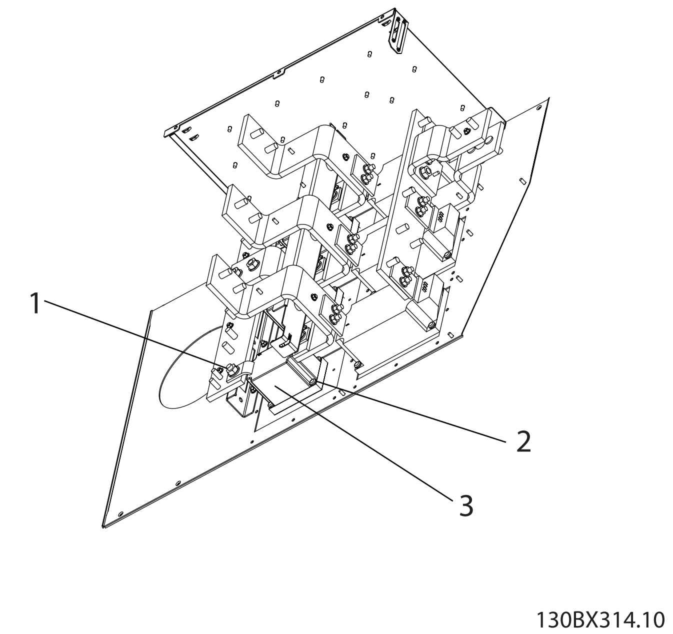
1	13mm retaining nut (step 5)	3	13mm retaining nut (step 3)
2	17mm retaining nut (step 4)	4	SCR module

9.2.9 Diode Module

1. Remove power card mounting plate in accordance with instructions.
2. Remove soft charge mounting plate in accordance with instructions.
3. Remove two mounting nuts (17mm) from diode module, one on AC input side and one on (-)DC side of module.
4. Remove diode module by removing four retaining screws (T30) and washers from corners of module.

Reassembly

1. Replace diode module in accordance with instructions included with replacement module.
2. Reassemble in reverse order of this procedure.



1	17mm retaining nut (step 3)	3	Diode module
2	T30 screws (step 4)		

10 Special Test Equipment

10.1 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 frequency converter 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 GE.

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

10.1.1 Split-bus Power Supply

Powering the drive in the split bus mode allows dynamic testing on the drive in a safer manner.
In the split bus mode, the DC bus in each module is split into two portions. One connects to the DC bus and power card to provide low voltage power for the SMPS. By powering only the SMPS in each module, the various logic circuits can be tested without the danger of damaging the power components.
The other provides low voltage power to the DC capacitors and the output IGBTs for test purposes. A low voltage power supply connected to the DC bus allows testing the functionality of the output section safely.
The following procedure will be referred to throughout the dynamic test section.

Powering the Drive in Split Bus Mode

1. Ensure that AC power has been removed and that all DC capacitors are fully discharged.
2. Remove the top and bottom safety covers from each inverter module as well as the top safety cover from the rectifier module.
3. If a motor is connected to the drive, remove all output bus bars from each inverter module. Also remove the brake bus bars if the drive is equipped with the brake option.
4. Remove the plugs from the 6-pin sockets on each module.
5. Connect the power supply cable (p/n 6KAF6H8766) to the 6-pin sockets of each module.
6. Connect a 610 – 800VDC power supply to the input end of the power supply cable.
7. Apply power to the power supply. The Keypad should light up as if the drive were powered normally.
8. Warning 24, *External Fan Failure* will be displayed in the Keypad. This is because the fan circuitry is not powered in this mode. This will not affect the operation.

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10.1.2 Signal Test Board (p/n 6KAF6H8437)

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

The signal test board is plugged into the 30 pin panel connector on the top of each inverter module. Points on the signal test board can be monitored with or without the DC bus disabled. In some cases, the frequency converter 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. The section *Test Procedures* describes when these tests would be called for and what the signal should be at that given test point.

