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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 FC series frequency converters in the D and E frames.

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 a better understanding of the frequency converter's operation to assist in 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 VLT FC Product Overview


VLT HVAC FC 102 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 well suited for fan and pump applications within the HVAC market.


VLT® AQUA FC 202 series frequency converters are designed for water and waste water markets. They can operate in either constant torque or variable torque with limited overload capabilities. They include specific features and options which make them well suited for use on a variety of water pumping and processing applications.

VLT AutomationDrive series frequency converters are fully programmable for either constant torque or variable torque industrial applications. They are full-featured frequency converters capable of operating a myriad of applications and incorporating a wide variety of control and communication options.

These models are available in Chassis/IP00, 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 energised 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.

1. DO NOT touch electrical parts of frequency converter when connected to mains. After disconnecting from mains, wait 20 minutes before touching any components in D-frame size units or 40 minutes for E-frame size units. See the label on the front of the frequency converter door for specific discharge time.
2. When repair or inspection is made, mains must be disconnected.

3. The STOP key on the control panel does not disconnect mains.
4. During operation and while programming parameters, the motor may start without warning. Activate the STOP key when changing data.



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

1.4 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 reduce the life, affect performance, or completely destroy sensitive electronic components.

1.5 Frame Size Definitions

380-480 VAC		Power		
Model Drive and FC-202 VLT AQUA Drive				
	kW @400 VAC	HP @460 VAC	Frame Size	
P110	110	150	D1 / D3	
P132	132	200	D1 / D3	
P160	160	250	D2 / D4	
P200	200	300	D2 / D4	
P250	250	350	D2 / D4	
P315	315	450	E1 / E2	
P355	355	500	E1 / E2	
P400	400	550	E1 / E2	
P450	450	600	E1 / E2	

Table 1.1: and FC 202 380-480 VAC

380-500 VAC		Power		
Model FC 302				
	kW @400 VAC	HP @460 VAC	kW @500 VAC	Frame Size
P90K	90 / 110	125 / 150	110 / 132	D1 / D3
P110	110 / 132	150 / 200	132 / 160	D1 / D3
	132 / 160	200 / 250	160 / 200	D2 / D4
	160 / 200	250 / 300	200 / 250	D2 / D4
	200 / 250	300 / 350	250 / 315	D2 / D4
	250 / 315	350 / 450	315 / 355	E1 / E2
P315	315 / 355	450 / 500	355 / 400	E1 / E2
	355 / 400	500 / 550	400 / 500	E1 / E2
	400 / 450	550 / 600	500 / 530	E1 / E2

Table 1.2: FC 302 380-500 VAC

525-690 VAC		Power			
Model	and FC-202	VLT AQUA Drive			
		kW @550 VAC	HP @575 VAC	kW @690 VAC	Frame Size
P45K		37	50	45	D1 / D3
P55K		45	60	55	D1 / D3
P75K		55	75	75	D1 / D3
P90K		75	100	90	D1 / D3
P110		90	125	110	D1 / D3
P132		110	150	132	D1 / D3
P160		132	200	160	D1 / D3
P200		160	250	200	D2 / D4
P250		200	300	250	D2 / D4
P315		250	350	315	D2 / D4
P400		315	400	400	D2 / D4
P450		355	450	450	E1 / E2
P500		400	500	500	E1 / E2
P560		450	600	560	E1 / E2
P630		500	650	630	E1 / E2

Table 1.3: and FC 202 525-690 VAC

525-690 VAC		Power			
Model	FC 302	High / Normal Overload			
		kW @550 VAC	HP @575 VAC	kW @690 VAC	Frame Size
P37k		30 / 37	40 / 50	37 / 45	D1 / D3
P45k		37 / 45	50 / 60	45 / 55	D1 / D3
P55k		45 / 55	60 / 75	55 / 75	D1 / D3
P75k		55 / 75	75 / 100	75 / 90	D1 / D3
P90K		75 / 90	100 / 125	90 / 110	D1 / D3
P110		90 / 110	125 / 150	110 / 132	D1 / D3
P132		110 / 132	150 / 200	132 / 160	D1 / D3
P160		132 / 160	200 / 250	160 / 200	D2 / D4
P200		160 / 200	250 / 300	200 / 250	D2 / D4
P250		200 / 250	300 / 350	250 / 315	D2 / D4
P315		250 / 315	350 / 400	315 / 400	D2 / D4
P355		315 / 355	400 / 450	355 / 450	E1 / E2
P400		315 / 400	400 / 500	400 / 500	E1 / E2
P500		400 / 450	500 / 600	500 / 560	E1 / E2
P560		450 / 500	600 / 650	560 / 630	E1 / E2

Table 1.4: FC 302 525-690 VAC

1.6 Tools Required

Operating Instructions for the FC 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	
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 176F8439	
Signal test board p/n 176F8437	

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1.7 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	9.6
M10	T-50 / 17 mm	170	19.2

Table 1.5: Torque Values Table

1.8 Exploded Views

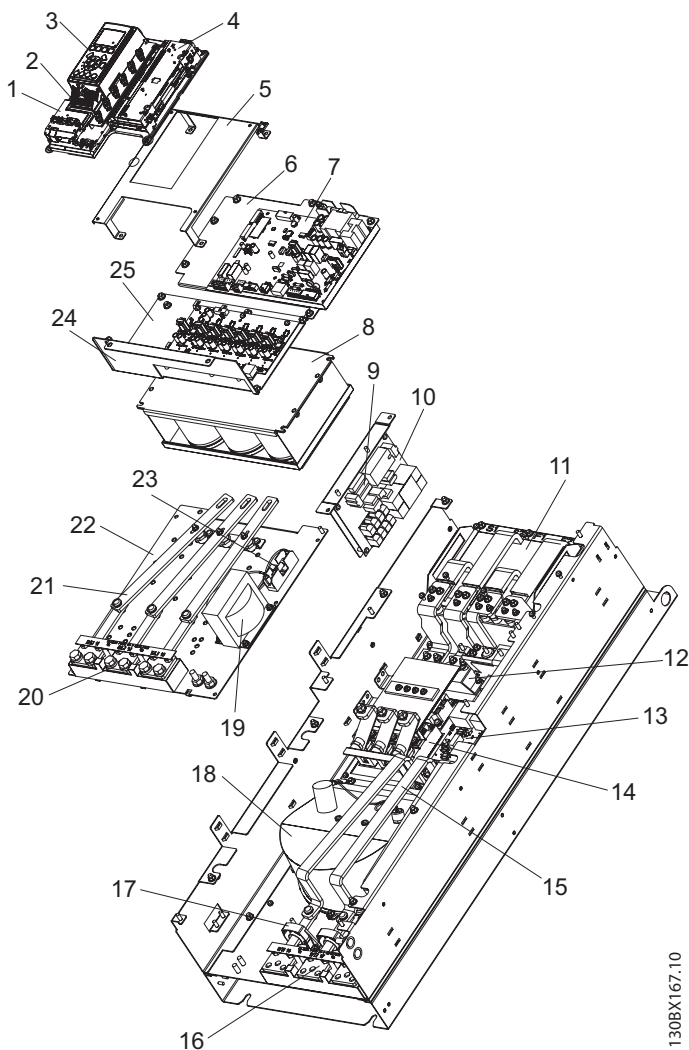
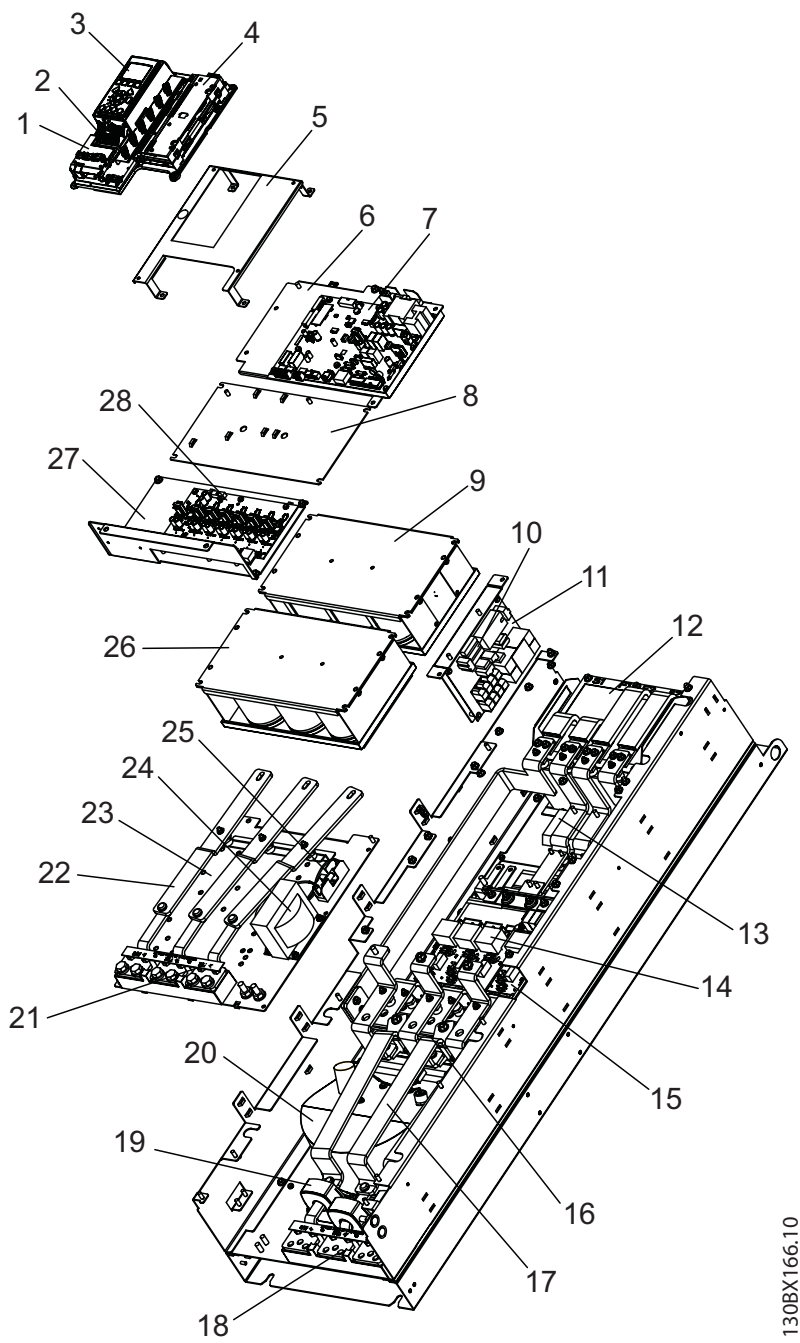


Illustration 1.1: Exploded view D3 Frame size, D1 frame is similar.

1	Control card PCA1	14	SCR/Diode module SCR 1, 2, 3
2	Control input terminals	15	IGBT output bus bar
3	Local Control Panel LCP	16	Output motor terminals TB2
4	Control card C option	17	Current sensor L2, L3, L4
5	Mounting bracket	18	Fan assembly F1 + C1 +CBL11
6	Power card mounting plate	19	Fan transformer TR1
7	Power card PCA 3	20	Main AC power input terminals TB1
8	Capacitor bank assembly CBANK1 + PCA9	21	AC input bus bar
9	Soft charge fuses	22	Input terminal mounting plate assembly
10	Soft charge card PCA11	23	Fan fuse FU4
11	DC inductor L1	24	Capacitor bank cover plate
12	Soft charge module R1 + CBL26	25	IGBT gate drive card PCA5
13	IGBT module IGBT 1		

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Illustration 1.2: Exploded view D4 frame size, D2 frame is similar.

1	Control card PCA1	15	IGBT module IGBT1, 2
2	Control input terminals	16	SCR/Diode module SCR1, 2, 3
3	Local Control Panel LCP	17	IGBT output bus bar
4	Control card C option	18	Output motor terminals TB2
5	Mounting bracket	19	Current sensor L2, L3, L4
6	Power card mounting plate	20	Fan assembly F1 + C1 + CBL11
7	Power card PCA3	21	Main AC power input terminals TB1
8	Upper capacitor bank cover plate	22	AC input bus bar
9	Upper capacitor bank assembly CBANK2 + PCA10	23	Input terminal mounting plate assembly
10	Soft charge fuses	24	Fan transformer TR1
11	Soft charge card PCA11	25	Fan fuse FU4
12	DC inductor L1	26	Lower capacitor bank assembly CBANK1 + PCA9
13	Soft charge resistor assy R1 + CBL26	27	Lower capacitor bank cover plate
14	IGBT snubber capacitors C2, C3, C4, C5, C6, C7	28	IGBT gate drive card PCA5

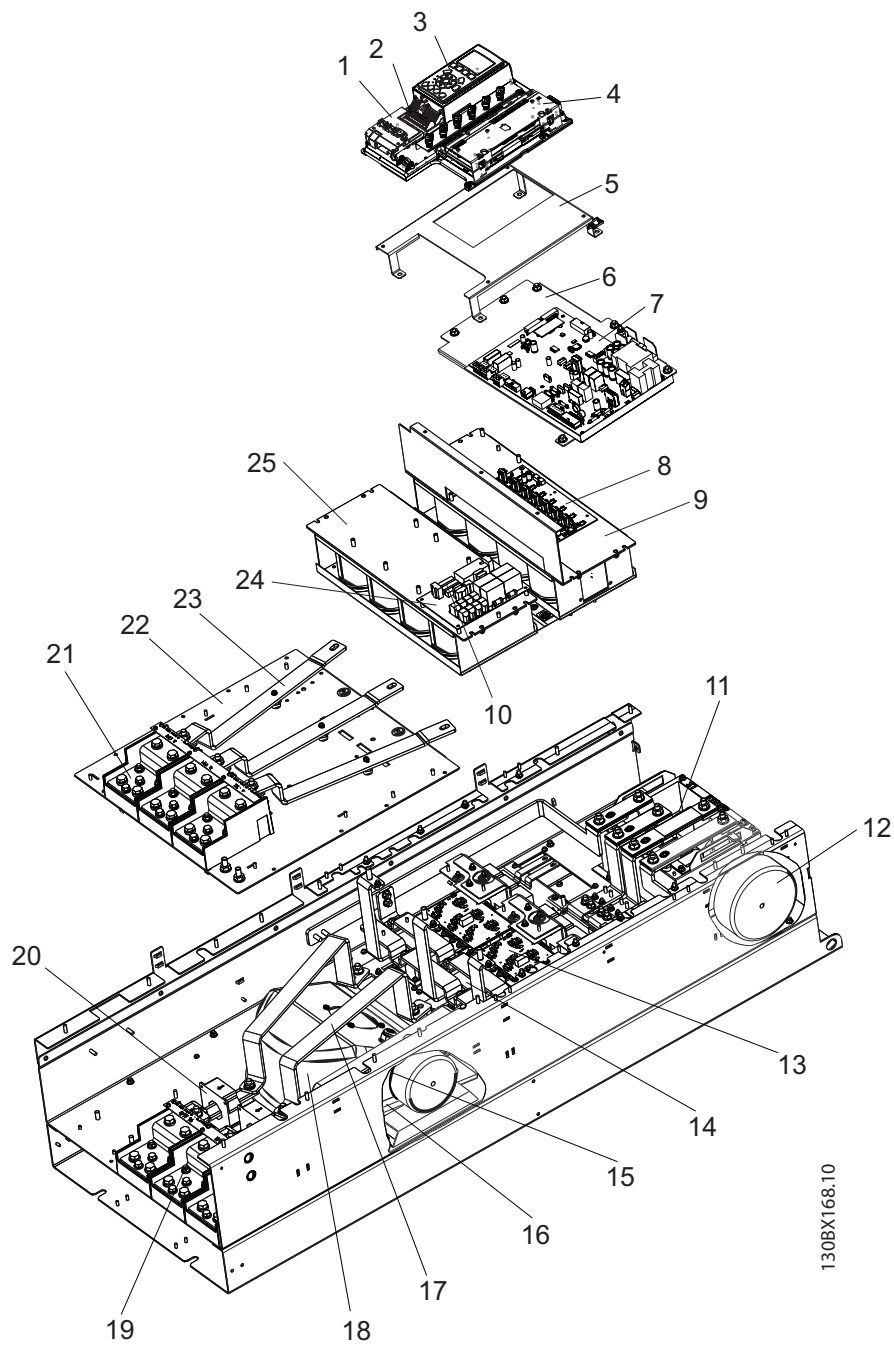


Illustration 1.3: Exploded view E2 frame size, E1 frame is similar.

1	Control card PCA1	14	SCR and Diode SCR1, SCR2, SCR3 and D1, D2, D3
2	Control input terminals	15	Fan inductor (not on all units)
3	Local Control Panel LCP	16	Soft charge resistor assy R1
4	Control card C option	17	IGBT output bus bar
5	Mounting bracket	18	Fan assembly F1 + C1
6	Power card mounting plate	19	Output motor terminals TB2
7	Power card PCA3	20	Current sensor L2, L3, L4
8	IGBT gate drive card PCA5	21	Main AC power input terminals TB1
9	Upper capacitor bank assembly CBANK2 + PCA11	22	Input terminal mounting plate assembly
10	Soft charge fuses	23	AC input bus bar
11	DC inductor L1	24	Soft charge card PCA12
12	Fan transformer TR1	25	Lower capacitor bank assembly CBANK1 + PCA10
13	IGBT module IGBT1, 2, 3		

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1.9 Ratings Tables

DC Voltage Levels	380–480 and 380–500 units	525–690 units
Inrush Circuit Enabled	370 VDC	548 VDC
Inrush Circuit Disabled	395 VDC	600 VDC
Inverter Undervoltage Disable	402 VDC	553 VDC
Undervoltage Warning	423 VDC	585 VDC
Inverter Undervoltage Re-Enable (warning re-set)	442 VDC	602 VDC
Overvoltage Warning (without brake)	817 VDC	1084 VDC
Dynamic Brake Turn On	810 VDC	1099 VDC
Inverter Overvoltage Re-Enable (warning re-set)	821 VDC	1099 VDC
Overvoltage Warning (with brake)	828 VDC	1109 VDC
Overvoltage Trip	855 VDC	1130 VDC

Mains supply 3 x 380–480/500 V		FC102/202	P110	P132	P160	P200	P250
Model number		FC302	P90K	P110	P132	P160	P200
Normal overload current ratings (110%):							
Output current	Nominal [A] (380–440 V)		212	260	315	395	480
	MAX (60 sec) [A] (380–440 V)		233	286	347	434	528
	Nominal [A] (441–500 V)		190	240	302	361	443
	MAX (60 sec) [A] (441–500 V)		209	264	332	397	487
Output	Nominal [kVA] (400 V)		147	180	218	274	333
	Nominal [kVA] (460 V)		151	191	241	288	353
	Nominal [kVA] (500 V)		165	208	262	313	384
Typical shaft output	[kW] (400 V)		110	132	160	200	250
	[HP] (460 V)		150	200	250	300	350
	[kW] (500 V)		132	160	200	250	315
High overload torque (160%):							
Output current	Nominal [A] (380–440 V)		177	212	260	315	395
	MAX (60 sec) [A] (380–440 V)		266	318	390	473	593
	Nominal [A] (441–500 V)		160	190	240	302	361
	MAX (60 sec) [A] (441–500 V)		240	285	360	453	542
Output	Nominal [kVA] (400 V)		123	147	180	218	274
	Nominal [kVA] (460 V)		127	151	191	241	288
	Nominal [kVA] (500 V)		139	165	208	262	313
Typical shaft output	[kW] (400 V)		90	110	132	160	200
	[HP] (460 V)		125	150	200	250	300
	[kW] (500 V)		110	132	160	200	250
Power loss Normal overload [W]			3234	3782	4213	5117	5893
Power loss High overload [W]			2641	2995	3425	3910	4625
Limits and Ranges							
Overcurrent Warning	VLT A ^{RMS} Out		329	394	484	586	735
Overcurrent Alarm (1.5 sec delay)	VLT A ^{RMS} Out		329	394	484	586	735
Earth (Ground) Fault Alarm	VLT A ^{RMS} Out		80	95	120	151	180
Short Circuit Alarm	VLT A ^{RMS} Out		420	502	616	747	936
Heatsink Overtemperature	Degrees C		85	90	105	105	115
Heatsink Undertemperature Warning	Degrees C		0	0	0	0	0
Power Card Ambient Overtemperature	Degrees C		60	60	60	60	60
Power Card Ambient Undertemperature	Degrees C		-20	-20	-20	-20	-20
Mains Phase Warning (5 sec delay)	DC Bus Ripple VAC		50	50	50	50	50
Mains Phase Alarm (25 sec delay)	DC Bus Ripple VAC		50	50	50	50	50