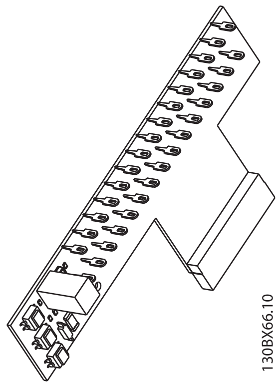
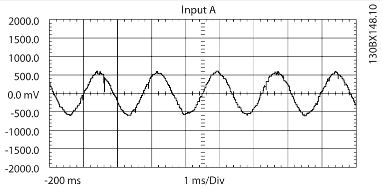
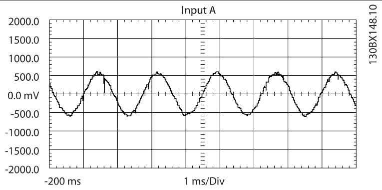
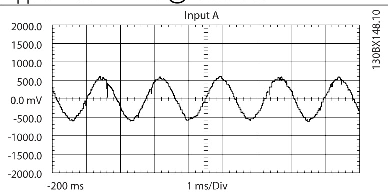
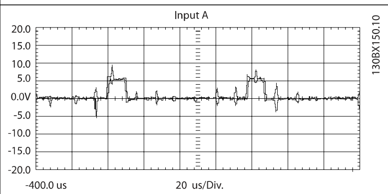
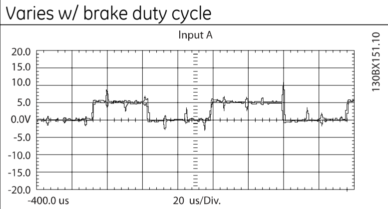
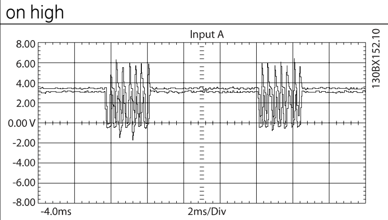


Illustration 10.1: Signal Test Board

10.1.3 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 the section *Test Procedures*. 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 instrument prefered. 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 VACpeak @ 165% of CT current rating. AC waveform @ output frequency of the frequency converter.
2	IV1	Current sensed, V phase, not conditioned	 Approx 400 mv RMS @100% load	.937 VACpeak @ 165% of CT current rating. AC waveform @ output frequency of the frequency converter.
3	IW1	Current sensed, W phase, not conditioned	 Approx 400 mv RMS @100% load	.937 VACpeak @ 165% of CT current rating. AC waveform @ output frequency of the frequency converter.
4	COMMON	Logic common	This common is for all signals.	
5	AMBT	Ambient temp.	Used to control FAN high and low fan speeds.	1 VDC approximately equal to 25C
6	FANO	Control Card signal	Signal from the control card to turn the fans on and off.	0 VDC – ON command 5 VDC – OFF command
7	INRUSH	Control Card signal	Signal from the control card to start gating the SCR front end	3.3 VDC – SCRs disabled 0 VDC – SCRs enabled
8	RL1	Control Card signal	Signal from Control Card to provide status of Relay 01	0 VDC – Relay active 0.7 VDC – inactive
9		Not used		
10		Not used		
11	VPOS	+18 VDC regulated supply +16.5 to 19.5 VDC	The red LED indicates voltage is present between VPOS and VNEG terminals.	+18 VDC regulated supply +16.5 to 19.5 VDC
12	VNEG	-18 VDC regulated supply -16.5 to 19.5 VDC	The red LED indicates voltage is present between VPOS and VNEG terminals.	-18 VDC regulated supply -16.5 to 19.5 VDC
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 VDC as brake duty cycle reaches max.
14	BRT_ON	Brake IGBT 5V logic level signal.	 Varies w/ brake duty cycle	5.10 VDC 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	+5VDC – disabled 0VDC – 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 3Khz	5VDC - fans off

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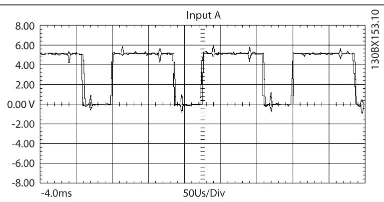
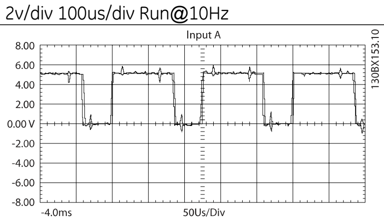
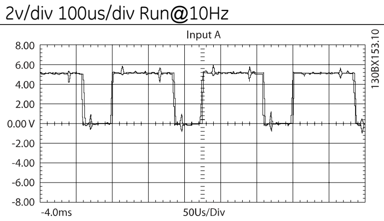
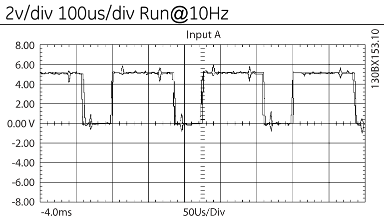
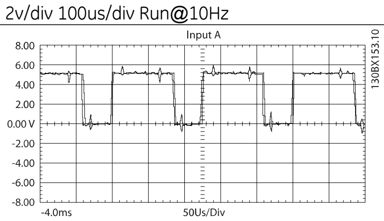
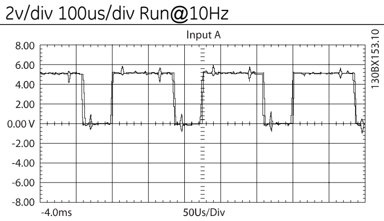
Pin No.	Schematic Acronym	Function	Description	Reading Using a Digital Voltmeter
18	HI_LOW	Control signal from Power Card	Signal to switch fan speeds between high and low	+5VDC = fans on high, Otherwise, 0VDC.
19	SCR_DIS	Control signal for SCR front end	Indicates SCR front end is enabled or disabled.	0.6 to 0.8 VDC – SCRs enabled 0VDC – SCR disabled
20	INV_DIS	Control signal from Power Card	Disables IGBT gate voltages	5VDC – inverter disabled 0VDC – inverter enabled
21		Not used		
22	UINVEX	Bus Voltage scaled down	Signal proportional to UDC	OV switch must be off - 1 VDC = 450 VDC [T4/T5] - 1 VDC = 610 VDC [T7]
23	VDD	+24 VDC power supply	Yellow LED indicates voltage is present.	+24 VDC regulated supply +23 to 25 VDC
24	VCC	+5.0 VDC regulated supply. +4.75-5.25 VDC	The green LED indicates voltage is present.	+5.0 VDC regulated supply +4.75 to 5.25 VDC
25	GUP_T	IGBT gate signal, buffered, U phase, positive. Signal originates on Control Card.	 2v/div 100us/div Run@10Hz	2.2–2.5 VDC Equal on all phases TP25-TP30
26	GUN_T	IGBT gate signal, buffered, U phase, negative. Signal originates on Control Card.	 2v/div 100us/div Run@10Hz	2.2–2.5 VDC Equal on all phases TP25-TP30
27	GVP_T	IGBT gate signal, buffered, V phase, positive. Signal originates on Control Card.	 2v/div 100us/div Run@10Hz	2.2–2.5 VDC Equal on all phases TP25-TP30
28	GVN_T	IGBT gate signal, buffered, V phase, negative. Signal originates on Control Card.	 2v/div 100us/div Run@10Hz	2.2–2.5 VDC Equal on all phases TP25-TP30
29	GWP_T	IGBT gate signal, buffered, W phase, positive. Signal originates on Control Card.	 2v/div 100us/div Run@10Hz	2.2–2.5 VDC Equal on all phases TP25-TP30
30	GWN_T	IGBT gate signal, buffered, W phase, negative. Signal originates on Control Card.	 2v/div 100us/div Run@10Hz	2.2–2.5 VDC Equal on all phases TP25-TP30