Mains supply 3 x 380–480/500 V						
Model number		FC102/202	P315	P355	P400	P450
		FC302	P250	P315	P355	P400
Normal overload current ratings (110%):						
Output current	Nominal [A] (380–440 V)		600	658	745	800
	MAX (60 sec) [A] (380–440 V)		660	724	820	880
	Nominal [A] (441–500 V)		540	590	678	730
	MAX (60 sec) [A] (441–500 V)		594	649	746	803
Output	Nominal [kVA] (400 V)		416	456	516	554
	Nominal [kVA] (460 V)		430	470	540	582
	Nominal [kVA] (500 V)		468	511	587	632
Typical shaft output	[kW] (400 V)		315	355	400	450
	[HP] (460 V)		450	500	550/600	600
	[kW] (500 V)		355	400	500	530
High overload torque (160%):						
Output current	Nominal [A] (380–440 V)		480	600	658	695
	MAX (60 sec) [A] (380–440 V)		720	900	987	1043
	Nominal [A] (441–500 V)		443	540	590	678
	MAX (60 sec) [A] (441–500 V)		665	810	885	1017
Output	Nominal [kVA] (400 V)		333	416	456	482
	Nominal [kVA] (460 V)		353	430	470	540
	Nominal [kVA] (500 V)		384	468	511	587
Typical shaft output	[kW] (400 V)		250	315	355	400
	[HP] (460 V)		350	450	500	550
	[kW] (500 V)		315	355	400	500
Power loss Normal overload [W]			6790	7701	8879	9670
Power loss High overload [W]			5165	6960	7691	8636
Limits and Ranges						
Overcurrent Warning	VLT A ^{RMS} Out		893	1169	1169	1301
Overcurrent Alarm (1.5 sec delay)	VLT A ^{RMS} Out		893	1169	1169	1301
Earth (Ground) Fault Alarm	VLT A ^{RMS} Out		265	322	352	405
Short Circuit Alarm	VLT A ^{RMS} Out		1138	1490	1490	1654
Heatsink Overtemperature	Degrees C		95	95	95	95
Heatsink Undertemperature Warning	Degrees C		0	0	0	0
Power Card Ambient Overtemperature	Degrees C		68	68	68	68
Power Card Ambient Undertemperature	Degrees C		-20	-20	-20	-20
Mains Phase Warning (5 sec delay)	DC Bus Ripple VAC		70	70	70	70
Mains Phase Alarm (25 sec delay)	DC Bus Ripple VAC		70	70	70	70

1

Mains supply 3 x 525–690 V							
Model number		FC102/202			P25	P31	P40
		P132	P160	P200	0	5	0
		FC302			P20	P25	P31
		P110	P132	P160	0	0	5
Normal overload current ratings (110%):							
Output current	Nominal [A] (525–550 V)	162	204	253	303	360	418
	MAX (60 sec) [A] (525–550 V)	178	224	278	333	396	460
	Nominal [A] (551–690 V)	155	192	242	290	344	400
	MAX (60 sec) [A] (551–690 V)	171	211	266	319	378	440
Output	Nominal [kVA] (550 V)	154	194	241	289	343	398
	Nominal [kVA] (575 V)	154	191	241	289	343	398
	Nominal [kVA] (690 V)	185	229	289	347	411	478
Typical shaft output	[kW] (550 V)	110	132	160	200	250	315
	[HP] (575 V)	150	200	250	300	350	400
	[kW] (690 V)	132	160	200	250	315	400
High overload torque (160%):							
Output current	Nominal [A] (525–550 V)	137	162	204	253	303	360
	MAX (60 sec) [A] (525–550 V)	206	243	306	380	455	540
	Nominal [A] (551–690 V)	131	155	192	242	290	344
	MAX (60 sec) [A] (551–690 V)	197	233	288	363	435	516
Output	Nominal [kVA] (550 V)	131	154	194	241	289	343
	Nominal [kVA] (575 V)	130	154	191	241	289	343
	Nominal [kVA] (690 V)	157	185	229	289	347	411
Typical shaft output	[kW] (550 V)	90	110	132	160	200	250
	[HP] (575 V)	125	150	200	250	300	350
	[kW] (690 V)	110	132	160	200	250	315
Power loss Normal overload [W]		3114	3612	4293	515	582	614
					5	1	9
Power loss High overload [W]					427	487	518
		2665	2953	3451	5	5	5
Limits and Ranges							
Overcurrent Warning	VLT A ^{RMS} Out	256	329	483	483	585	734
Overcurrent Alarm (1.5 sec delay)	VLT A ^{RMS} Out	256	329	483	483	585	734
Earth (Ground) Fault Alarm	VLT A ^{RMS} Out	66	78	96	121	145	172
Short Circuit Alarm	VLT A ^{RMS} Out	325	420	614	614	742	932
Heatsink Overtemperature	Degrees C	85	90	110	110	110	110
Heatsink Undertemperature							
Warning	Degrees C	0	0	0	0	0	0
Power Card Ambient Overtemperature	Degrees C	60	60	60	60	60	60
Power Card Ambient Undertemperature	Degrees C	-20	-20	-20	-20	-20	-20
Mains Phase Warning (5 sec delay)	DC Bus Ripple VAC	70	70	70	70	70	70
Mains Phase Alarm (25 sec delay)	DC Bus Ripple VAC	70	70	70	70	70	70

Mains supply 3 x 525–690 V		FC102/202	P45K	P55K	P75K	P90K	P110K
Model number		FC302	P37K	P45K	P55K	P75K	P90K
Normal overload current ratings (110%):							
Output current	Nominal [A] (525–550 V)		56	76	90	113	137
	MAX (60 sec) [A] (525–550 V)		62	84	99	124	151
	Nominal [A] (551–690 V)		54	73	86	108	131
	MAX (60 sec) [A] (551–690 V)		59	80	95	119	144
Output	Nominal [kVA] (550 V)		53	72	86	108	131
	Nominal [kVA] (575 V)		54	73	86	108	130
	Nominal [kVA] (690 V)		65	87	103	129	157
Typical shaft output	[kW] (550 V)		37	45	55	75	90
	[HP] (575 V)		50	60	75	100	125
	[kW] (690 V)		45	55	75	90	110
High overload torque (160%):							
Output current	Nominal [A] (525–550 V)		48	56	76	90	113
	MAX (60 sec) [A] (525–550 V)		77	90	122	135	170
	Nominal [A] (551–690 V)		46	54	73	86	108
	MAX (60 sec) [A] (551–690 V)		74	86	117	129	162
Output	Nominal [kVA] (550 V)		46	53	72	86	108
	Nominal [kVA] (575 V)		46	54	73	86	108
	Nominal [kVA] (690 V)		55	65	87	103	129
Typical shaft output	[kW] (550 V)		30	37	45	55	75
	[HP] (575 V)		40	50	60	75	100
	[kW] (690 V)		37	45	55	75	90
Power loss Normal overload [W]		1458	1717	1913	2262	2662	
Power loss High overload [W]		1355	1459	1721	1913	2264	
Limits and Ranges							
Overcurrent Warning	VLT A ^{RMS} Out		256	256	256	256	256
Overcurrent Alarm (1.5 sec delay)	VLT A ^{RMS} Out		256	256	256	256	256
Earth (Ground) Fault Alarm	VLT A ^{RMS} Out		23	27	37	43	54
Short Circuit Alarm	VLT ARMS Out		325	325	325	325	325
Heatsink Overtemperature	Degrees C		85	85	85	85	85
Heatsink Undertemperature Warning	Degrees C		0	0	0	0	0
Power Card Ambient Overtemperature	Degrees C		60	60	60	60	60
Power Card Ambient Overtemperature	Degrees C		-20	-20	-20	-20	-20
Mains Phase Warning (5 sec delay)	DC Bus Ripple VAC		70	70	70	70	70
Mains Phase Alarm (25 sec delay)	DC Bus Ripple VAC		70	70	70	70	70

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Mains supply 3 x 525–690 V						
Model number		FC102/202	P450	P500	P560	P630
		FC302	P355	P400	P500	P560
Normal overload current ratings (110%):						
Output current	Nominal [A] (525–550 V)		470	523	596	630
	MAX (60 sec) [A] (525–550 V)		517	575	656	693
	Nominal [A] (551–690 V)		450	500	570	630
	MAX (60 sec) [A] (551–690 V)		495	550	627	693
Output	Nominal [kVA] (550 V)		448	498	568	600
	Nominal [kVA] (575 V)		448	498	568	627
	Nominal [kVA] (690 V)		538	598	681	753
Typical shaft output	[kW] (550 V)		355	400	450	500
	[HP] (575 V)		450	500	600	650
	[kW] (690 V)		450	500	560	630
High overload torque (160%):						
Output current	Nominal [A] (525–550 V)		395	429	523	596
	MAX (60 sec) [A] (525–550 V)		593	644	785	894
	Nominal [A] (551–690 V)		380	410	500	570
	MAX (60 sec) [A] (551–690 V)		570	615	750	855
Output	Nominal [kVA] (550 V)		376	409	498	568
	Nominal [kVA] (575 V)		376	408	498	568
	Nominal [kVA] (690 V)		454	490	598	681
Typical shaft output	[kW] (550 V)		315	315	400	450
	[HP] (575 V)		400	400	500	600
	[kW] (690 V)		355	400	500	560
Power loss Normal overload [W]			6449	7249	8727	9673
Power loss High overload [W]			5383	5818	7671	8715
Limits and Ranges						
Overcurrent Warning	VLT A ^{RMS} Out		824	824	989	1168
Overcurrent Alarm (1.5 sec delay)	VLT A ^{RMS} Out		824	824	989	1168
Earth (Ground) Fault Alarm	VLT A ^{RMS} Out		190	205	250	285
Short Circuit Alarm	VLT A ^{RMS} Out		1046	1046	1255	1490
Heatsink Overtemperature	Degrees C		85	85	85	85
Heatsink Undertemperature Warning	Degrees C		0	0	0	0
Power Card Ambient Overtemperature	Degrees C		68	68	68	68
Power Card Ambient Undertemperature	Degrees C		-20	-20	-20	-20
Mains Phase Warning (5 sec delay)	DC Bus Ripple VAC		70	70	70	70
Mains Phase Alarm (25 sec delay)	DC Bus Ripple VAC		70	70	70	70

2 Operator Interface and Frequency Converter Control

2

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 local control panel LCP display. Fault logs are maintained within the frequency converter for fault history.

The frequency converter monitors supply and output voltages along with the operational condition of the motor and load. When the frequency converter issues a warning or alarm, 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 LCP.

2.2 User Interface

2.2.1 How to Operate the Graphic Local Control Panel (LCP)

The LCP is divided into four functional groups:

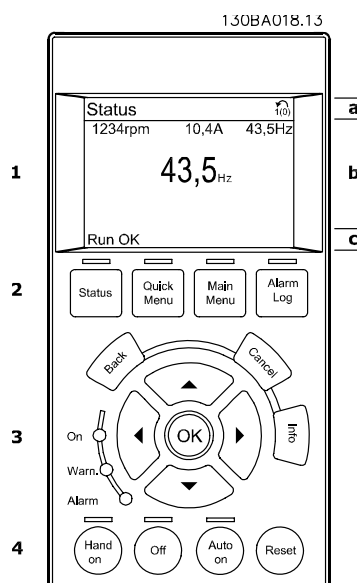
1. Graphical display with status lines.
2. Menu keys and indicator lights (LEDs) - selecting mode, changing parameters and switching between display functions.
3. Navigation keys and indicator lights (LEDs).
4. Operation keys and indicator lights (LEDs).

Graphical display:

The LCD display is back lit with a total of 6 alpha-numeric lines. All data is displayed on the LCP which can show up to five operating variables whilst in [Status] mode.

Display lines:

- a. **Status line:** Status messages displaying icons and graphics.
- b. **Line 1-2:** Operator data lines displaying data and variables defined or chosen by the user. By pressing the [Status] key, up to one extra line can be added.
- c. **Status line:** Status messages displaying text.



The display is divided into three sections:

Top section (a) shows the status when in status mode or up to two variables when not in status mode and in the case of Alarm/Warning.

The number of the Active Set-up (selected as the Active Set-up in par.) is shown. When programming in another Set-up than the Active Set-up, the number of the Set-up being programmed appears to the right in brackets.

The **Middle section (b)** shows up to 5 variables with related unit, regardless of status. In case of alarm/warning, the warning is shown instead of the variables.

It is possible to toggle between three status readout displays by pressing the [Status] key. Operating variables with different formatting are shown in each status screen - see below.

Several values or measurements can be linked to each of the displayed operating variables. The values/measurements to be displayed can be defined via par. 0-20, 0-21, 0-22, 0-23, and 0-24, which can be accessed via [QUICK MENU] *Q3 Function Setups, Q3-1 General Settings, Q3-13 Display Settings.*

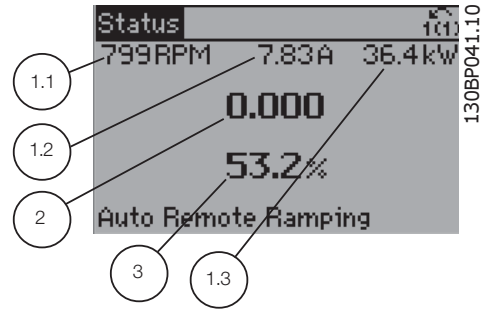
Each value/measurement readout parameter selected in par. 0-20 *Display Line 1.1 Small* to par. 0-24 *Display Line 3 Large* has its own scale and number of digits after a possible decimal point. Larger numeric values are displayed with few digits after the decimal point.

Ex.: Current readout
5.25 A; 15.2 A 105 A.

Status display I:

This readout state is standard after start-up or initialisation.

Use [INFO] to obtain information about the value/measurement linked to the displayed operating variables (1.1, 1.2, 1.3, 2, and 3). See the operating variables shown in the display in this illustration. 1.1, 1.2 and 1.3 are shown in small size. 2 and 3 are shown in medium size.

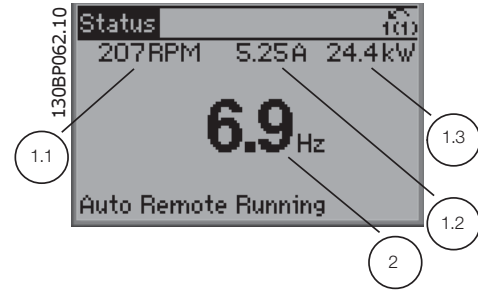


Status display II:

See the operating variables (1.1, 1.2, 1.3, and 2) shown in the display in this illustration.

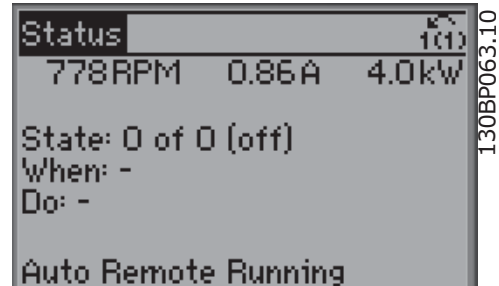
In the example, Speed, Motor current, Motor power and Frequency are selected as variables in the first and second lines.

1.1, 1.2 and 1.3 are shown in small size. 2 is shown in large size.



Status display III:

This state displays the event and action of the Smart Logic Control.

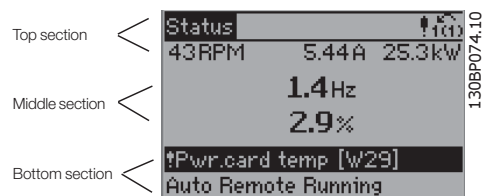


The **Bottom** section always shows the state of the frequency converter in Status mode.

Display contrast adjustment

Press [status] and [▲] for darker display

Press [status] and [▼] for brighter display

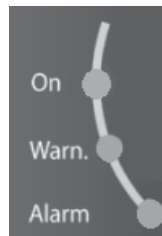


Indicator lights (LEDs):

If certain threshold values are exceeded, the alarm and/or warning LED lights up. A status and alarm text appears on the control panel.

The On indicator lamp is activated when the frequency converter receives power from mains voltage, a DC bus terminal, or an external 24 V supply. At the same time, the back light is on.

- Green LED/On: Control section is working.
- Yellow LED/Warn.: Indicates a warning.
- Flashing Red LED/Alarm: Indicates an alarm.



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LCP keys

Menu keys

The menu keys are divided into functions. The keys below the display and indicator lamps are used for parameter set-up, including choice of display indication during normal operation.



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[Status]

indicates the status of the frequency converter and/or the motor. Three different readouts can be chosen by pressing the [Status] key:

5 line readouts, 4 line readouts or Smart Logic Control.

Use [Status] for selecting the mode of display or for changing back to Display mode from either the Quick Menu mode, the Main Menu mode or Alarm mode. Also use the [Status] key to toggle single or double readout mode.

[Quick Menu]

allows quick set-up of the frequency converter. **The most common functions can be programmed here.**

The [Quick Menu] consists of:

- **My Personal Menu**
- **Quick Set-up**
- **Function set-up**
- **Changes Made**
- **Loggings**

The Function set-up provides quick and easy access to all parameters required for the majority of applications. Among other features it also includes parameters for selecting which variables to display on the LCP.

[Main Menu]

is used for programming all parameters. The Main Menu parameters can be accessed immediately unless a password has been created via par. 0-60, 0-61, 0-65 or 0-66.

Parameter shortcut can be carried out by pressing down the **[Main Menu]** key for 3 seconds. The parameter shortcut allows direct access to any parameter.

[Alarm Log]

displays an Alarm list of the five latest alarms (numbered A1-A5). To obtain additional details about an alarm, use the arrow keys to find the alarm number and press **[OK]**. Information is displayed about the condition of the frequency converter before it enters the alarm mode.

The **[Alarm log]** button on the LCP allows access to both the Alarm log and Maintenance log.

[Back]

reverts to the previous step or layer in the navigation structure.

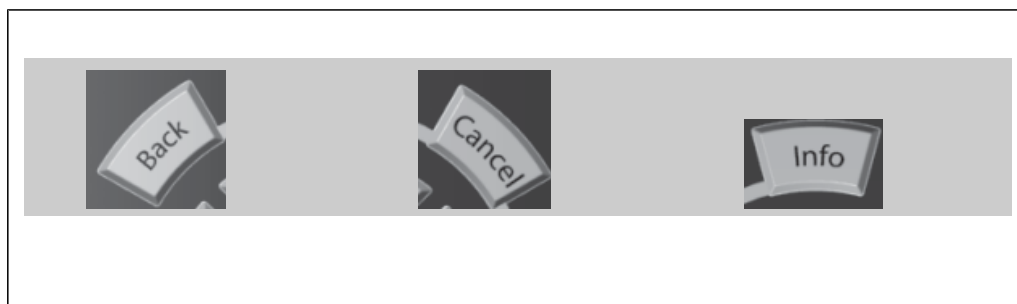
[Cancel]

last change or command will be cancelled as long as the display has not been changed.

[Info]

displays information about a command, parameter, or function in any display window. **[Info]** provides detailed information when needed.

Exit Info mode by pressing either **[Info]**, **[Back]**, or **[Cancel]**.



Navigation keys

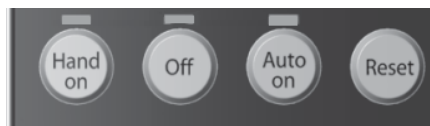
The four navigation arrows are used to navigate between the different choices available in **[Quick Menu]**, **[Main Menu]** and **[Alarm Log]**. Use the keys to move the cursor.

[OK] is used for choosing a parameter marked by the cursor and for enabling the change of a parameter.



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



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[Hand On]

Enables control of the frequency converter via the LCP. [Hand On] also starts the motor, and it is now possible to enter the motor speed data by means of the arrow keys. The key can be selected as *Enable* [1] or *Disable* [0] via par. 0-40 *[Hand on] Key on LCP*.

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

- [Hand On] - [Off] - [Auto On]
- Reset
- Coasting stop inverse
- Reversing
- Set-up select lsb - Set-up select msb
- Stop command from serial communication
- Quick stop
- DC brake

**NB!**

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

[Off]

stops the connected motor. The key can be selected as *Enable* [1] or *Disable* [0] via par. 0-41 *[Off] Key on LCP*. 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 On]

enables the frequency converter to be controlled via the control terminals and/or serial communication. When a start signal is applied on the control terminals and/or the bus, the frequency converter will start. The key can be selected as *Enable* [1] or *Disable* [0] via par. 0-42 *[Auto on] Key on LCP*.

**NB!**

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

[Reset]

is used for resetting the frequency converter after an alarm (trip). It can be selected as *Enable* [1] or *Disable* [0] via par. 0-43 *[Reset] Key on LCP*.

The **parameter shortcut** can be carried out by holding down the [Main Menu] key for 3 seconds. The parameter shortcut allows direct access to any parameter.

2.2.2 Numeric Local Control Panel (NLCP)

See the FC Series Operating Instructions for instructions for using the numeric LCP.

2.2.3 Tips and Tricks

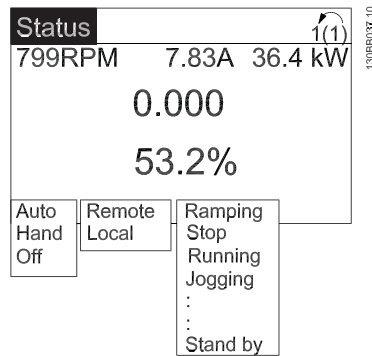
*	For the majority of applications the Quick Menu, Quick Set-up and Function Set-up provides the simplest and quickest access to all the typical parameters required.
*	Whenever possible, performing an AMA will ensure best shaft performance.
*	Display contrast can be adjusted by pressing [Status] and [▲] 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 LCP, see par. for further information.

Table 2.1: Tips and tricks

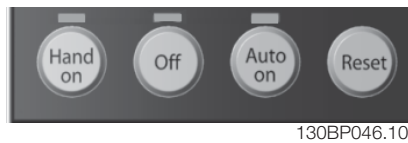
2.3 Status Messages

Status messages appear in the bottom of the display - see the example below. The left part of the status line indicates the active operation model 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 FC does not react to any control signal until [Auto On] or [Hand On] on the LCP are pressed.

[Auto On] The FC is controlled via the control terminals and/or the serial communication.

[Hand On] Only *stop* commands, alarm resets (Reset), *reversing*, DC brake, and *set-up selection* signals can be applied to the control terminals.