11 Block Diagrams

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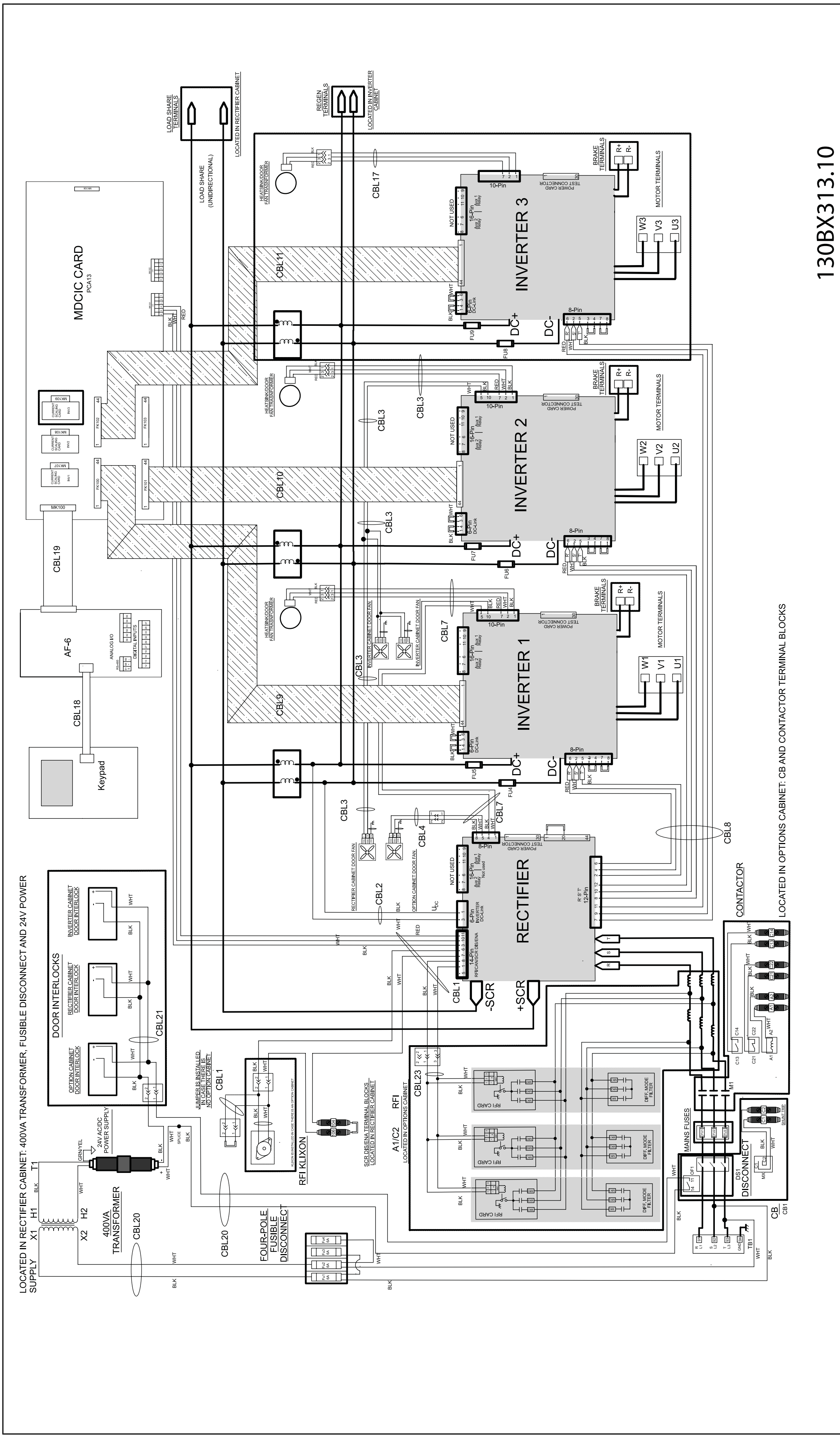