For further information about the LCD display, please see the chapter *How to programme* in the Programming Guide.

Reference Site

[Remote] The Reference is given via internal preset references (absolute or relative) and/or external signals (analog or digital) and/or via serial communication.

[Local] The FC uses the reference values set via the LCP.

For further information, please examine parameter 3-13.

Operation Status**AC Brake**

AC Brake was selected in par. 2-10 *Brake Function*. The motor is slowed down via the active down ramp and feeds the FC with generative energy. The AC Brake over-magnetizes the motor to achieve a controlled end of the active ramp.

AMA finish OK

Enable complete or reduced AMA was selected in par. 1-29 *Automatic Motor Adaptation (AMA)*. The Automatic Motor Adaptation was carried out successfully.

AMA ready

Enable complete or reduced AMA was selected in par. 1-29 *Automatic Motor Adaptation (AMA)*. The Automatic Motor Adaptation is ready to start. Press [Hand On] on the LCP to start.

AMA running

Enable complete or reduced AMA was selected in par. 1-29 *Automatic Motor Adaptation (AMA)*. The AMA 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. 2-12 *Brake Power Limit (kW)* is reached.

Bus Jog 1

PROFIDrive profile was selected in par. 8-10 *Control Word Profile*. The Jog 1 function is activated via serial communication. The motor is running with par. 8-90 *Bus Jog 1 Speed*.

Bus Jog 2

PROFIDrive profile was selected in par. 8-10 *Control Word Profile*. The Jog 2 function is activated via serial communication. The motor is running with par. 8-91 *Bus Jog 2 Speed*.

Catch up

The output frequency is corrected by the value set in par. 3-12 *Catch up/slow Down Value*.

1. Catch up is selected as a function for a digital input (parameter group 5-1*). 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 5-1*). The corresponding terminal (e.g. Terminal 27) is not connected.
2. Coast is on 0 on serial communication

Control ready

PROFIDrive profile was selected in par. 8-10 *Control Word Profile*. The FC 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. Ramp-down

A function with Ctrl. Ramp-down was selected in par. 14-10 *Mains Failure*. The Mains Voltage is below the value set in par. 14-11 *Mains Voltage at Mains Fault*. The FC ramps down the motor using a controlled ramp down.

Current High

In par. 4-51 *Warning Current High*, a current limit is set. The output current of the FC is above this limit.

Current Low

In par. 4-52 *Warning Speed Low*, a current limit is set. The output current of the FC is below this limit.

DC Hold

The motor is driven with a permanent DC current, par. 2-00 *DC Hold Current*. DC hold is selected in par. 1-80 *Function at Stop*. A Stop command (e.g. Stop (inverse)) is active.

DC Stop

The motor is momentarily driven with a DC current, par. 2-01 *DC Brake Current*, for a specified time, par. 2-02 *DC Braking Time*.

1. DC Brake is activated (OFF) in par. 2-03 *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 5-1*). The corresponding terminal is not active.
3. The DC Brake is activated via serial communication.

DC Voltage U0

In par. 1-01 *Motor Control Principle U/f* and in par. 1-80 *Function at Stop* DC Voltage U0 is selected. A Stop command (e.g. Stop (inverse)) is activated. The voltage selected according to the par. 1-55 *U/f Characteristic - U [0]* (UF Characteristic – U[V]) is applied to the motor.

Feedback high

In par. 4-57 *Warning Feedback High*, an upper feedback limit is set. The sum of all active feedbacks is above the feedback limit.

Feedback low

In par. 4-56 *Warning Feedback Low*, a lower feedback limit is set. The sum of all active feedbacks is below the feedback limit.

Flying start

In par. 1-73 *Flying Start*, the Flying start function is activated. The FC is testing if the connected motor is running with a speed that is in the adjusted speed range. The process was started by connecting a digital input (parameter group 5-1*) 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 5-1*). 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 5-1*). The corresponding terminal is controlled. The FC 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. 3-19 *Jog Speed [RPM]*.

1. Jog was selected as function for a digital input (parameter group 5-1*). 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. 14-10 *Mains Failure*, a function was set as kinetic backup. The Mains Voltage is below the value set in par. 14-11 *Mains Voltage at Mains Fault*. The FC is running the motor momentarily with kinetic energy from the inertia of the load.

Motor check (FC 100/200 only)

In par. 1-80 *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 FC, a permanent test current is applied to the motor.

Off1

PROFIDrive profile was selected in par. 8-10 *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. 8-10 *Control Word Profile*. The OFF 2 function is activated via serial communication. The output of the FC is disabled immediately and the motor coasted.

Off3

PROFIDrive profile was selected in par. 8-10 *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. 2-17 *Over-voltage Control*. The connected motor is supplying the FC with generative energy. The Overvoltage Control adjusts the UF ratio to run the motor in controlled mode and to prevent the FC 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. 1-80 *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 FC 100/200/300 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. 14-26 *Trip Delay at Inverter Fault*.

QStop

The motor is stopped using a quick stop ramp par. 3-81 *Quick Stop Ramp Time*.

1. Quick stop inverse was chosen as a function for a digital input (parameter group 5-1*). The corresponding terminal (e.g. Terminal 27) is not active.
2. The Quick stop function was activated via serial communication.

Ramping

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

Ref. high

In par. 4-55 *Warning Reference High* a reference high limit is set. The sum of all active references is above the reference limit.

Ref. low

In par. 4-55 *Warning Reference High* a reference low limit is set. The sum of all active references is below the reference limit.

Run on ref.

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

Run request (FC 100/200 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 FC, the ramping phase is done and the motor revolutions are outside the *On Reference* range. Occurs when one of the motor speed limits (Par. 4-11/4-12/4-13 or 4-14) is set, but the maximum reference is outside this range.

Sleep Boost (FC 100/200 only)

The boost function in parameter 406 *Boost setpoint* is enabled. This function is only possible in *Closed loop* operation.

Sleep Mode (FC 100/200)

The energy saving function in parameter 403 *Sleep mode timer* is enabled. 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. 3-12 *Catch up/slow Down Value*.

1. Speed down was selected as a function for a digital input (parameter group 5-1*). The corresponding terminal is active.
2. Speed down was activated via serial communication.

Speed high

In par. 4-53 *Warning Speed High*, a value is set. The speed of the motor is above this value.

Speed low

In par. 4-52 *Warning Speed Low*, a value is set. The speed of the motor is below this value.

Standby

[Auto On] The FC 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. 1-71 *Start Delay*, 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 5-1*). 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. 8-10 *Control Word Profile*. The start inhibition is active. The FC 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 LCP or Stop inverse was selected as a function for a digital input (Group 5-1*). 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 LCP, 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 LCP, a control terminal or serial communication).

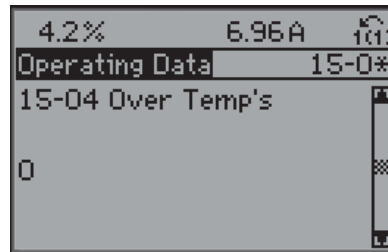
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2.4 Service Functions

Unit/Drive not ready

PROFIDrive profile was selected in par. 8-10 *Control Word Profile*. A control word is sent to the FC via serial communication with Off 1, Off 2 and Off 3 active. Start inhibit is active. To enable start, see operation status Start inhibit.

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 15-** parameter group.



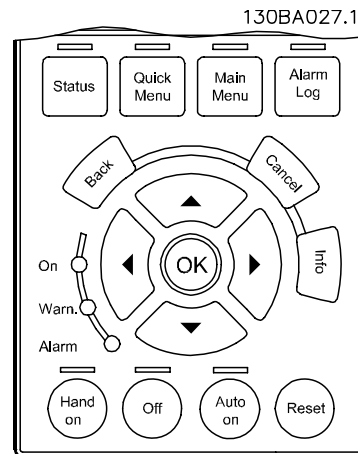
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Parameter settings are displayed by pressing the [MAIN MENU] key on the LCP.



130BP045.10

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



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See the FC Series Operating Instructions for detailed information on accessing and displaying parameters and for descriptions and procedures for service information available in the 15-** parameter group.

2.5 Frequency Converter Inputs and Outputs

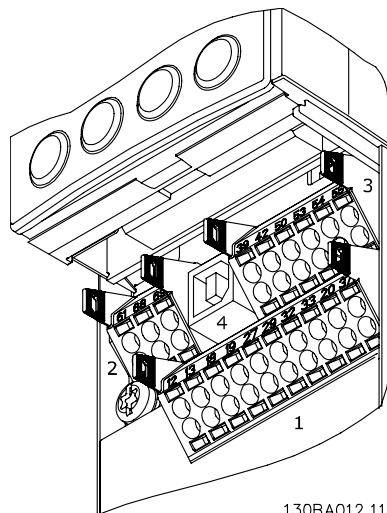
The frequency converter operates by receiving control input signals. The frequency converter can also output status data or control auxiliary devices. Control input is connected to the frequency converter in three possible ways. One way for frequency converter control is through the LCP on the front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

Another control source is through serial communication from a 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 LCP. Improperly connected control wiring can be the cause of a motor not operating or the frequency converter not responding to a remote input.

Terminal Descriptions

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



130BA012.11

Illustration 2.1: 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 LCP. 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

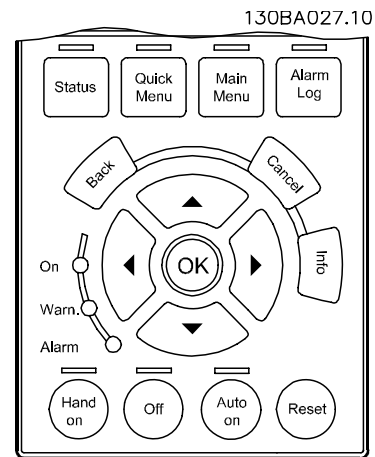
Control terminals must be programmed. Each terminal has specific functions it is capable of performing and a numbered parameter associated with it. See table below. The setting selected in the parameter enables the function of the terminal.

It is important to confirm that the control terminal is programmed for the correct function.

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



Use the arrow keys [▲], [▼], [▶] and [◀] on the LCP 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 6.

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 2-2.

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 (some units).
39	Common for analog and digital outputs.
42	Analog and digital outputs for indicating values such as frequency, reference, current and torque. The analog signal is 0/4 to 20 mA at a maximum of 500 Ω. The digital signal is 24 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.	5-10	5-11	5-12	5-13	5-14	5-15	5-19	6-1*	6-2*	6-5*	5-4*	5-4*

Table 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 FC Series Operating Instructions for details.

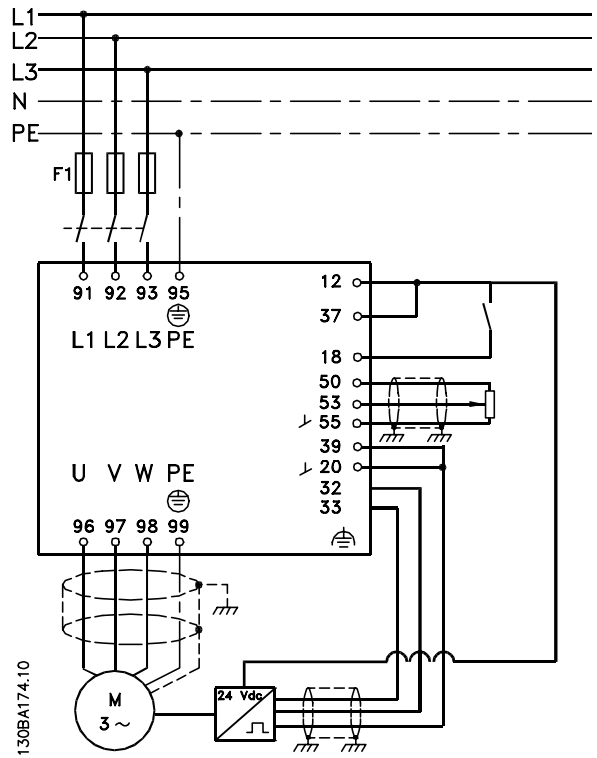


Illustration 2.2: Control Terminals Electrical Diagram

2

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. Table 2-3 shows earth cabling for optimal results.

	<p>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.</p>
	<p>Incorrect earthing Do not use twisted cable ends (pigtailed) since these increase screen impedance at high frequencies.</p>
	<p>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.</p>
	<p>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.</p>
	<p>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.</p>

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

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 3-1).

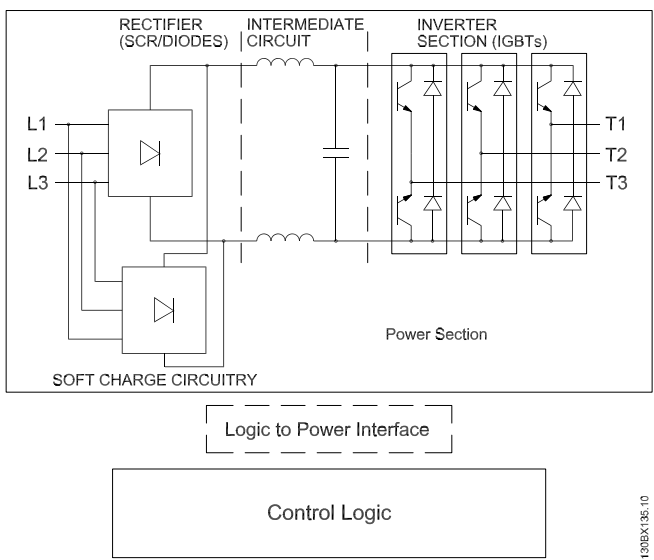


Illustration 3.1: Control Card Logic

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.

3.2.1 Logic Section

The control card contains most of the logic section (see Illustration 3-2). 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.

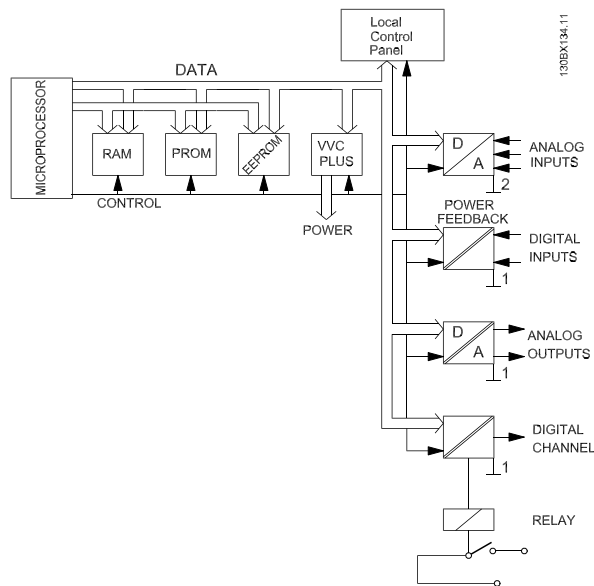


Illustration 3.2: Logic Section

The PWM waveform is created using an improved control scheme called VVC^{plus}, a further development of the earlier VVC (Voltage Vector Control) system. VVC^{plus} 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 group 14-**. The dynamic response of the system changes to meet the variable requirements of the load.

Another part of the logic section is the local control panel (LCP). This is a removable keypad/display mounted on the front of the frequency converter. The LCP 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 LCP. 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 LCP is removable during operation to prevent undesired program changes. With the addition of a remote mounting kit, the LCP can be mounted in a remote location of up to 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 5-4*. 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.

3.2.3 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 3-3) 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.

The DC coil is a single unit with 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 aids in the reduction of mains harmonics.

The DC bus capacitors are arranged into a capacitor bank along with bleeder and balancing circuitry. Due to the requirement for higher power capacity, some frequency converters have two capacitor banks connected in parallel.

The inverter section is made up of six IGBTs, commonly referred to as switches. One switch is necessary for each half phase of the three-phase power, for a total of six. The six IGBTs are contained in a single module. Due to higher current handling requirements, some models contain two or three larger six-pack style modules. In these units, each switch (half phase) is made up of two or three IGBTs in parallel.

A Hall effect type current sensor is located on each phase of the output to measure motor current. This type of device is used instead of more common current transformer (CT) devices in order to reduce the amount of frequency and phase distortion that CTs introduce into the signal. With Hall sensors, the average, peak, and earth leakage currents can be monitored.

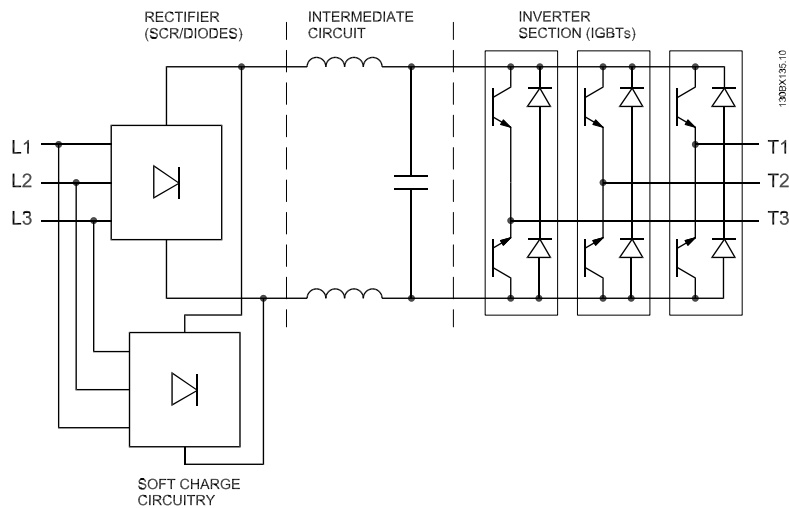


Illustration 3.3: Typical Power Section

3.3 Sequence of Operation

3.3.1 Rectifier Section

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. In E frequency converter models, 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.

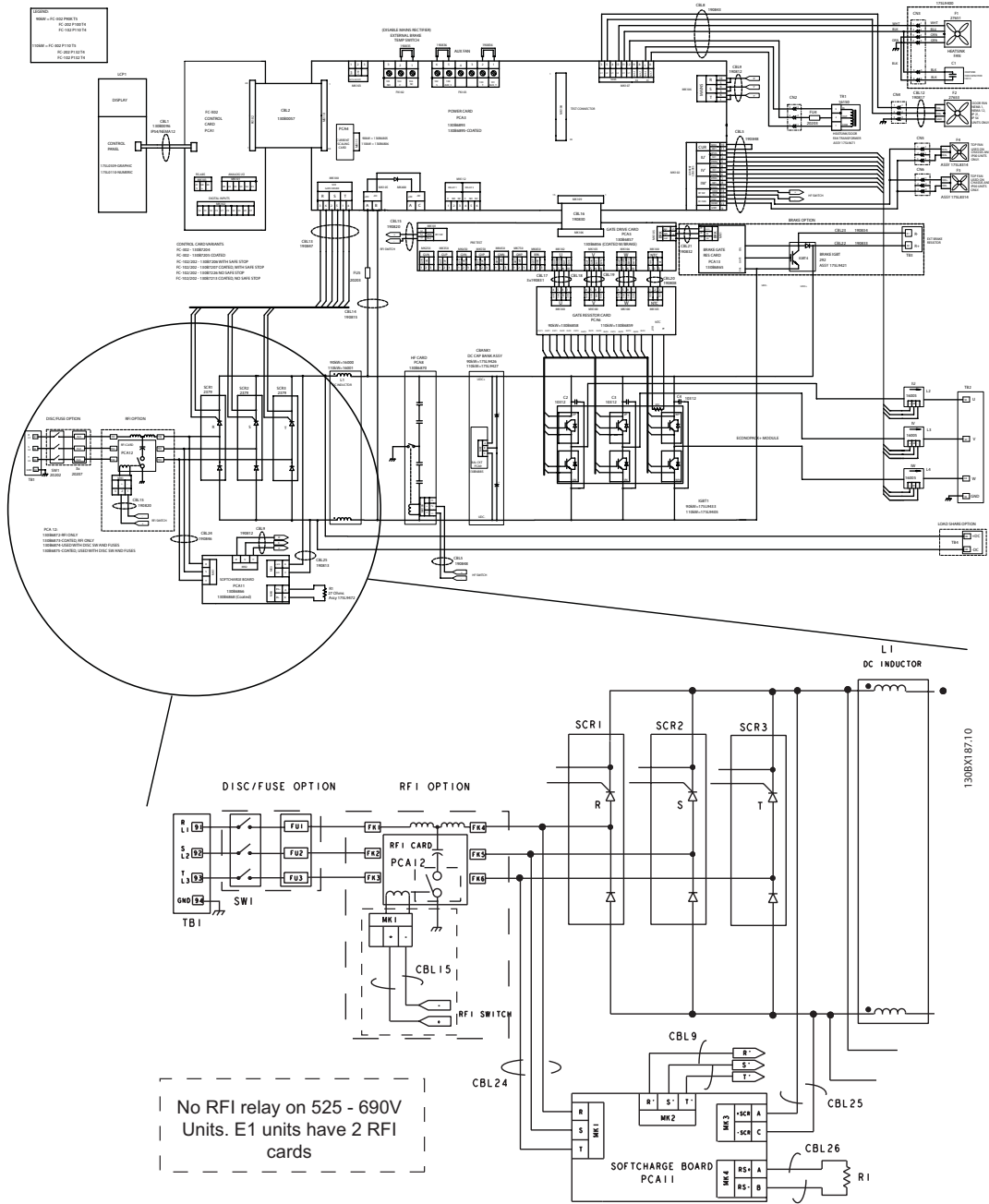
Positive temperature coefficient (PTC) resistors located on the soft charge card are in series with the soft charge resistor. Frequent cycling of the input power or the DC bus charging over an extended time can cause the PTC resistors to heat up due to the current flow. Resistance of the PTC device increases 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 ($VAC \times 1.414$). However, since AC ripple voltage is present on the DC bus, the actual DC value will be closer to $VAC \times 1.38$ under unloaded conditions and may drop to $VAC \times 1.32$ 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 (460×1.38).

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.

3



3.3.2 Intermediate Section

Following the rectifier section, voltage passes to the intermediate section. (see Illustration 3-5). This rectified voltage is smoothed by an LC filter circuit consisting of the DC bus inductor and the DC bus capacitor bank.

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.

The DC capacitor bank assembly consists of up to eight capacitors arranged in series/parallel configuration. Higher power units have two capacitor bank assemblies. 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. 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. 14-50 *RFI Filter*. This disconnects the earth references to all filters should unbalanced phase-to-earth voltages create nuisance overvoltage conditions.

For 525–690 V frequency converters, there are no relay contacts that disconnect the earthing.

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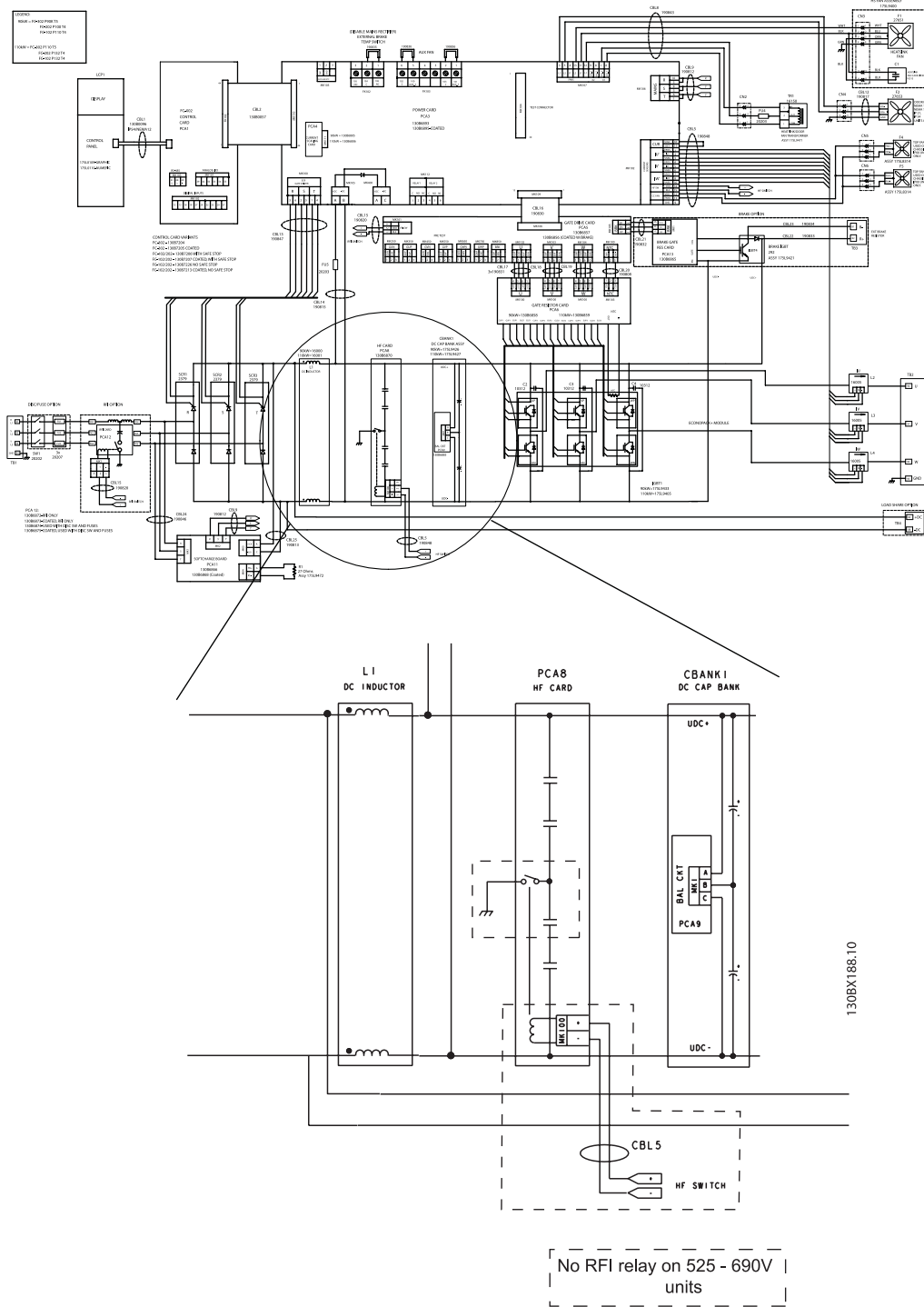


Illustration 3.5: Intermediate section

3.3.3 Inverter Section

In the inverter section (see Illustration 3-7), gate signals are delivered from the control card, through the power card and gate frequency converter card to the gates of the IGBTs. The series connection of each set of IGBTs is delivered to the output, first passing through the current sensors.

Once a run command and speed reference are present, the IGBTs begin switching to create the output waveform, as shown in Illustration 3-6. 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 Danfoss VVCplus PWM principle at the control card, provides optimal performance and minimal losses in the motor.

Hall effect current sensors monitor the output current and deliver proportional signals to the power card where they are buffered and delivered to the control card. 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 one of IGBT modules provides heatsink temperature feedback.

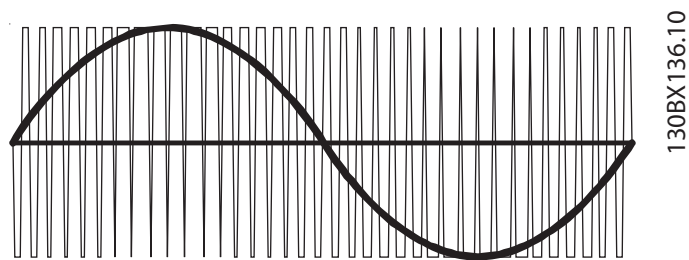


Illustration 3.6: Output Voltage and Current Waveforms

3

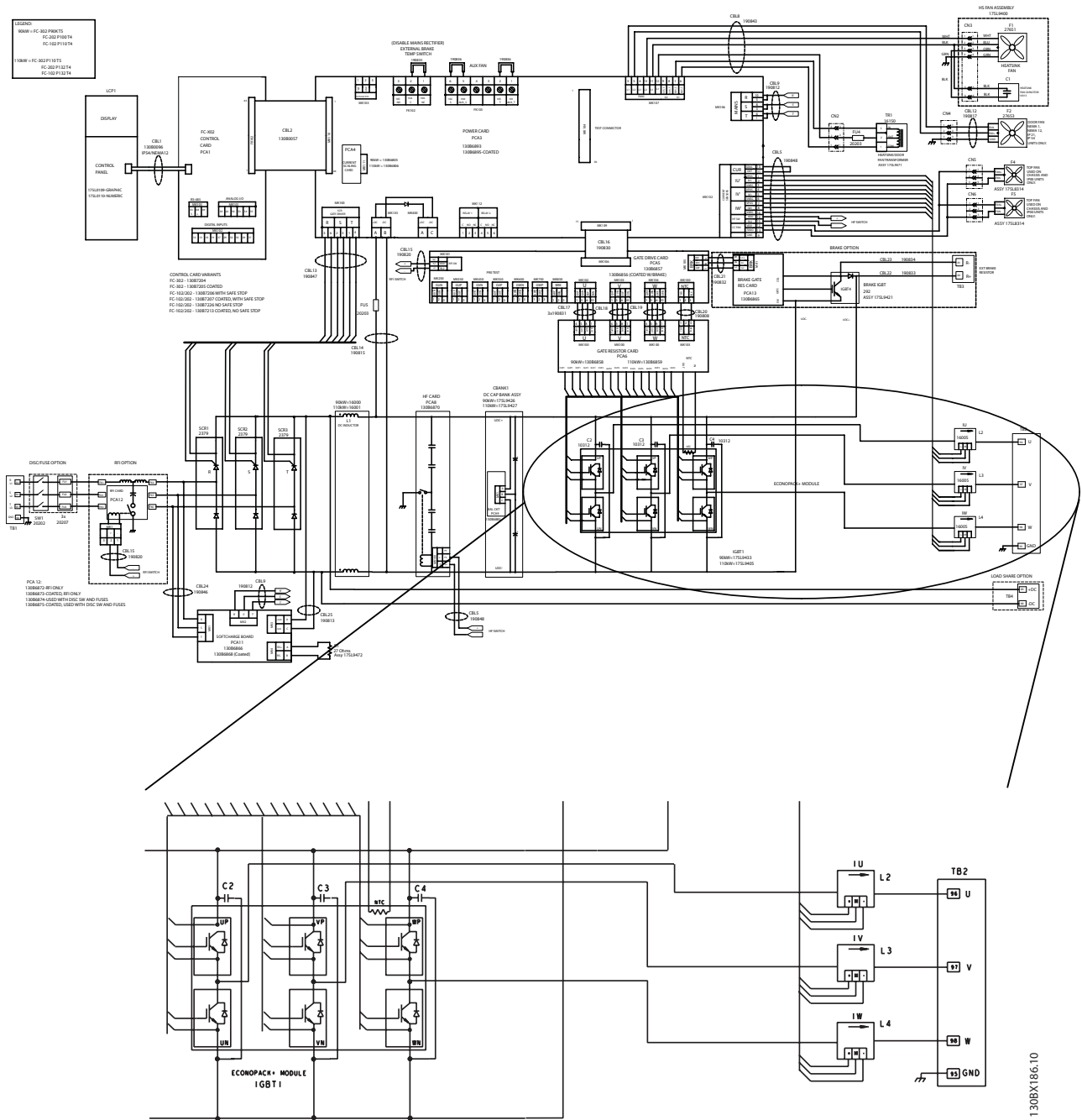


Illustration 3.7: Inverter section

3.3.4 Brake Option

For frequency converters equipped with the dynamic brake option, a brake IGBT along with terminals 81(R-) and 82(R+) is included for connecting an external brake resistor.

The function of the brake IGBT (see Illustration 3-8) 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 frequency converters 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 control panel, 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 IGBT via the power card and gate frequency converter card. Additionally, the power and control cards monitor the brake IGBT and brake resistor connection for short circuits and overloads.

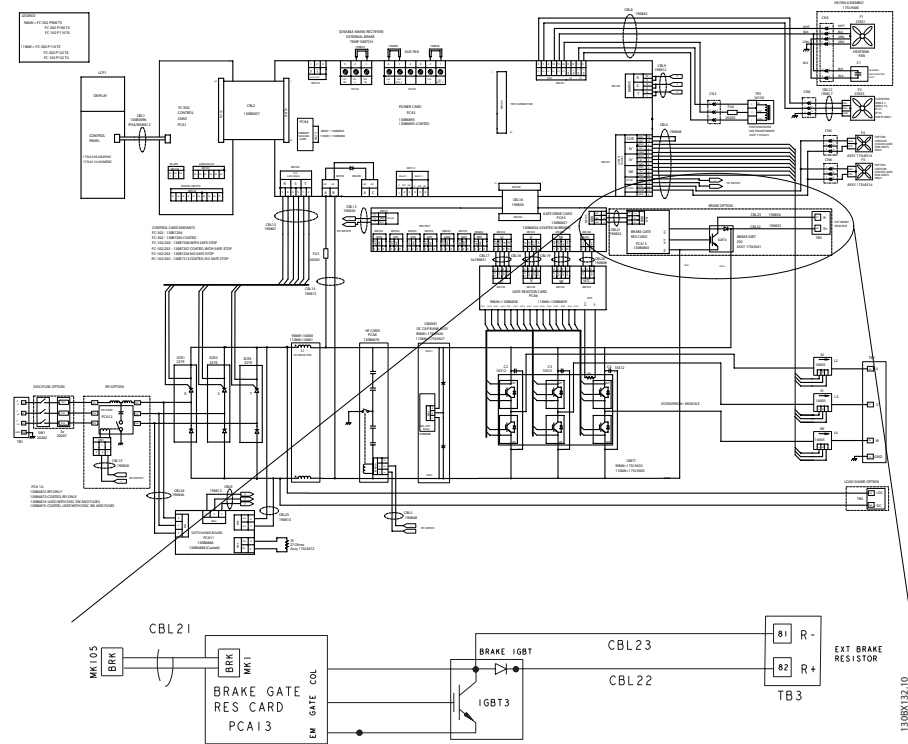


Illustration 3.8: Brake option

3.3.5 Cooling Fans

All frequency converters in this size range are equipped with cooling fans to provide airflow along the heatsink. Units in NEMA 1 (IP21) and NEMA 12 (IP54) enclosures have a fan mounted in the enclosure door to provide additional airflow to the unit. Chassis (IP00) enclosures have a fan or fans mounted to the top of the unit for additional cooling. Some frequency converters in this size range have a small 24 VDC fan mounted on the input plate. This fan is only mounted on E-frame size units equipped with both an RFI filter and mains fuses. The fan provides air flow around the main fuses. The fan operates anytime the frequency converter is powered.

All fans are powered by mains voltage which is stepped down by an autotransformer and regulated to 200 or 230 VAC by circuitry provided on the power card. On/off and high/low speed control of the fans is provided to reduce overall acoustical noise and extend the life of the fans.

Fans are activated by the following causes:

- 60% of nominal current exceeded
 - Specific heatsink temperature exceeded (power size dependent)
 - 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.

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

IGBT Thermal Sensor	D Frame Units	E Frame Units
Fan Turn On Low Speed	45° C	45° C
Fan Low Speed to High Speed	50° C	50° C
Fan High Speed to Low Speed	40° C	40° C
Fan Turn Off from Low Speed	30°C	30°C

Table 3.1: IGBT Thermal Sensor

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

Power Card Ambient	D Frame Units	E Frame Units
Fan turn on to High Speed	35° C	45° C
Fan turn off from High Speed	30° C	40° C
Fan turn on to High Speed	<10° C	<10° C

Table 3.2: Power Card Ambient Temperature Sensor

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

Control Card Ambient	D Frame Units	E Frame Units
Fan turn on to Low Speed	55° C	55° C
Fan turn off from Low Speed	45° C	45° C

Table 3.3: Control Card Thermal Sensor

4. 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 in the DC link connections and AC reactors on the mains. Attempting such a configuration requires specific considerations and should not be attempted without first consulting Danfoss Application Engineering.

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. Again such a configuration should not be attempted without first consulting Danfoss Application Engineering.

3.3.8 Specific Card Connections

Connector FK102, terminals 104, 105 and 106 located on the power card, 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 29, Overtemperature. 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 card, 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 2 auxiliary relays. 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. 5-40 *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. Note all warnings concerning voltages present in the frequency converter. Always verify the presence of AC input voltage and DC bus voltage before working on the unit. 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.
Remember that voltage may be present for as long as 40 minutes on E-frame size frequency converters or 20 minutes on D-frame size frequency converters after removing power from the unit. See the label on the front of the frequency converter door for the specific discharge time.
2. 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 5, Test Procedures.
3. Never attempt to defeat any fault protection circuitry within the frequency converter. That will result in unnecessary component damage and may cause personal injury.
4. 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.
5. Read the instruction and service manuals. A thorough understanding of the unit is the best approach. If ever in doubt, consult the factory or authorised repair centre for assistance.

4

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 4-1, 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 Table 4-1 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 necessarily 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. Section 5, 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 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 etc. 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 6–8 inches (150–200 mm) between the cables or separate them with an earthed conductive partition. Avoid routing cables through free air.
Control wiring	Check for broken or damaged wires and connections. Check the voltage source of the signals. Though not always necessary depending on the installation conditions, the use of screened cable or a twisted pair is recommended. Ensure the screen is terminated correctly. Refer to the section on earthing screened cables in Section 2.
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 local control panel display 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. Refer to the frequency converter operating instructions and Section 5 of this manual for further details.
Environmental conditions	Under specific conditions, these units can be operated within a maximum ambient of 50° C (122° F). Humidity levels must be less than 95% noncondensing. Check for harmful airborne contaminants 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 (1-20 – 1-25) 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	These frequency converters require adequate top and bottom clearance to ensure proper air flow for cooling in accordance with the frequency converter size. Frequency converters with exposed heatsinks out the back of the frequency converter must be mounted on a flat solid surface.
Vibration	Although this is a somewhat subjective procedure, look for any unusual amount of vibration that the frequency converter may be subjected to. The frequency converter 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

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



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

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

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.

LCP Stop

The [OFF] key has been pressed. Line 2 of the display will also flash when this occurs.

Press the [AUTO ON] or [HAND ON] 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 (6.3.16).

Unit ready

Terminal 27 is low (no signal).

Ensure that terminal 27 is logic "1". Refer to the Input Terminal Signal Test (6.3.16).

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 (6.3.16).

Off 1 (2 or 3)

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

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

STOP

One of the digital input terminals 18, 19, 27, 29, 32, or 33 (parameter 5-1*) 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").

Display Indication That the Unit is Functioning, but No Output

Make sure that par. 14-22 *Operation Mode* is not set to *Run With Inverter Disabled*.

If the unit is equipped with an external 24 VDC option, check that main power is applied to the frequency converter.

Note: In this case, the display will alternately flash Warning 8.

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. Perform Input Terminal Signal Test (6.3.16) to check for faulty reference signals.

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. Perform Input Terminal Signal Test (6.3.16) to check for faulty reference signals. Perform the Output Imbalance of Supply Voltage Test (6.3.10) to check for loss of motor phase.

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. Perform the Output Imbalance of Supply Voltage Test (6.3.10).

If output voltage is unbalanced, perform the Gate Drive Signal Test (6.3.11).

Motor draws high current but cannot start

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

Perform the Output Imbalance of Supply Voltage Test (6.3.10) to ensure the frequency converter is providing correct output (see Motor Runs Rough above).

Run an AMA 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 ramp down time too short. Note: May be accompanied by an alarm or warning message.

Check all brake parameters and ramp down time (parameters 2-0* and 3-4*).

Perform Brake Check (6.3.13).

4.6 Warning/Alarm Messages

4.6.1 Warning/Alarm Code List


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

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

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

This may be done in three ways:

1. Pressing the [reset] button on the control panel LCP.
2. A digital reset input.
3. Serial communication/optional fieldbus reset signal.



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

A **trip lock** is an action when an alarm occurs which may cause damage to the frequency converter or connected equipment. Power is removed from the motor. A trip lock can only be reset after the condition is cleared by cycling power. Once the problem has been rectified, only the alarm continues flashing until the frequency converter is reset.

An X marked in the table below means that action occurs. A warning precedes an alarm.

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock
1	10 volts low	X		
2	Live zero error	(X)	(X)	
3	No motor	(X)		
4	Mains phase loss	(X)	(X)	(X)
5	DC link voltage high	X		
6	DC link voltage low	X		
7	DC overvoltage	X	X	
8	DC undervoltage	X	X	
9	Inverter overloaded	X	X	
10	Motor overtemperature	(X)	(X)	
11	Motor thermistor overtemperature	(X)	(X)	
12	Torque limit	X	X	
13	Overcurrent	X	X	X
14	Earth (ground) fault	X	X	X
15	Hardware mismatch		X	X
16	Short circuit		X	X
17	Control word time-out	(X)	(X)	
22	Hoist mechanical brake		X	
23	Internal fan fault	X		
24	External fan fault	X		
25	Brake resistor short circuit	X		

Table 4.2: Warning/alarm code list

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock
26	Brake resistor power limit	(X)	(X)	
27	Brake chopper fault	X	X	
28	Brake check failed	(X)	(X)	
29	Heatsink temp	X	X	X
30	Motor phase U missing	(X)	(X)	(X)
31	Motor phase V missing	(X)	(X)	(X)
32	Motor phase W missing	(X)	(X)	(X)
33	Inrush fault		X	X
34	Fieldbus communication fault	X	X	
36	Mains failure	X	X	
38	Internal fault		X	X
39	Heatsink sensor		X	X
40	Overload of Digital Output Terminal 27	(X)		
41	Overload of Digital Output Terminal 29	(X)		
42	Overload of Digital Output on X30/6 or Overload of Digital Output on X30/7	(X)		
46	Power card supply		X	X
47	24 V supply low	X	X	X
48	1.8 V supply low		X	X
49	Speed limit	X		
50	AMA calibration failed		X	
51	AMA check U_{nom} and I_{nom}		X	
52	AMA low I_{nom}		X	
53	AMA motor too big		X	
54	AMA motor too small		X	
55	AMA parameter out of range		X	
56	AMA interrupted by user		X	
57	AMA time-out		X	
58	AMA internal fault	X	X	
59	Current limit	X		
60	External interlock	X		
61	Encoder loss	(X)	(X)	
62	Output frequency at maximum limit	X	X	
63	Mechanical brake low		(X)	
64	Voltage limit	X		
65	Control board overtemperature	X	X	X
66	Heatsink temperature low	X		
67	Option configuration has changed		X	
68	Safe stop activated	(X)	(X) ¹⁾	
69	Power card temperature		X	X
70	Illegal FC configuration			X
71	PTC 1 safe stop	X	X	
72	Dangerous failure	X	X	X
73	Safe stop auto restart	X		
79	Illegal PS config		X	X
80	Drive initialised to default value		X	
81	CSIV corrupt		X	
82	CSIV parameter error		X	
90	Encoder loss	(X)	(X)	
91	Analog input 54 wrong settings			X
92	No flow	(X)	(X)	
93	Dry pump	(X)	(X)	
94	End of curve	(X)	(X)	
95	Broken belt	(X)	(X)	
96	Start delayed	(X)		
97	Stop delayed	(X)		
98	Clock fault	X		
100-199	See Operating Instructions for MCO 305			
200	Fire mode	(X)		
201	Fire mode was active	(X)		
202	Fire mode limits exceeded	(X)		
243	Brake IGBT	X	X	
244	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 type code		X	X

Table 4.3: Alarm/warning code list

(X) Programmable: dependent on parameter setting.