Illustration 11.1: Unit Size 6x drive: Top Level Block Diagram

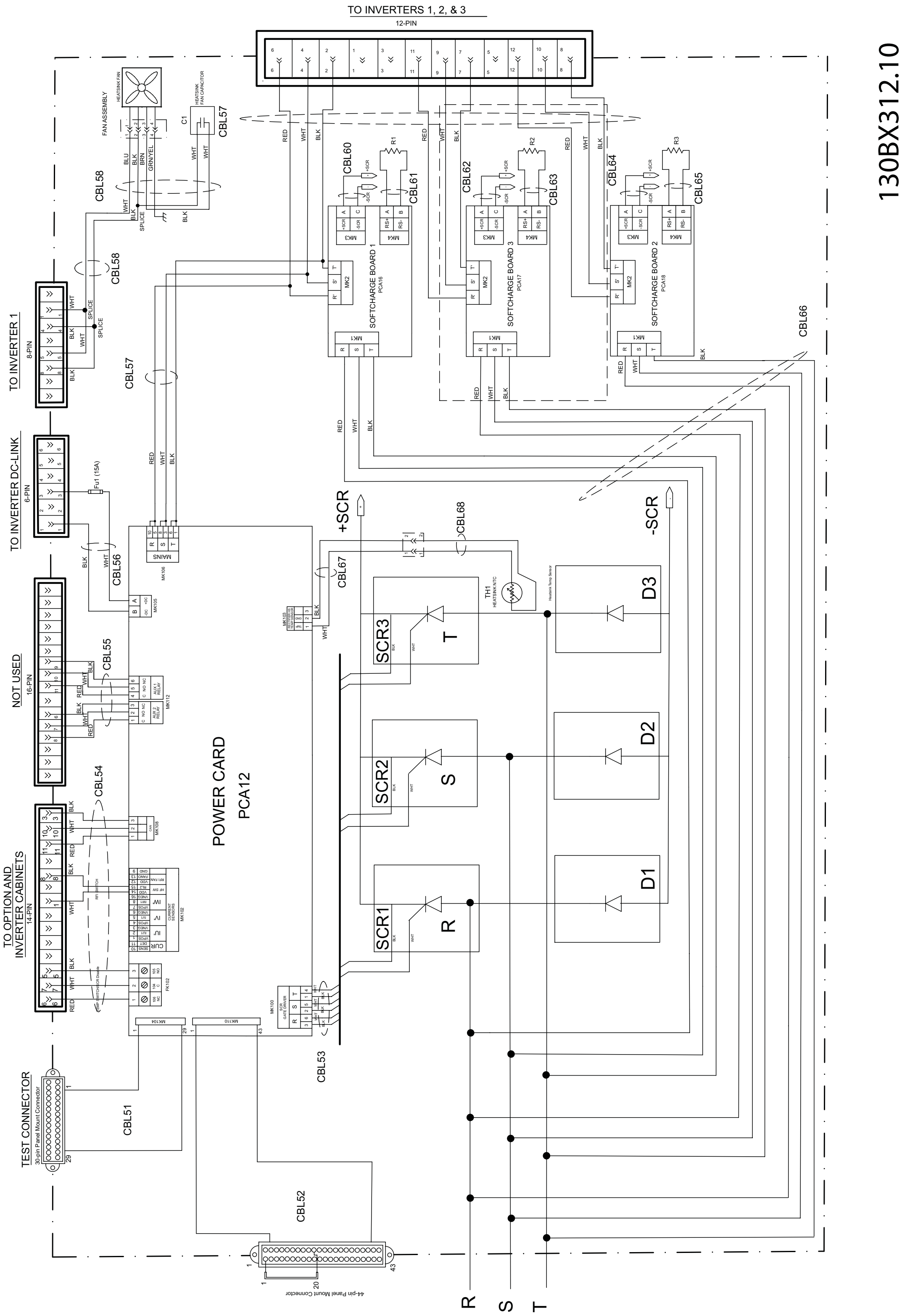

Illustration 11.2: Unit Size 6x: Rectifier Module

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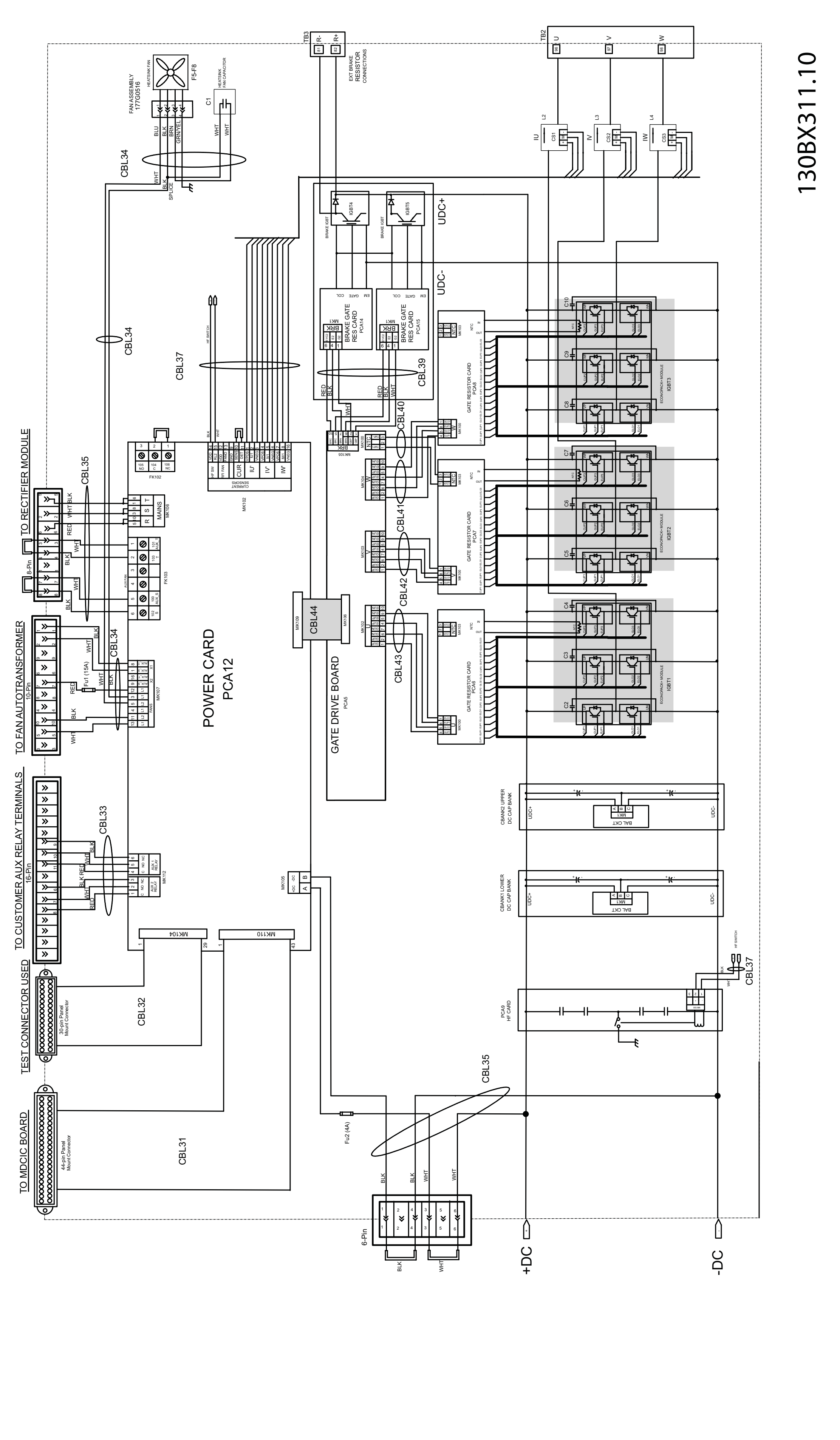

Illustration 11.3: Unit Size 6x drive: Inverter Module

The instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the GE company.

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