¹⁾ Cannot be auto reset via parameter selection.

<i>LED indication</i>	
Warning	yellow
Alarm	flashing red
Trip locked	yellow and red

WARNING 1, 10 volts low

The control card voltage is below 10 V from terminal 50.

Remove some of the load from terminal 50, as the 10 V supply is overloaded. Max. 15 mA or minimum 590 Ω.

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

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

WARNING/ALARM 2, Live zero error

This warning or alarm will only appear if programmed by the user in par. 6-01 *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. MCB 101 terminals 11 and 12 for signals, terminal 10 common. MCB 109 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.

Perform the Input Terminal Signal Test in Section 6.3.16.

WARNING/ALARM 3, No motor

No motor has been connected to the output of the frequency converter. This warning or alarm will only appear if programmed by the user in par. 1-80 *Function at Stop*.

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

WARNING/ALARM 4, Mains phase loss

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

Troubleshooting: Check the supply voltage and supply currents to the frequency converter. See Section 5.1.2 for troubleshooting details.

WARNING 5, DC link voltage high

The intermediate circuit voltage (DC) is higher than the high voltage warning limit. The limit is dependent on the frequency converter voltage rating. The frequency converter is still active.

See ratings table in Section 1.9 for the voltage limits.

WARNING 6, DC link voltage low

The intermediate circuit voltage (DC) is lower than the low voltage warning limit. The limit is dependent on the frequency converter voltage rating. The frequency converter is still active.

See ratings table in Section 1.9 for the voltage limits.

WARNING/ALARM 7, DC overvoltage

If the intermediate circuit voltage exceeds the limit, the frequency converter trips after a time.

Troubleshooting:

- Connect a brake resistor
- Extend the ramp time
- Change the ramp type

Activate functions in par. 2-10 *Brake Function*

Increase par. 14-26 *Trip Delay at Inverter Fault*

See ratings table in Section 1.9 for the voltage limits. See Section 5.1.1 for troubleshooting details.

WARNING/ALARM 8, DC undervoltage

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

See ratings table in Section 1.9 for the voltage limits.

Troubleshooting:

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

Perform Input voltage test (Section 6.3.2)

Perform soft charge and rectifier circuit test (Section 6.2.1 or 6.2.3)

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. The frequency converter *cannot* be reset until the 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 LCP with the frequency converter rated current.

Compare the output current shown on the LCP with measured motor current.

Display the Thermal Drive Load on the LCP 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.

Note: See the derating section in the Design Guide for more details if a high switch frequency is required.

WARNING/ALARM 10, Motor overload temperature

According to the electronic thermal protection (ETR), the motor is too hot. Select whether the frequency converter should give a warning or an alarm when the counter reaches 100% in par. 1-90 *Motor Thermal Protection*. The fault is that the motor is overloaded by more than 100% for too long.

Troubleshooting:

Check if motor is overheating.

If the motor is mechanically overloaded

That the motor par. 1-24 *Motor Current* is set correctly.

Motor data in parameters 1-20 through 1-25 are set correctly.

The setting in par. 1-91 *Motor External Fan*.

Run AMA in par. 1-29 *Automatic Motor Adaptation (AMA)*.

WARNING/ALARM 11, Motor thermistor overtemp

The thermistor or the thermistor connection is disconnected. Select whether the frequency converter gives a warning or an alarm when the counter reaches 100% in par. 1-90 *Motor Thermal Protection*.

Troubleshooting:

Check if motor is overheating.

Check 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. 1-93 *Thermistor Resource* matches sensor wiring.

If using a KTY sensor, check the programming of parameters 1-95, 1-96, and 1-97 match sensor wiring.

WARNING/ALARM 12, Torque limit

The torque is higher than the value in par. 4-16 *Torque Limit Motor Mode* (in motor operation) or the torque is higher than the value in par. 4-17 *Torque Limit Generator Mode* (in regenerative operation). par. 14-25 *Trip Delay at Torque Limit* can be used to change this from a warning only condition to a warning followed by an alarm.

See section 5.1 for troubleshooting.

WARNING/ALARM 13, Overcurrent

The inverter peak current limit (approx. 200% of the rated current) is exceeded. The warning lasts about 1.5 sec., then the frequency converter trips and issues an alarm. If extended mechanical brake control is selected, trip can be reset externally.

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 parameters 1-20 through 1-25.

See section 1.9 for current trip points.

ALARM 14, Earth (ground) 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.

See section 1.9 for trip levels.

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.

Perform the current sensor test (section 6.3.14).

See section 5.2 for more details.

ALARM 15, Hardware mismatch

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

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

par. 15-40 *FC Type*

par. 15-41 *Power Section*

par. 15-42 *Voltage*

par. 15-43 *Software Version*

par. 15-45 *Actual Typecode String*

par. 15-49 *SW ID Control Card*

par. 15-50 *SW ID Power Card*

par. 15-60 *Option Mounted*

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

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.

See section 1.9 for trip levels.

WARNING/ALARM 17, Control word time-out

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

Troubleshooting:

- Check connections on the serial communication cable.
- Increase par. 8-03 *Control Word Timeout Time*
- Check the operation of the communication equipment.
- Verify a proper installation based on EMC requirements. See section 5.

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.

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. 14-53 *Fan Monitor* ([0] Disabled).

For the D, E, and F Frame frequency converters, the regulated voltage to the fans is monitored.

Troubleshooting:

- Check fan resistance (see section 6.2.9 or 6.2.10).
- Check soft charge fuses (see section 6.2.1 or 6.2.3).

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. 14-53 *Fan Monitor* ([0] Disabled).

For the D, E, and F Frame frequency converters, the regulated voltage to the fans is monitored.

Troubleshooting:

- Check fan resistance (see section 6.2.9 or 6.2.10).
- Check soft charge fuses (see section 6.2.1 or 6.2.3).

WARNING 25, Brake resistor short circuit

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. 2-15 *Brake Check*).

WARNING/ALARM 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 seconds, on the basis of the resistance value of the brake resistor, 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. 2-13 *Brake Power Monitoring*, the frequency converter cuts out and issues this alarm, when the dissipated braking power is higher than 100%.



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

WARNING/ALARM 27, Brake chopper fault

The brake transistor is monitored during operation and if it short-circuits, the brake function disconnects and issues a warning. 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.

WARNING/ALARM 28, Brake check failed

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

Check par. 2-15 *Brake Check*.

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 D, E, and F Frame frequency converters, this alarm is based on the temperature measured by the heatsink sensor mounted inside the IGBT modules. For the F Frame frequency converters, this alarm can also be caused by the thermal sensor in the rectifier module. See the rating table in Section 1.9 for the trip point.

Troubleshooting:

- Check fan resistance (see section 6.2.9 or 6.2.10).
- Check soft charge fuses (see section 6.2.1 or 6.2.3).
- IGBT thermal sensor (see section 6.2.8).

ALARM 30, Motor phase U missing

Motor phase U between the frequency converter and 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.

WARNING/ALARM 34, Fieldbus communication fault

The fieldbus on the communication option card is not working.

WARNING/ALARM 35, Out of frequency range:

This warning is active if the output frequency has reached the high limit (set in parameter 4-53) or low limit (set in parameter 4-52). In *Process Control, Closed Loop*, par. 1-00 *Configuration Mode* this warning is displayed.

WARNING/ALARM 36, Mains failure

This warning/alarm is only active if the supply voltage to the frequency converter is lost and par. 14-10 *Mains Failure* is NOT set to OFF. Check the fuses to the frequency converter

ALARM 38, Internal fault

It may be necessary to contact your Danfoss supplier. Some typical alarm messages:

0	Serial port cannot be initialised. Serious hardware failure	1792	DSP watchdog is active. Debugging of power part data Motor Orientated Control data not transferred correctly
256-258	Power EEPROM data is defect or too old	2049	Power data restarted
512	Control board EEPROM data is defect or too old	2064-2072	H081x: option in slot x has restarted
513	Communication time out reading EEPROM data	2080-2088	H082x: option in slot x has issued a power up-wait
514	Communication time out reading EEPROM data	2096-2104	H083x: option in slot x has issued a legal power up-wait
515	Application Orientated Control cannot recognise the EEPROM data	2304	Could not read any data from power EEPROM
516	Cannot write to the EEPROM because a write command is on progress	2305	Missing SW version from power unit
517	Write command is under time out	2314	Missing power unit data from power unit
518	Failure in the EEPROM	2315	Missing SW version from power unit
519	Missing or invalid Barcode data in EEPROM	2316	Missing io_statepage from power unit
783	Parameter value outside of min/max limits	2324	The power card configuration is determined to be incorrect at power up.
1024-1279	A CAN telegram that must be sent, couldn't be sent	2325	A power card has stopped communicating while main power is applied
1281	Digital Signal Processor flash time-out	2326	The power card configuration is determined to be incorrect after the power card register delay.
1282	Power micro software version mismatch	2327	Too many power card locations have been registered as present.
1283	Power EEPROM data version mismatch	2330	Power size information between the power cards does not match.
1284	Cannot read Digital Signal Processor software version	2561	No communication from DSP to ATACD
1299	Option SW in slot A is too old	2562	No communication from ATACD to DSP (state running)
1300	Option SW in slot B is too old	2816	Stack overflow of control board module
1301	Option SW in slot C0 is too old	2817	Scheduler slow tasks
1302	Option SW in slot C1 is too old	2818	Fast tasks
1315	Option SW in slot A is not supported (not allowed)	2819	Parameter thread
1316	Option SW in slot B is not supported (not allowed)	2820	LCP Stack overflow
1317	Option SW in slot C0 is not supported (not allowed)	2821	Serial port overflow
1318	Option SW in slot C1 is not supported (not allowed)	2822	USB port overflow
1379	Option A did not respond when calculating Platform Version.	2836	cflistMempool too small
1380	Option B did not respond when calculating Platform Version.	3072-5122	Parameter value is outside its limits
1381	Option C0 did not respond when calculating Platform Version.	5123	Option in slot A: Hardware incompatible with control board hardware
1382	Option C1 did not respond when calculating Platform Version.	5124	Option in slot B: Hardware incompatible with control board hardware
1536	An exception in the Application Orientated Control is registered. Debug information written in LCP	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. 5-00 *Digital I/O Mode* and par. 5-01 *Terminal 27 Mode*.

WARNING 41, Overload of Digital Output Terminal 29

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

WARNING 42, Overload of Digital Output on X30/6 or Overload of Digital Output on X30/7

For X30/6, check the load connected to X30/6 or remove the short-circuit connection. Check par. 5-32 *Term X30/6 Digi Out (MCB 101)*.

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

ALARM 46, Power card supply

The supply on the power card is out of range.

There are three power supplies generated by the switch mode power supply (SMPS) on the power card: 24 V, 5V, +/- 18V. When powered with 24 VDC with the MCB 107 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 24 VDC is measured on the control card. The external 24 VDC backup power supply may be overloaded, otherwise contact your Danfoss 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.

WARNING 49, Speed limit

The speed is not within the specified range in par. 4-11 *Motor Speed Low Limit [RPM]* and par. 4-13 *Motor Speed High Limit [RPM]*.

ALARM 50, AMA calibration failed

Contact your Danfoss supplier.

ALARM 51, AMA check Unom and Inom

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

ALARM 52, AMA low Inom

The motor current is too low. Check the settings.

ALARM 53, AMA motor too big

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

ALARM 54, AMA motor too small

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

ALARM 55, AMA parameter out of range

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

ALARM 56, AMA interrupted by user

The AMA has been interrupted by the user.

ALARM 57, AMA time-out

Try to start the AMA again a number of times, until the AMA is carried out. Please note that repeated runs may heat the motor to a level where the resistances R_s and R_r are increased. In most cases, however, this is not critical.

ALARM 58, AMA internal fault

Contact your Danfoss supplier.

WARNING 59, Current limit

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

WARNING 60, External interlock

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

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. 4-30 *Motor Feedback Loss Function*, error setting in par. 4-31 *Motor Feedback Speed Error*, and the allowed error time in par. 4-32 *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. 4-19 *Max Output Frequency*

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 overtemperature

Control card overtemperature: The cutout 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 the ratings table in Section 1.9 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 (see section 6.2.8).

ALARM 67, Option module configuration has changed

One or more options have 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 VDC to terminal 37, then send a reset signal (via bus, digital I/O, or by pressing the reset key. See par. 5-19 *Terminal 37 Safe Stop*.

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 FC Configuration

The current control board and power board combination is illegal.

WARNING/ALARM 71, PTC 1 safe stop

Safe Stop has been activated from the MCB 112 PTC thermistor card (motor too warm). Normal operation can be resumed when the MCB 112 applies 24 V DC to T-37 again (when the motor temperature reaches an acceptable level) and when the digital input from the MCB 112 is deactivated. When this happens, a reset signal is sent (via serial communication, digital I/O, or by pressing reset button on LCP). Note that if automatic restart is enabled, the motor may start when the fault is cleared.

ALARM 72, Dangerous failure

Safe stop with trip lock. Unexpected signal levels on the safe stop and digital input from the MCB 112 PTC thermistor card.

Warning 73, Safe stop auto restart

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

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, Drive initialised to default value

Parameter settings are initialised to default settings after a manual 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 22-2*.

ALARM 93, Dry pump

A no-flow situation and high speed indicate that the pump has run dry. See parameter group 22-2*.

ALARM 94, End of curve

Feedback stays lower than the setpoint which may indicate leakage in the pipe system. See parameter group 22-5*.

ALARM 95, Broken belt

Torque is below the torque level set for no load, indicating a broken belt. See parameter group 22-6*.

ALARM 96, Start delayed

Motor start has been delayed due to short-cycle protection active. See parameter group 22-7*.

WARNING 97, Stop delayed

Stopping the motor has been delayed due to short cycle protection is active. See parameter group 22-7*.

WARNING 98, Clock fault

Clock Fault. The time is not set or the RTC clock (if mounted) has failed. See parameter group 0-7*.

WARNING 200, Fire mode

The input command fire mode is active. See parameter group 24-0*.

WARNING 201, Fire mode was active

Fire mode has been active. See parameter group 0-7*.

WARNING 202, Fire mode limits exceeded

One or more warranty voiding alarms have been suppressed during fire mode operation. See parameter group 0-7*.

ALARM 243, Brake IGBT

This alarm is only for F Frame 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 F2 or F4 drive.
- 2 = right inverter module in F1 or F3 drive.
- 3 = right inverter module in F2 or F4 drive.

5 = rectifier module.

ALARM 244, Heatsink temperature

This alarm is only for F Frame 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 F2 or F4 drive.
- 2 = right inverter module in F1 or F3 drive.
- 3 = right inverter module in F2 or F4 drive.
- 5 = rectifier module.

ALARM 245, Heatsink sensor

This alarm is only for F Frame 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 F2 or F4 drive.
- 2 = right inverter module in F1 or F3 drive.
- 3 = right inverter module in F2 or F4 drive.
- 5 = rectifier module.

ALARM 246, Power card supply

This alarm is only for F Frame 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 F2 or F4 drive.
- 2 = right inverter module in F1 or F3 drive.
- 3 = right inverter module in F2 or F4 drive.
- 5 = rectifier module.

ALARM 247, Power card temperature

This alarm is only for F Frame 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 F2 or F4 drive.
- 2 = right inverter module in F1 or F3 drive.
- 3 = right inverter module in F2 or F4 drive.
- 5 = rectifier module.

ALARM 248, Illegal power section configuration

This alarm is only for F frame 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 F2 or F4 drive.
- 2 = right inverter module in F1 or F3 drive.
- 3 = right inverter module in F2 or F4 drive.
- 5 = rectifier module.

ALARM 250, New spare part

The power or switch mode power supply has been exchanged. The frequency converter type code must be restored in the EEPROM. Select the correct type code in par. 14-23 *Typecode Setting* according to the label on the unit. Remember to select 'Save to EEPROM' to complete.

ALARM 251, New type code

The frequency converter has a new type code.

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 Table 3-1.
2. Perform static test procedures 6.2.1., 6.2.2 and 6.2.5 for D-frame size units or 6.2.3, 6.2.4 and 6.2.5 for E-frame size units to ensure frequency converter is safe to start.
3. Disconnect the motor leads from the output terminals (U, V, W) of the frequency converter.
4. Apply AC power to the frequency converter.
5. Give the frequency converter a run command and slowly increase the reference (speed command) to approximately 40 Hz.
6. Using an analog voltmeter or a DVM capable of measuring true RMS, measure phase-to-phase output voltage on all three phases: U to V, U to W, V to W. All voltages must be balanced within 8 volts. If unbalanced voltage is measured, refer to Input Voltage Test (6.3.2).
7. Stop the frequency converter and remove the input power. Allow 40 minutes for DC capacitors to fully discharge for E-frame size frequency converters or 20 minutes for D-frame size frequency converters.
8. Reconnect the motor leads to the frequency converter output terminals (U, V, W).
9. Reapply power and restart the frequency converter. Adjust the motor speed to a nominal level.
10. Using a clamp-on style ammeter, measure the output current on each output phase. All currents should be balanced. If unbalanced current is measured, refer to Current Sensor Test (6.3.14).

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 settings need careful attention.

par. 1-03 *Torque Characteristics* sets the mode in which the frequency converter will operate.

Parameters 1-20 through 1-29 match the frequency converter to the motor and adapt to the motor characteristics.

Parameters 4-17 and 14-25 set the torque control features of the frequency converter for the application.

par. 1-00 *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. 1-03 *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 1-20 through 1-25 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. 1-29 *Automatic Motor Adaptation (AMA)* activates the automatic motor adaptation (AMA) function. When AMA is performed, the frequency converter measures the electrical characteristics of the motor and sets various frequency converter parameters based on the findings. Two key parameter values set by this function are stator resistance and main reactance, parameters 1-30 and 1-35. If unstable motor operation is experienced and AMA has not been performed, it should be done. AMA can only be performed on single motor applications within the programming range of the frequency converter. Consult the Operating Instructions for more on this function.

Parameters 1-30 and 1-35, as stated, should be set by the AMA function, 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. 4-17 *Torque Limit Generator Mode* sets the limit for frequency converter torque. The factory setting is 160% for FC 302 series and 110% for /202 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. 14-25 *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.

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 fieldbus (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 0-2* LCP 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 16-6*.

If there is not a correct indication, the next step is to determine whether the signal is present at the input terminals of the 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 Drive Inputs and Outputs in Section 2.

The frequency converter must be set up correctly for the motor(s) connected to it. Parameters 1-20 – 1-25 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 automatic motor adaptation (AMA) 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 3-0* parameter group.

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 5-0* and 6-0* 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.

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. See Output Imbalance of Supply Voltage Test procedure.

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. Perform the output imbalance of supply voltage test procedure (6.3.10) on all three phases with an analog voltmeter. 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. Perform the IGBT gate signal test (6.3.11).

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

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

5

5.2.2 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 half way 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 display of the frequency converter. With the motor disconnected, the current should, of course, be zero. A frequency converter with a defective current sensor will indicate some current flow. Because the current sensors for the higher horsepower frequency converters have less resolution, an indication of a fraction of an amp on a frequency converter is tolerable. However, that value should be considerably less than one amp. Therefore, 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 of each current sensor. See the current sensor test procedure.

5.2.3 Signal and Power Wiring Considerations for Frequency Converter Electromagnetic Compatibility

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. Only certain high-frequency phenomena (RF emissions, RF immunity) are discussed. Low-frequency phenomena (harmonics, mains voltage imbalance, notching) are not covered. Special installations or compliance to the European CE EMC directives will require strict adherence to relevant standards and are not discussed here.

5.2.4 Effect of EMI

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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

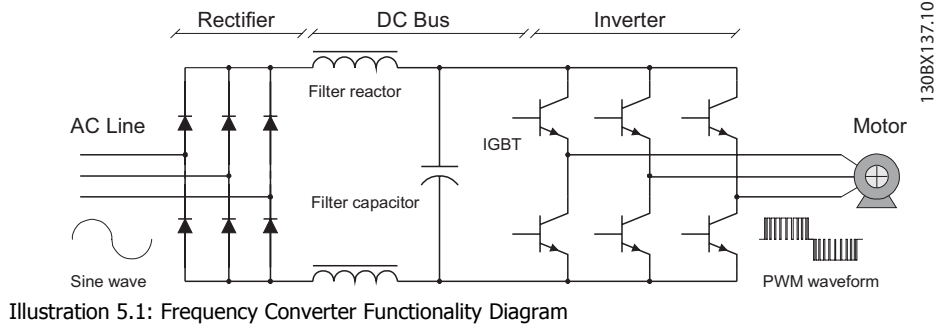
A disturbance resulting from other nearby equipment is more common. Generally, other industrial control equipment has a high level of EMI immunity. However, non-industrial, commercial, and consumer equipment is often susceptible to lower levels of EMI. Detrimental effects to these systems may include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

5.2.5 Sources of EMI

Modern frequency converters (see Illustration 5-1) 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.



5.2.6 EMI Propagation

Frequency converter generated EMI is both conducted to the mains and radiated to nearby conductors. See Illustrations 5-2 and 5-3.

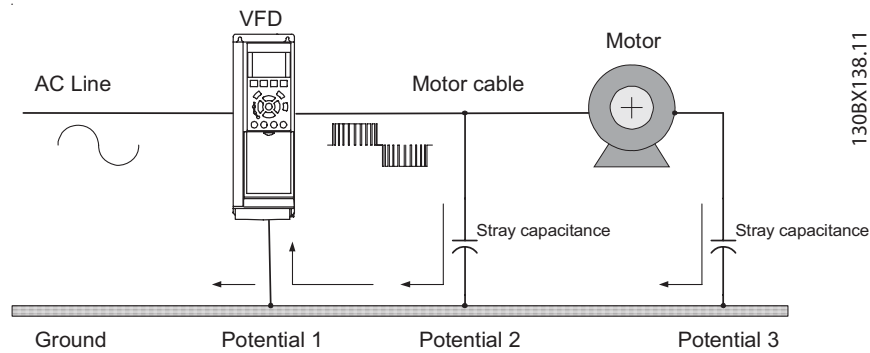


Illustration 5.2: Earth Currents

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.

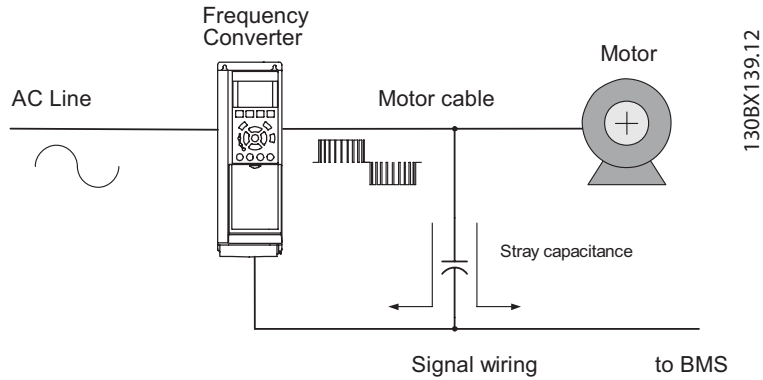


Illustration 5.3: Signal Conductor Currents

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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 Illustration 5-4.

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.

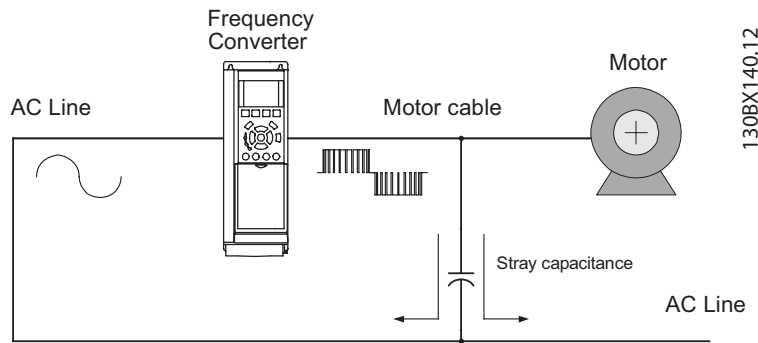


Illustration 5.4: Alternate Signal Conductor Currents

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

5.2.7 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 through 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 2.8, 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.

5.2.8 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.

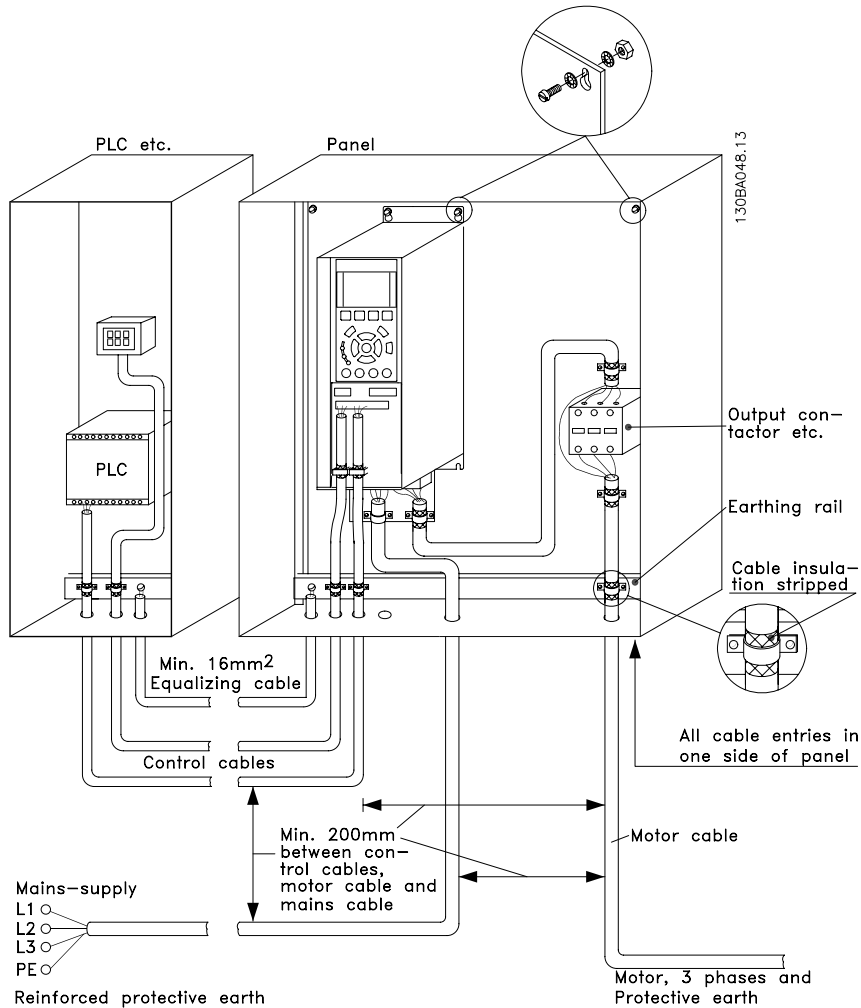


Illustration 5.5: Proper EMC Installation

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 20 minutes for D-frame sizes or 40 minutes for E-frame sizes after power has been removed before touching any internal components to ensure that capacitors have fully discharged. See label on front of frequency converter door for specific discharge time.

This section contains detailed procedures for testing 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. Sections 7 and 8, Disassembly and Assembly Instructions, describes detailed procedures for removing and replacing frequency converter components, as required (D- or E-sized frequency converters, respectively).

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



For dynamic test procedures, main input power is required. 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.

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

Both D-frame and E-frame size frequency converters are covered here. Differences in the procedures are noted, as required. However, the Soft Charge and Rectifier Circuit Test, Soft Charge Rectifier Test, and Fan Continuity Test sections are independent for D-frame and E-frame frequency converters.

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 Drive Tests*.



6.1.1 Tools Required for Testing

- Digital volt/ohm meter capable of reading real RMS
- Analog volt meter
- Oscilloscope
- Clamp-on style ammeter
- Signal test board p/n 176F8437
- Test cable p/n 176F8439

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 connector MK104 on the power card. Its use is described in the procedures where called out. See *Signal Test Board* in Section 9, *Special Test Equipment*, for detailed pin descriptions.

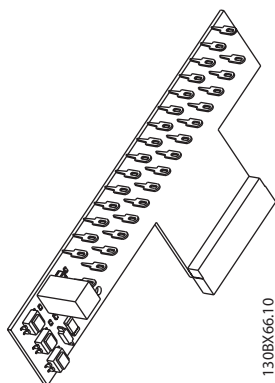


Illustration 6.1: Signal Test Board

6.1.3 Test Cables

The test cables bypass the main DC bus capacitors and supply DC voltage to the power card from the soft charge card. This provides voltage for testing the power card without the frequency converter circuitry being powered. The SCR shorting plug ensures that the SCRs do not fire. There are two cable types, the D-frame frequency converters use the 2-pin cable and the E-frame frequency converters use the 3-pin cable (see the illustrations below). The D-frame cable connects to the wire harness above the power card by the SMPS fuse to the power card connector MK105. The E-frame connects between the soft charge connector MK3 and the power card connector MK105.

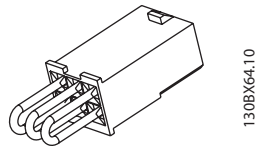


Illustration 6.2: SCR Shorting Plug



Illustration 6.3: Two-Pin D-frame Test Cable



Illustration 6.4: Three-Pin E-frame Test Cable

6.2 Static Test Procedures

All tests should be made with a meter capable of testing diodes. Use a digital volt/ohmmeter (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.

Illustration 6-3 Power Card PCA Connector Identification is provided as a reference for finding the appropriate connectors described in the test procedures in this section. Some connectors are optional and not on all frequency converter configurations.



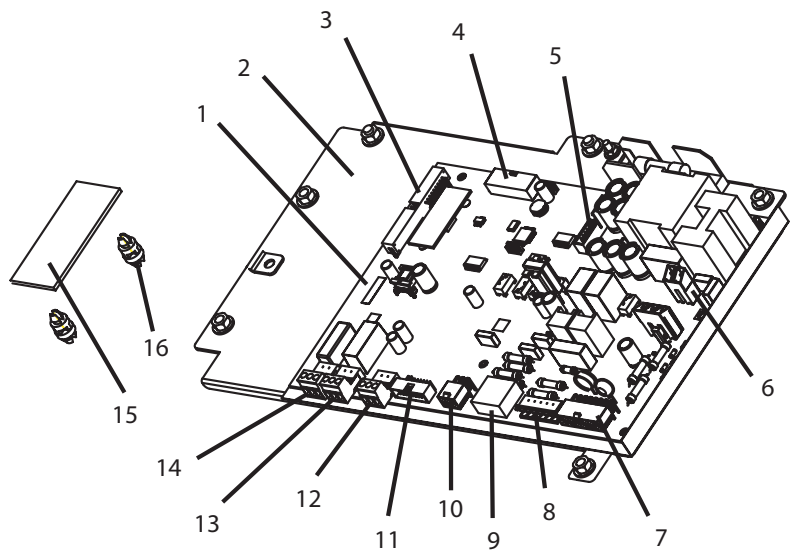
NB!

For best troubleshooting results, it is recommended that static test procedures described in this section be performed in the order presented.

6

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 .300 to .500. The opposite reading is referred to as infinity and most DMVs will display the value OL for overload.



130BX172.10

Illustration 6.5: Power Card, and Mounting Plate

380–480/500V: Yellow tape on the main SMPS transformer in the upper right corner.

525–690V: White tape on the main SMPS transformer in the upper right corner.

1	Power card PCA3	9	MK106
2	Mounting plate	10	MK100
3	MK110	11	MK109
4	MK102	12	FK102
5	MK104	13	MK112 terminals 4, 5, 6
6	MK105	14	MK112 terminals 1, 2, 3
7	MK107	15	Scaling card
8	FK103	16	Scaling card standoff

6.2.1 Soft Charge and Rectifier Circuits Test: D-frame size

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 frequency converter. 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.

Prior to performing the test, it is necessary to ensure the soft charge fuses, F1, F2, and F3, located on the soft charge card, are good.

Illustration 6-4 shows the soft charge card and the location of the fuses. It is for reference only. It is not necessary to remove the card to perform the tests.

Soft charge fuse test

Use a digital ohmmeter to test continuity on rectifier fuses F1, F2, and F3 at connector MK106 on the power card.



NB!

If the unit has fused disconnect option, make test connections L1, L2, and L3 to the output (drive) side of the disconnect. Do not unplug the connector.

1. Measure fuse F1 from the mains input L1 (R) to MK106 pin 10 on the power card.
2. Measure fuse F2 from the mains input L2 (S) to MK106 pin 8 on the power card.
3. Measure fuse F3 from the mains input L3 (T) to MK106 pin 6 on the power card.

A measurement of 0 ohms indicates good continuity. Replace any open fuse (infinite resistance).

To replace a soft charge fuse, follow the soft charge disassembly instructions in Section 7.

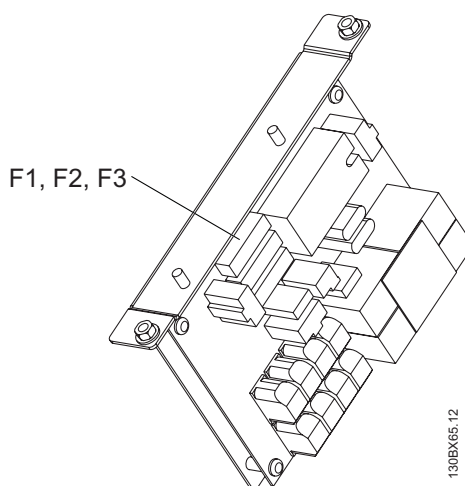


Illustration 6.6: Soft Charge Card Fuses

380–480/500V: Blue MOV & 8 PTCs

525–690V: Red MOV & 6 PTCs.

Main rectifier circuit test part I

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

Each reading should show infinity. The meter will start at a low value and slowly climb towards infinity due to capacitance within the frequency converter 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, perform the Soft Charge Rectifier Test.

Main rectifier circuit test part II

1. Reverse meter leads by connecting the negative (–) meter lead to the positive (+) DC bus connector MK105 (A) on the power card.
2. Connect the positive (+) meter lead to L1, L2, and L3 in sequence. 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, perform the Soft Charge Fuse Test and Soft Charge Rectifier Test.

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, perform the Soft Charge Rectifier Test.

Main rectifier circuit test part III

1. Connect the positive (+) meter lead to the negative (–) DC bus connector MK105 (B) on the power card.
2. Connect the negative (–) meter lead to terminals L1, L2 and L3 in sequence. 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, perform the Soft Charge Rectifier Test.

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 the negative (–) meter lead to the negative (–) DC bus connector MK105 (B) on the power card.
2. Connect the positive (+) meter lead to L1, L2 and L3 in sequence. 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 frequency converter 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, perform the Soft Charge Rectifier Test, 6.2.2.

6.2.2 Soft Charge Rectifier Test: D-frame size

Testing the soft charge rectifier requires access to the soft charge card connectors. It requires removing the control card and power card mounting plate. Refer to removal instructions for soft charge card in Section 7.

Do not remove the soft charge card completely or unplug any connectors not called out. Doing so will break the continuity path of these measurements and may result in a false interpretation of a failure. 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.



1. Extract the soft charge card far enough to access the connectors.
2. Disconnect the DC cable at the connector MK3.

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

3. Measure the resistance between pins A and B of connector MK4 on the soft charge card. It should read 27 ohms (±10%) for 380–500V frequency converters and 68 ohms (±10%) for 525–690V. A reading outside this range indicates a defective soft charge resistor. Replace the resistor in accordance with disassembly procedures in Section 7. 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.

4. 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.

An incorrect reading here indicates the soft charge rectifier is shorted. The rectifier is not serviced as a component. Replace the entire soft charge card in accordance with the disassembly procedures in Section 7.

5. 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.
6. 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.

An incorrect reading here indicates the soft charge rectifier is shorted. The rectifier is not serviced as a component. Replace the entire soft charge card in accordance with the disassembly procedures in Section 7.

7. 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.

If all tests indicate correctly while isolating between the SCR/diode modules and the soft charge card, the SCR/diode modules are suspect. Before reconnecting the cable at MK3, return to the Main Rectifier tests and repeat those tests. Put the power card temporarily back in place to retest the main rectifier. Replace any defective assemblies in accordance with the disassembly procedures in Section 7.

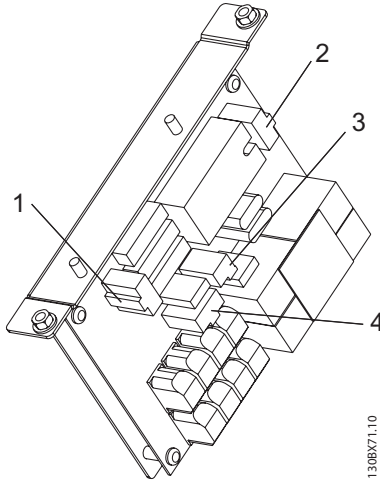


Illustration 6.7: Soft Charge Card Connectors

380–480/500V: Blue MOV & 8 PTCs

525–690V: Red MOV & 6 PTCs.

1	MK1	3	MK4
2	MK2	4	MK3

6.2.3 Soft Charge and Rectifier Circuits Test: E-frame sizes

For E-frame size frequency converters, the rectifier and soft charge circuits are tested separately. 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 and diode modules. The soft charge resistor limits the inrush current when power is applied to the frequency converter. The soft charge circuit card also provides snubbing for the SCRs.

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.

Prior to performing the test, it is necessary to ensure the soft charge fuses, F1, F2, and F3, located on the soft charge card, are good. An open fuse could indicate a problem in the soft charge circuit. Continue test procedures.

Illustration 6-6 shows the soft charge card and the location of the fuses. It is for reference only. It is not necessary to remove the card to perform the tests.

Disconnect the MK3 from the soft charge card and leave disconnected until completion of soft charge and rectifier tests.

Soft charge fuse test

Use a digital ohmmeter to test continuity on rectifier fuses F1, F2, and F3 on the soft charge card.

1. Measure F1 across fuse. Open reading indicates open (blown) fuse.
2. Measure F2 across fuse. Open reading indicates open (blown) fuse.
3. Measure F3 across fuse. Open reading indicates open (blown) fuse.

A measurement of 0 ohms indicates good continuity. Replace any open fuse (infinite resistance).

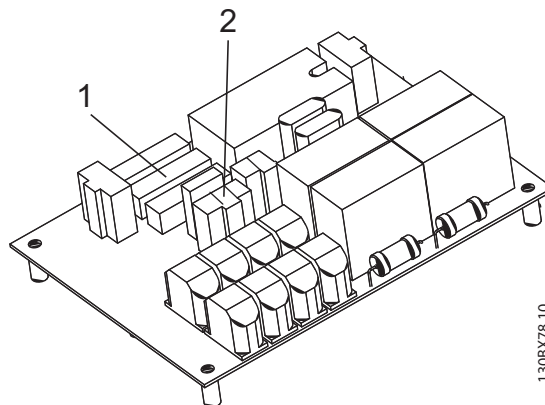


Illustration 6.8: Soft Charge Card Fuse Location

380–480/500V: Blue MOV and 8 PTCs.

525–690V: Red MOV and 6 PTCs.

1	Fuses F1, F2 and F3	2	MK3 (disconnect for soft charge and rectifier tests)
---	---------------------	---	--

Main rectifier circuit test E-frames part I

1. Connect the positive (+) meter lead to the positive (+) DC bus connector MK105 (A) on the power card.
2. Connect the negative (-) meter lead to terminals L1, L2, and L3 in sequence. If a disconnect option is used, measure on top side of fuses.

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

Incorrect reading

With the Part I test connection, the SCR modules are blocking current flow. A short indicates a shorted SCR module.

Main rectifier circuit test E-frames part II

1. Reverse meter leads by connecting the negative (-) meter lead to the positive (+) DC bus connector MK105 (A) on the power card.
2. Connect the positive (+) meter lead to L1, L2, and L3 in sequence. Each reading should show open.

Incorrect reading

With the Part II test connection, the SCR modules are blocking current flow. A short indicates a shorted SCR module.

Main rectifier circuit test E-frames part III

1. Connect the positive (+) meter lead to the negative (-) DC bus connector MK105 (B) on the power card.
2. Connect the negative (-) meter lead to terminals L1, L2 and L3 in sequence. Each reading should show a diode drop.

Incorrect reading

With the Part III test connection, the diodes in the main rectifier diode modules are forward biased. The meter reads the diode drops. If a short circuit or an open circuit exists, the diode module is damaged.

Main rectifier circuit test E-frames part IV

1. Reverse meter leads by connecting the negative (-) meter lead to the negative (-) DC bus connector MK105 (B) on the power card.
2. Connect the positive (+) meter lead to L1, L2 and L3 in sequence. 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 frequency converter being charged by the meter.

Incorrect reading

With the Part IV test connection, the diodes in the main diode modules are reversed biased. If a short circuit exists, the diode module is damaged.

Continue to Soft Charge Rectifier Tests: E-frames.

6.2.4 Soft Charge Rectifier Test: E-frame size

The DC cable at connector MK3 remains disconnected for this procedure.

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 ohms ($\pm 10\%$) for 380–500 V frequency converters or 68 ohms ($\pm 10\%$) 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 in Section 8. 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.

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 in Section 8.

Reconnect the MK3 on the soft charge card after these tests.

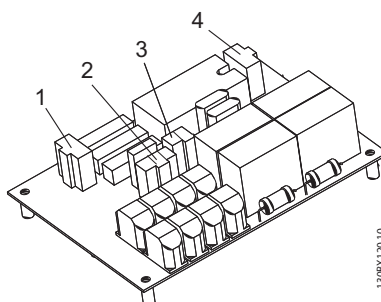


Illustration 6.9: Soft Charge Card Connectors

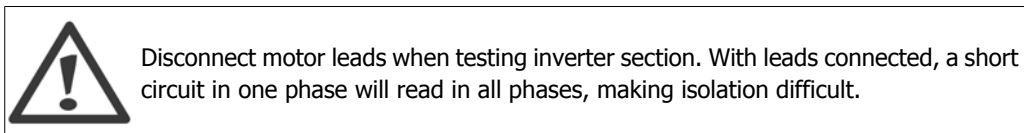
380–480/500V: Blue MOV and 8 PTCs.

525–690V: Red MOV and 6 PTCs.

1	MK1	3	MK4
2	MK3	4	MK2

6.2.5 Inverter Section Tests

The inverter section is primarily made up of the IGBTs used for switching the DC bus voltage to create the output to the motor. IGBTs are grouped into modules comprised of six IGBTs. Depending on the size of the unit, either one, two, or three IGBT modules are present. The frequency converter also has 3 snubber capacitors on each IGBT module.



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

6

Inverter test part

1. Connect the positive (+) meter lead to the (+) positive DC bus connector MK105 (A) on the power card.
2. Connect the negative (-) meter lead to terminals 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.

Inverter test part II

1. Reverse the meter leads by connecting the negative (-) meter lead to the positive (+) DC bus connector MK105 (A) on the power card.
2. Connect the positive (+) meter lead to 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 module. Replace the IGBT module according to the disassembly instructions in Section 7 or 8. It is further recommended for units with two IGBT modules that both modules be replaced even if the second module tests correctly.

Inverter test part III

1. Connect the positive (+) meter lead to the negative (-) DC bus connector MK105 (B) on the power card.
2. Connect the negative (-) meter lead to 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 connector MK105 (B) on the power card.
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 IGBT module. Replace the IGBT module according to the disassembly instructions in Section 7 or 8. It is further recommended for units with two IGBT modules that both modules be replaced even if the second module tests correctly.

Indications of a failure in this circuit

IGBT failures may be caused by the frequency converter being exposed to repeated short circuits or earth faults, or by extended frequency converter operation outside of its normal operating parameters. Following an IGBT failure, it is important to verify the gate frequency converter signals are present and of the correct waveform. See the dynamic test section on checking IGBT gate drive signals.

Gate resistor test

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

Located on the gate drive card near each of the gate signal leads is a 3 pin test connector (see Illustration 6-17). These are labelled MK 250, 350, 450, 550, 650, 750, and, if the frequency converter is equipped with a brake option, 850.

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

1. With ohmmeter, measure pins 1 and 2 of each test connector. Reading should indicate 7.8K ohms for D1/D3 Frames, 3.9K ohms for D2/D4 Frames, and 2.6K ohms for E1/E2 frames.

Incorrect reading

An incorrect reading indicates that either the gate signal wires are not connected from the gate drive card to the gate resistor board or the gate resistors are defective. Connect the gate signal wires, or if the resistors are defective, the entire IGBT module assembly requires replacement. Replace the IGBT module according to the disassembly procedures in Section 7 or 8.

6.2.6 Brake IGBT Test

This test can only be carried out on units equipped with a dynamic brake option. If a brake resistor is connected to terminals 81 and 82, disconnect it before proceeding. Use an ohmmeter set on diode check or Rx100 scale.

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 connector MK105 (B) on the power card.

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 that the brake IGBT is defective. Replace the brake IGBT in accordance with the disassembly procedures in Section 7 or 8.

The failure of any IGBT may also lead to a failure of the gate drive circuit supplying that device. Following the replacement of an IGBT, always ensure the gate drive signals are tested in accordance with the procedures in the dynamic test section.

6.2.7 Intermediate Section Tests

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

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

Incorrect reading

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

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

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

There is not an effective test of the capacitor bank when it is fully assembled. Although it is unlikely that a failure within the capacitor bank would not be indicated by a physically damaged capacitor, if suspect, the entire capacitor bank must be replaced. Replace the capacitor bank in accordance with the disassembly procedures in Section 7 or 8.

6.2.8 Heatsink Temperature Sensor Test

The temperature sensor is an NTC (negative temperature coefficient) device. As a result, high resistance means low temperature. As temperature decreases, resistance increases. Each IGBT module has a temperature sensor mounted internally. The sensor is wired from the IGBT module to the gate drive card connector MK100. For frequency converters with two IGBTs, the sensor on the right module is used. For frequency converters with three IGBT modules, the centre 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 ohms.
2. Unplug connector MK100 on the gate drive card (see Illustration 6-17) 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 Ohms. At 0° C, the resistance will be approximately 13.7k Ohms. At 60° C, the resistance will be approximately 1.5k Ohms. The higher the temperature, the lower the resistance.

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6.2.9 Fan Continuity Tests: D-frame size

Make all continuity checks using an ohmmeter set to Rx1 scale. Digital or analog ohmmeter can be used.

To aid in making the measurements, unplug the connector CN2 from its mate. CN2 terminals correspond to the terminal numbers labelled on the transformer. Connector CN2 is located near the fan transformer on the input plate. See Illustration 6.10.

Fan Fuse test

1. Test the fan fuse on the input plate by checking the continuity across the fuse.

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

Checking continuity of connections

For the following tests, read the plug end of connector CN2 that is not connected to the transformer.

1. Measure from L3 (T) to CN2 terminal 1. A reading of <1ohm should be indicated.
2. Measure from L2 (S) to CN2 terminal 3. A reading of <1 ohm should be indicated.
3. Measure from CN2 terminal 2 to terminal 12 on the power card connector MK107. A reading of <1 ohm should be indicated.

Incorrect reading

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

Ohm test of transformer (380–500V)

For the following tests, read the plug end of connector CN2 that is connected to the transformer.

1. Measure between CN2 terminals 1 and 3. Approximately 15 ohms should be read.
2. Measure between CN2 terminals 1 and 2. Approximately 12 ohms should be read.
3. Measure between CN2 terminals 2 and 3. Approximately 4 ohms should be read.

Incorrect reading

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

When finished, be sure to reconnect CN2.

Ohm test of transformer (525–690V)

For the following tests, read the plug end of connector CN2 that is connected to the transformer.

1. Measure between CN2 terminals 1 and 3. Approximately 20 ohms should be read.
2. Measure between CN2 terminals 1 and 2. Approximately 8 ohms should be read.
3. Measure between CN2 terminals 2 and 3. Approximately 12 ohms should be read.

Incorrect reading

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

When finished, be sure to reconnect CN2.

Ohm test of fans

1. Measure between terminals 11 and 13 of power card connector MK107. A reading of 20 ohms should be indicated.
2. On IP21 and IP 54 units: Disconnect the spade connectors from the door fan and repeat the measurement. A reading of 21 ohms should be indicated.
3. On IP21 and IP 54 units: Read the door fan terminals with the wires disconnected. A reading of 400 ohms should be indicated.
4. Reconnect the wires to the door fan.

Incorrect reading

An incorrect reading of one or both of the fans indicates a defective fan. Replace the defective fan.

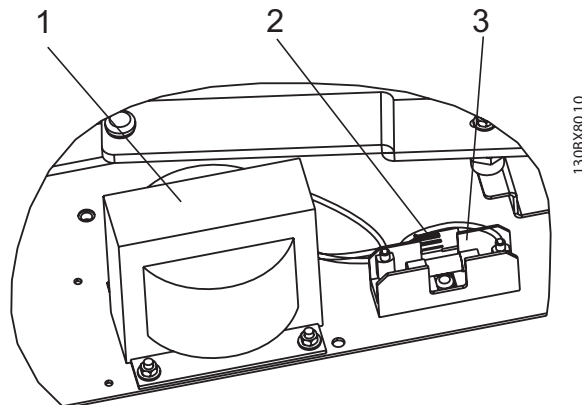


Illustration 6.10: Fan Transformer and Fuse Location

380–480/500V: White label on fan transformer.

525–690V: Orange label on fan transformer.

1	Fan transformer	3	Fan fuse
2	CN2		

6.2.10 Fan Continuity Tests: E-frame size

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 multi-meter. This can be reduced by turning off the auto-ranging function and setting the measurement manually.

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

Checking continuity of connections

For the following tests, read connector MK107 on the power card.

1. Measure from L3 (T) to MK107 terminal 8. Reading of <1ohm should be indicated.
2. Measure from L2 (S) to MK107 terminal 1. Reading of <1 ohm should be indicated.

Incorrect reading

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

Fan fuse test

1. Test the fan fuses on the power card mounting plate by checking the continuity across the fuse.

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

Ohm test of transformer

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

1. Measure between MK107 terminals 1 and 8. Should read approximately value A in Table 6-1.
2. Measure between MK107 terminals 8 and 12. Should read approximately value B in Table 6-1.
3. Measure between MK107 terminals 1 and 12. Should read approximately value C in Table 6-1.

AC Voltage	Drive			Resistance (in Ohms)			Heatsink Fan	Fan Inductor
	FC202	FC 302		A	B	C	D	
380-500	P315	P315	P250	15	12	4	21	no
380-500	P355	P355	P315	4	3	1	4	yes
380-500	P400	P400	P355	4	3	1	4	yes
380-500	P450	P450	P400	4	3	1	4	yes
525-690	P400	P400	P355	20	8	12	21	no
525-690	P500	P500	P400	20	8	12	21	no
525-690	P560	P560	P500	7.4	3.6	3.2	4	yes
525-690	P630	P630	P560	7.4	3.6	3.2	4	yes

Table 6.1: Fan transformer resistance

Incorrect reading

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

When finished, reconnect the MK107.



Ohm test of fans

1. Measure between terminals 3 and 5 of power card connector MK107. It should read approximately value D in Table 6-1.

Incorrect reading

For fans without an inductor, replace the fan. For frequency converters with a fan and inductor, isolate the fault between the fan and the inductor as follows.

- 1a Disconnect CN3 and measure the resistance between pins 1 and 2 on the fan side of the connector. Reading should be approx 4 ohms. If incorrect, replace fan.
- 1b Disconnect CN4 and CN5. Measure the resistance across the inductor. Reading should be less than 1 ohm. If incorrect, replace the inductor.
2. Measure between terminals 11 and 13 of power card connector MK107. For units with one top mounted fan, a reading of 400 ohms is expected. For units with two door mounted fans, a reading of 200 ohms is expected.

Incorrect reading

For units with one top mounted fan, replace the fan. For units with two door mounted fans, isolate the faulty fan as follows.

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

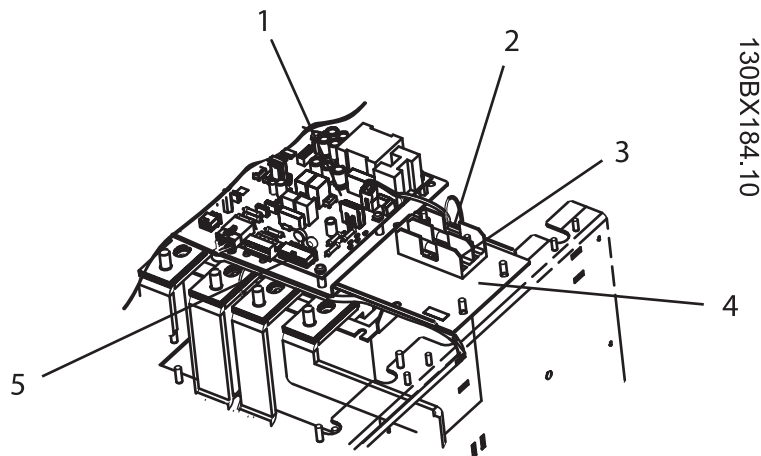




Illustration 6.11: Fan and DC Bus Fuse Locations


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

6.3 Dynamic Test Procedures

Refer to the terminal locations in Illustration 6-10 for performing dynamic test procedures.

 **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.

 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.

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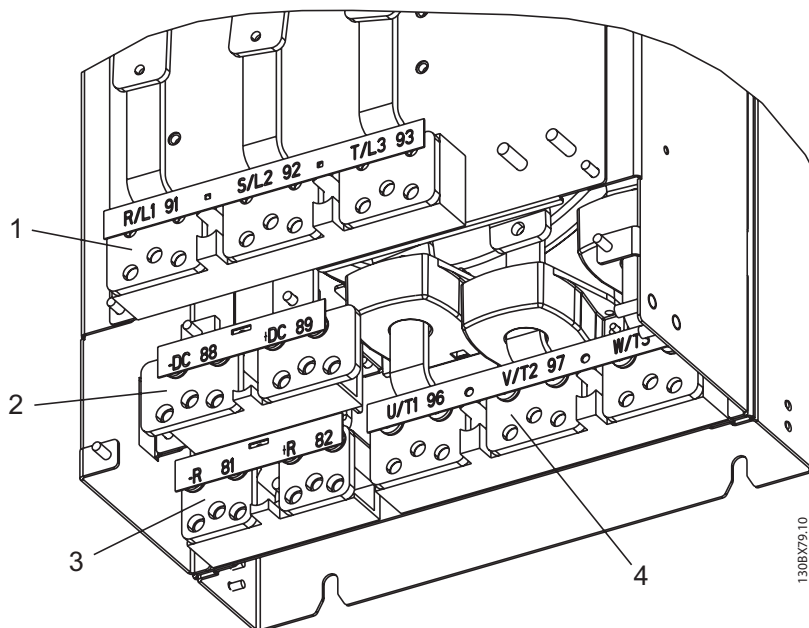


Illustration 6.12: Drive Power Terminals (D-size Frames)

1	Main 3-phase AC power to frequency converter	3	Brake resistor connection
2	DC bus/load sharing connections	4	3-phase output to motor

6.3.1 No Display Test

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

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.

6.3.2 Input Voltage Test

6

1. Apply power to frequency converter.
2. Use the DVM to measure the input mains voltage between the frequency converter input terminals in sequence:
 - L1 to L2
 - L1 to L3
 - L2 to L3

For 380–500 V frequency converters, all measurements must be within the range of 342–550 VAC. Readings of less than 342 VAC indicate problems with the input mains voltage. For 525–690 V frequency converters, all measurements must be within the range of 446–759 VAC. Readings of less than 446 VAC indicate problems with the input mains voltage.

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


Danfoss calculates mains imbalance per an IEC specification.

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

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 V_{max} , 478.5 VAC is V_{min} , and 485.7 VAC is V_{avg} , resulting in an imbalance of 3%.

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

Incorrect reading

	<p>Open (blown) input fuses or tripped circuit breakers usually indicate a more serious problem. Prior to replacing fuses or resetting breakers, perform static tests described in section 6.2.</p>
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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

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

6.3.3 Basic Control Card Voltage Test

1. Measure the control voltage at terminal 12 with respect to terminal 20. The meter should read between 21 and 27 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, then continue. Remember to check the customer connections. If still unsuccessful, proceed to the Switch Mode Power Supply (SMPS) test.

2. Measure the 10 V DC control voltage at terminal 50 with respect to terminal 55. The meter should read between 9.2 and 11.2 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, then continue. Remember to check the customer connections. If still unsuccessful, proceed to the SMPS test.

A correct reading of both control card voltages would indicate the LCP or the control card is defective. Replace the LCP with a known good one. If the problem persists, replace the control card in accordance with the disassembly procedures in Section 7 or 8.

6.3.4 Switch Mode Power Supply (SMPS) Test

The SMPS derives its power from the DC bus. The first indication that the DC bus is charged is the DC bus charge indicator light located on the power card being lit. This LED however can be lit at a voltage still too low to enable the power supplies.

First test for the presence of the DC bus.

1. Using a voltmeter, read DC bus voltage at power card connector MK105 (A) with respect to MK105 (B). The meter should indicate approximately 1.35 x AC input voltage to the frequency converter.
2. If the voltage is correct, proceed to set 3. If voltage is present but out of range, proceed to DC Undervoltage test. If voltage is at zero, proceed to Zero DC Bus Voltage test.
3. Test the remaining power supplies. Insert the signal test board into the power card connector MK104.

- Connect the negative (-) meter lead to terminal 4 (common) of the signal board. With a positive (+) meter lead, check the following terminals on the signal board.

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

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

Red LED +/- 18VDC supplies present

Yellow LED +24VDC supply present

Green LED +5VDC supply present

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The lack of any one of these power supplies indicates the low voltage supplies on the power card are defective. This assumes of course that the proper DC bus voltage was read at power card connector MK105 (A) and (B). Replace the power card in accordance with the disassembly procedures in Section 7 or 8.

6.3.5 Zero DC Bus Voltage Test

If no voltage is present at power card connector MK105 (A) and (B), check the condition of the DC power supply fuse. The fuse is located on the power card mounting plate next to the power card. It can be tested without disassembling the unit.

- Remove power to the frequency converter and make sure the DC bus is fully discharged by measuring the voltage at the power card connector MK105 (A) with respect to MK105 (B).



If the DC power supply fuse is open (blown), it is not possible to detect the presence of bus voltage at these terminals. If uncertain, wait 20 minutes for D-frame sizes or 40 minutes for E-frame sizes to allow the DC bus to fully discharge. See label on front of frequency converter door for specific discharge time.

- With the ohmmeter set on a diode scale or Rx100, measure from power card connector MK105 (A) to any bus bars coming from the DC inductor. Bus bars are visible at the lower edge and beneath the power card mounting bracket. Depending on the bus bar readout, look for a diode drop or a complete short. In either case, this indicates a fuse is in the circuit providing a path for continuity. An open reading indicates an open fuse.

If the fuse is open, it indicates a failure of the power supplies on the power card. The power card and fuse require replacement. If the fuse checks good, there may be a problem with the soft charge circuitry. Proceed to the static checks of the soft charge and rectifier circuits earlier in this section.

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 mains voltage is out of tolerance or the soft charge circuit is restricting the DC bus from charging. Conduct the input voltage test (6.3.2) to ensure the mains 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.

1. Check DC bus voltage by reading power card connector MK105 (A) with respect to MK105 (B). If verified, disconnect the power from the frequency converter and allow it to cool for approximately 20 minutes.
2. Reapply power to the frequency converter after 20 minutes and recheck the DC bus voltage. If voltage remains, a short circuit may exist within the intermediate circuit preventing it from charging. Proceed to static checks (6.2) earlier in this section.

6

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 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 and input SCR in accordance with their procedures.

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 Illustration 6-13.

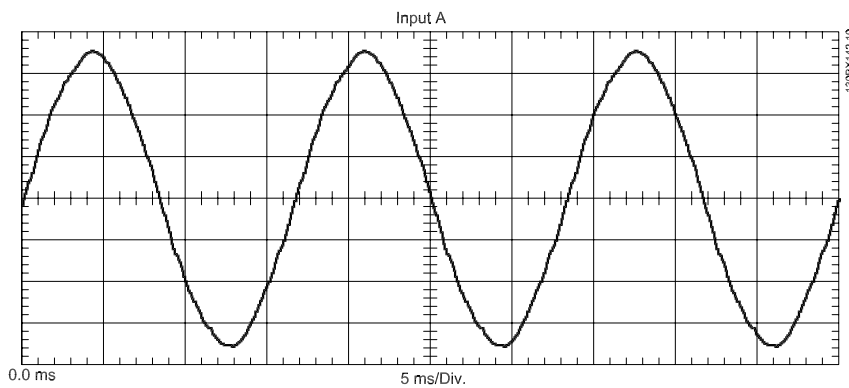


Illustration 6.13: Normal AC Input Voltage Waveform

The waveform shown in Illustration 6-14 represents the input current waveform for the same phase as Illustration 6-13 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.

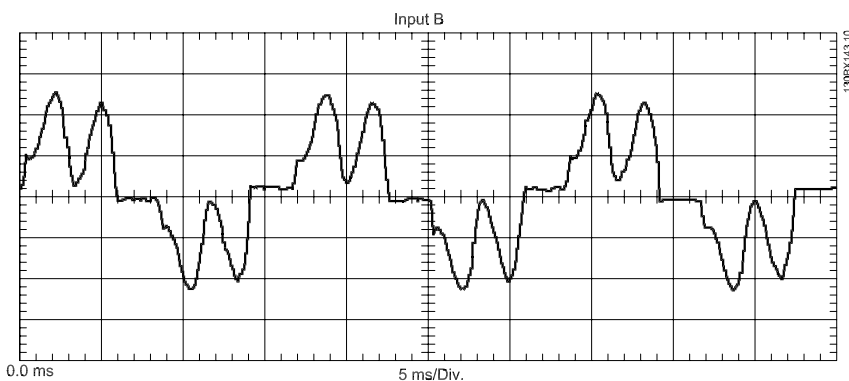


Illustration 6.14: AC Input Current Waveform with Diode Bridge

With a phase loss, the current waveform of the remaining phases would take on the appearance shown in Illustration 6-15.

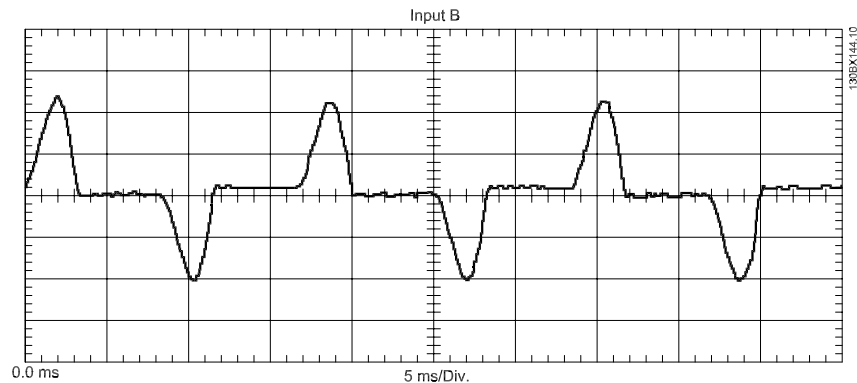


Illustration 6.15: Input Current Waveform with Phase Loss.

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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 and also the dynamic SCR/diode module test.

6.3.9 Input SCR Test

The SCR can be disabled by the frequency converter for various reasons. Check the following before making more complicated tests.

The SCRs can be disabled as a result of an input, or lack of input, at power card connector FK102, the external brake temperature switch. Unless used as an input, a jumper must be placed between terminals 104 and 106 of FK102

The SCRs are gated in sequence with the main supply. Verify that the voltage reference signal is correct as follows.

1. Using a voltmeter, measure phase to phase mains voltage at Terminals R, S, and T of power card connector MK106.
2. Measurements should correspond with measurements called out in the Input Voltage Test (6.3.2).

An incorrect reading at MK106 with a correct input voltage may indicate a problem in the soft charge card or the connecting cable.

If the above tests reveal no abnormalities, it is further possible that the inrush signal has not been enabled by the control card. Using the signal test card, verify the inrush signal is present and the SCR disable signal is at the correct voltage level as follows.

3. Insert the signal test board into power card connector MK104.
4. Check the SCR disable signal.
5. Using a voltmeter, connect the negative (-) meter lead to terminal 4 (common) of the test board.
6. Connect the positive (+) meter lead to terminal 19 of the signal board.

A reading of 0 VDC indicates the SCRs have been disabled. A reading of 0.6 to 0.8 VDC indicates the SCRs are active and should be gated.

With a reading of 0 VDC and proper mains applied to the frequency converter, it would be likely that the input at power card terminal FK102 has caused the SCRs to be disabled. Given the connection at FK102 has been verified the control card would be suspect. Check the inrush signal as follows.

7. Connect the positive (+) meter lead to terminal 7 of the signal board.

A reading of 0 VDC indicates the inrush signal is active and the SCRs are being gated. A reading of 5 VDC indicates the inrush signal is inactive and the SCRs are not gated.

With a reading of 5 VDC and proper mains applied to the frequency converter, it would be likely that the control card is defective.

If the control card is suspect, replace it in accordance with the disassembly procedures in Section 7 or 8.

Should the above tests check correctly, proceed to testing the SCR gate signals.

To view the gate signals, an oscilloscope and a current probe are required.

8. Run the frequency converter while under some degree of load. At least a 30% load may be required to consistently see gate signals produced since SCRs are only gated when the DC bus falls below the peak of line.

9. Connect the current probe, in sequence, to each (+) positive SCR gate wire (white leads) marked R, S, and T at power card connector MK100.

The waveform should appear as in Illustration 6-16.

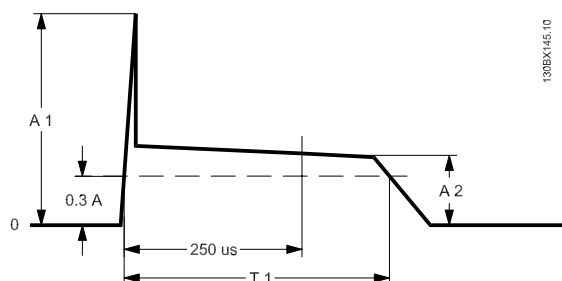


Illustration 6.16: SCR Gate Signal

The current pulse should have a waveform as shown.

$$A1 > 1.1 \text{ A}$$

$$A2 > 0.40 \text{ A}$$

$$T1 > 300 \mu\text{s}$$

Given all the other tests above were successful, a missing gate signal indicates the power card is defective. Replace the power card in accordance with the disassembly procedures in Section 7 or 8.


A distorted signal may be due to a defective gate on that particular SCR that is loading down the supply. Replace the SCR module which corresponds to the incorrect gate signal reading.

6.3.10 Output Imbalance of Supply Voltage Test

Checking the balance of the frequency converter output voltage and current measures the electrical functioning between the frequency converter and the motor. In testing the phase-to-phase output, both voltage and current are monitored. It is recommended that static tests on the inverter section of the frequency converter be conducted prior to this procedure.

If the voltage is balanced but the current is not, this indicates the motor is drawing an uneven load. This could be the result of a defective motor, a poor connection in the wiring between the frequency converter and the motor, or, if applicable, a defective motor overload.

If the output current is unbalanced as well as the voltage, the frequency converter is not gating the output properly. This could be the result of a defective power card, gate drive, connections between the gate drive card and IGBTs, or the output circuitry of the drive improperly connected.



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

The initial test can be made with the motor connected and running its load. If suspect readings are recorded then the motor leads may have to be disconnected to further isolate the problem.

1. Using a voltmeter, measure AC output voltage at frequency converter motor terminals 96 (U), 97 (V), and 98 (W). Measure phase to phase checking U to V, then U to W, and then V to W.

All three readings should be within 8 VAC of each other. The actual value of the voltage depends on the speed at which the frequency converter is running. The volts/hertz ratio is relatively linear (except in VT mode) so at 60Hz the voltage should be approximately equal to the mains voltage applied. At 30 Hz, it is about half of that and so on for any other speed selected. The exact voltage reading is less important than balance between phases.

2. Next, monitor three output phases at frequency converter motor terminals 96 (U), 97 (V), and 98 (W) with the clamp on the ammeter. An analog device is preferred. To achieve an accurate reading, run the frequency converter above 40Hz as this is normally the frequency limitation of such meters.

The output current should be balanced from phase to phase and no phase should be more than 2 to 3% different from another. If the above tests are successful, the frequency converter is operating normally.

3. If a greater imbalance exists than described above, disconnect the motor leads and repeat the voltage balance test.


Since the current will follow the voltage, it is necessary to differentiate between a load problem and a frequency converter problem. Should a voltage imbalance in the output be detected with the motor disconnected, it is necessary to test the gate drive circuits for proper firing. Proceed to the gate drive signals test (6.3.11).

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

6.3.11 IGBT Gate Drive Signals Test

This procedure tests the gate drive signals at the output of the gate drive card just prior to them being delivered to the IGBTs.

A simple test to check for the presence of the gate signals can be performed with a DVM, however, to actually check the waveforms, an oscilloscope is required.

	<p>Disable the DC bus when performing this test with Test Cable p/n 176F8437. Failure to do so could result in damage to the frequency converter if the probe is inadvertently connected to the wrong pins. Additionally, AC mains bus bars are in close proximity to these test points. Exercise caution when working close to high voltage components.</p>
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Prior to beginning the tests, ensure that power is removed from the unit and that the DC Bus capacitors have been discharged.

Check for the presence of DC bus voltage by measuring power card connector MK105 (A) with respect to MK105 (B). The voltage should be zero (0) before proceeding.

1. For D-frame size units, follow the procedure in Section 7 for soft charge card removal and disengage the soft charge card far enough to disconnect the cable plugged into the MK3.
2. Disconnect the cable from the MK3 connector on the soft charge card and connect one end of the test cable into the MK3.
3. For D-frame size units, reinstall the soft charge card.
4. Disconnect connectors MK100 and MK105 on the power card.
5. Connect the free end of test cable into MK105.
6. Connect the SCR gate shorting plug (included with test cable 176F8437) into the cable that was removed from MK100.

A 3 pin test connector is located on the gate drive card near each gate signal lead. These are labelled MK250, MK350, MK450, MK550, MK650, MK750, and, if the frequency converter is equipped with a brake option, MK850 (see Illustration 6-17).

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

7. Reconnect AC power to the frequency converter.
8. In stop mode, apply power to the frequency converter.
9. Measure pins 1 and 2 of each test connector. Each reading should be approximately -9 VDC, indicating all IGBTs are turned off.
10. Apply the run command to the frequency converter and 30 Hz reference.
11. If using a DVM, measure pins 1 and 2 of each connector. Waveform to IGBTs is a square wave that goes positive to 14 VDC and negative to -9 VDC. Average voltage read by DVM should be 2.2 to 2.5 VDC.

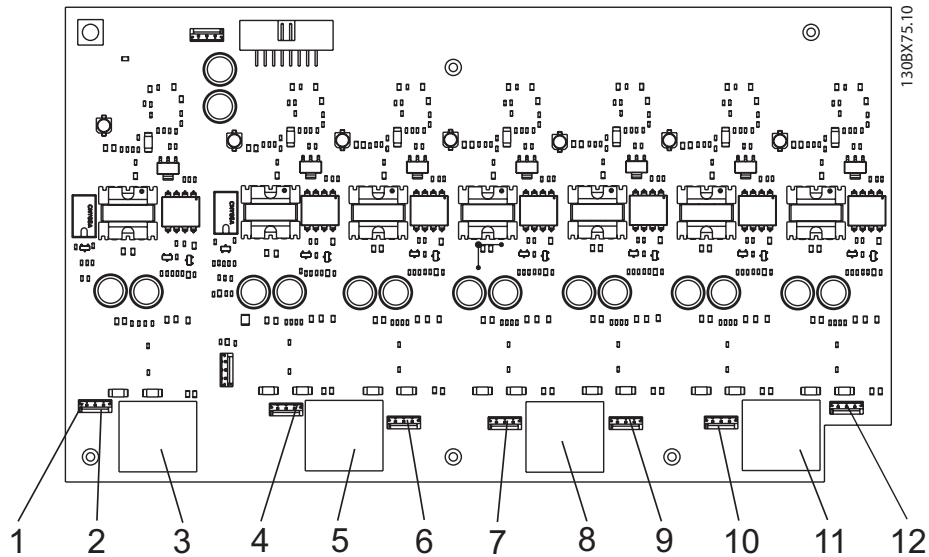


Illustration 6.17: Gate Drive Card Test Connectors

1	Pin 1	7	MK450
2	MK850 (brake)	8	MK103 (V)
3	MK105 (brake option)	9	MK550
4	MK250	10	MK650
5	MK102 (U)	11	MK104 (W)
6	MK350	12	MK750

When using an oscilloscope, the readings should appear as in Illustration 6-18.

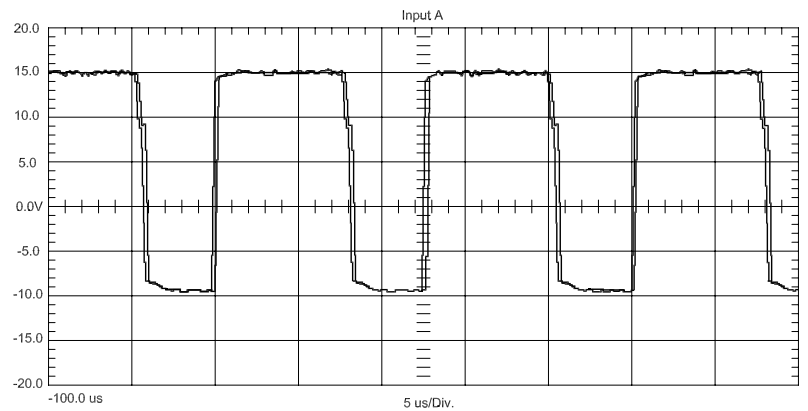


Illustration 6.18: Gate Signal Waveform from Gate Drive Card. IGBT Gate Signal measured on the Gate Drive Card: 5 volts per division vertical scale, 50 microseconds per division time scale. Unit running at 30 Hz.

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

12. Insert the signal test board into power card connector MK104.
13. With scope probe earth connected to terminal 4 (common) of signal board, measure six gate signals at signal board terminals 25 through 30.
14. Place the frequency converter in run at 30 Hz.

The waveform should appear as in Illustration 6-19.

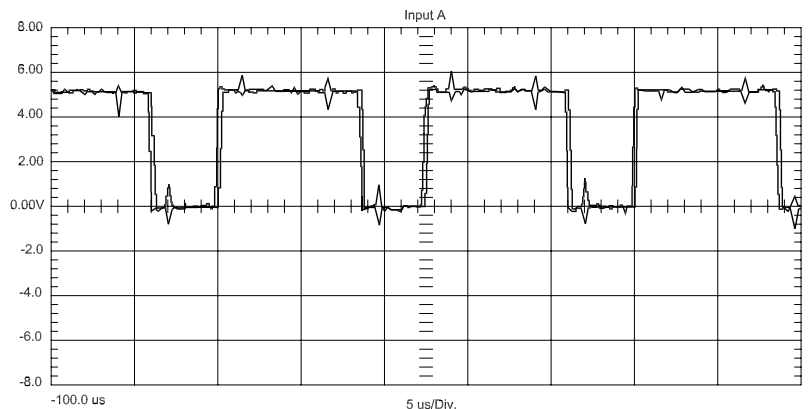


Illustration 6.19: Gate Signal Waveform from Signal Test Board. IGBT Gate Signal measured with the Signal Test Board: 2 volts per division vertical scale, 50 microseconds per division time scale. Unit running at 30 Hertz.

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15. Using a DVM, again check these same signal board terminals. DVM should read 2.2 to 2.5 VDC.

An incorrect reading of a gate signal indicates either the power card is defective or the signal has been lost prior to arriving at the power card. There is no test to verify the signals directly out of the control card. The power card would be suspect if a single gate signal is incorrect. The control card would be suspect if all six signals are incorrect. Replace the corresponding card in accordance with the disassembly procedures in Section 7 or 8.

6.3.12 IGBT Switching Test

Using the test cable 176F8439 while the frequency converter is powered and the DC bus is disabled, a simple test can be made to determine if the IGBTs are actually turning on.

Before proceeding, verify that the DC bus is in fact disabled.

1. Disconnect the cable from connector MK105 on the power card. With a voltmeter, measure between white lead of the cable disconnected from MK105 and output terminals U, V, and W in sequence. Switch between AC and DC scales. Voltage should read nearly zero.
2. Measure between the black lead of the same cable and the output terminals U, V, and W in sequence. Voltage should read nearly zero.

With the DC bus disabled, proceed using a DVM set on a diode scale.

1. With the frequency converter in stop mode, connect the positive (+) meter lead to the black lead of MK105 cable disconnected from the power card.
2. In sequence, connect the negative (-) meter lead to the frequency converter output terminals U, V, and W. The meter should indicate a diode drop.
3. Leave the positive meter lead connected to cable MK105, and run the frequency converter at 30 Hz.
4. In sequence, again connect the negative (-) meter lead to the frequency converter output terminals U, V, and W. The meter should effectively indicate a short circuit or around a 0.035 diode drop which indicates lower IGBTs are turned on and shorting the meter to a negative bus.



NB!

Some voltage leakage within the unit may cause the meter to indicate a small negative voltage drop.

5. Repeat the test for positive (+) or upper IGBTs.
6. With the frequency converter in stop mode, connect the negative (-) meter lead to the white lead of MK105 cable disconnected from the power card.
7. In sequence, connect the positive (+) meter lead to the frequency converter output terminals U, V, and W. The meter should indicate a diode drop.
8. Leave the negative meter lead connected to cable MK105, and run the frequency converter at 30 Hz.
9. In sequence, again connect the positive (+) meter lead to the frequency converter output terminals U, V, and W. The meter should effectively indicate a short circuit or around a 0.035 diode drop which indicates upper IGBTs are turned on and shorting the meter to a positive bus.



NB!

Some voltage leakage within the unit may cause the meter to indicate a small negative voltage drop.

Incorrect Reading

An incorrect reading indicates some of the IGBTs are not turning on. Replace the IGBT module according to the disassembly instructions in Section 7 or 8.

6.3.13 Brake IGBT Test

Use the signal test board to test the operation of the dynamic brake IGBT and gate drive circuitry. The following procedure can be used to force the brake circuit to activate for testing.

1. Connect the signal test board to connector MK104 on the control card.
2. Set the voltage test switch labelled Over V to the ON position.
3. Turn the potentiometer on the test board until the brake circuit activates. This causes the brake IGBT to turn on and off at approximately 1.2 KHz. Duty cycle (pulse width) increases as the potentiometer is increased.
4. Using an oscilloscope or DVM, measure at terminal 13. Terminal 13 represents the gate signal to the brake IGBT. This should be 4.04 VDC when brake is OFF and drop to zero when brake is ON.
5. Use an oscilloscope or DVM at terminal 14. Terminal 14 is a logic level (5V) signal representing voltage across brake IGBT. This should measure 5.1 VDC when brake is OFF and drop to zero when brake is ON.

Incorrect Reading

If the signal on terminal 13 is not correct, first check that the frequency converter is correctly programmed for dynamic braking (parameter 2-10). If the programming is correct, replace the control card in accordance with procedures in Section 7 or 8.

If the signal on terminal 13 is correct but the signal on terminal 14 is not, the brake IGBT gate signal must be checked to determine whether the fault lies in the IGBT or the gate drive card. See Gate Drive Signal Tests.

6.3.14 Current Sensors Test

The current sensors are Hall effect devices that send a signal proportional to the actual output current waveform to the power card. The current scaling card, attached to the power card, scales the signals from the current sensors to the proper level for monitoring and processing motor control data. A defective current sensor can cause erroneous earth faults and overcurrent trips. In such instances, the fault will usually only occur at higher loads. If the incorrect current scaling card is installed, the current signals will be improperly scaled. This could cause erroneous overcurrent trips. If the current scaling card is not installed, the frequency converter will trip.

A couple of simple checks can be made to determine the status of the sensors.

1. Apply power to the frequency converter.
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 the frequency converter with a zero speed reference. Note the output current reading in the display. The display should indicate approximately 1 to 2 amps.

If the current is greater than 1 to 2 amps and a current producing parameter is not active, the test will need to be made again with the motor leads disconnected.

4. Remove power from the frequency converter. Monitor the DC bus voltage at power card connector MK105 (A) and (B) to ensure the bus is fully discharged.
5. Remove the output motor leads from terminals U, V, and W.
6. Apply power to the frequency converter.
7. Run the frequency converter with a zero speed reference. Note the output current reading in the display. The display should indicate less than 1 amp.

If an incorrect reading was obtained from the above tests, further tests of the current feedback signals are required using the signal test board.

Testing current feedback with the signal test board.

8. Remove power to frequency converter. Make sure the DC bus is fully discharged.
9. Install the signal test board into power card connector MK104.
10. Using a DVM, measure the resistance between terminals 1 and 4, 2 and 4, and 3 and 4 of the signal test board. Resistance should be the same for all three readings. Table 6-2 shows approximate resistance readings based on frequency converter power and voltage rating. Note that values listed are values at the current scaling card. When measuring with a signal test board, the actual reading may be higher due to meter lead resistance. Absence of resistance indicates a missing scaling card.
11. Reapply power to the frequency converter.
12. Using a DVM, connect the negative (-) meter lead to terminal 4 (common) of the signal test board.
13. Run the frequency converter with a zero speed reference.
14. Measure the AC voltage at terminals 1, 2, and 3 of the signal test board in sequence. These terminals correspond with current sensor outputs U, V, and W, respectively. Expect a reading near zero volts but no greater than 15 mv.

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

The current sensor feedback signal at this point in the circuit will read approximately 400 mv at a 100% frequency converter load so any reading above 15 mv while the frequency converter is at zero speed has a negative effect on the way the frequency converter interprets the feedback signal.

A reading of greater than 15 mv suggests that the corresponding current sensor be replaced. See the disassembly instructions in Section 7 or 8.

Voltage (AC)		FC202	FC 302	Resistance (Ohms)
380-500	P110	P110	P90K	4.5
380-500	P132	P132	P110	3.8
380-500	P160	P160	P132	3.1
380-500	P200	P200	P160	2.6
380-500	P250	P250	P200	5.1
380-500	P315	P315	P250	4.2
380-500	P355	P355	P315	2.6
380-500	P400	P400	P355	2.6
380-500	P450	P450	P400	2.3
525-690	P45K	P45K	P37K	5.9
525-690	P55K	P55K	P45K	5.9
525-690	P75K	P75K	P55K	5.9
525-690	P90K	P90K	P75K	5.9
525-690	P110	P110	P90K	5.9
525-690	P132	P132	P110	5.9
525-690	P160	P160	P132	4.5
525-690	P200	P200	P160	3.1
525-690	P250	P250	P200	3.1
525-690	P315	P315	P250	2.6
525-690	P400	P400	P315	5.1
525-690	P450	P450	P355	4.5
525-690	P500	P500	P400	4.5
525-690	P560	P560	P500	3.8
525-690	P630	P630	P560	2.6

Table 6.2: Scaling Card Resistance Values

6.3.15 Fan Tests

The fan control circuit is made up of the fan transformer and the control circuitry located on the power card along with control signals for ON, OFF, and speed control from the control card. Since the fans do not necessarily run at all times, see the description for cooling fan operation under sequence of operation in Section 3.3.5.

Supply voltage

Supply voltage for the fans is from the soft charge card to power card connector MK106. First, verify the supply voltage is present as follows.

1. Use a voltmeter to measure the AC phase to phase voltage at R, S, and T of power card connector MK106. It should equal main supply voltage applied to frequency converter.
2. If voltage is not present, ensure proper mains voltage is applied to frequency converter. Conduct Input Voltage test (6.3.2).
3. If mains voltage is present at the input of the frequency converter but not at MK106 of the power card, conduct a static test of the soft charge fuses (6.2.1).

4. If voltage is present at MK106, check the voltage at the fan transformer read from connector CN2 located near the transformer. With a voltmeter, read the AC voltage at CN2 pins 1 and 3. The voltage should correspond to the main mains voltage applied to the frequency converter.
5. If voltage is not present, ensure jumpers are in place at power card connector FK103. Otherwise, connect an external source of power to terminal FK103 for fan supply voltage.

If the jumpers are in place or an auxiliary supply is connected and powered but no voltage is present at the fan transformer connector CN2, the power card is likely defective. Replace the power card in accordance with the disassembly instructions in Section 7 or 8.

Transformer output

If the appropriate voltage is present at CN2 pins 1 and 3, next check the output of the transformer. Prior to making this test, ensure the fan transformer fuse is good.

1. With a voltmeter, measure mains voltage from CN2 terminal 1 to terminal 2. Voltage should equal 66% of main AC supply voltage (48% for frequency converters 525–690 VAC) applied to frequency converter (or that of the auxiliary supply). If the voltage is incorrect, replace the fan transformer.
2. If the voltage is correct, check the fan voltage supplied to the fans themselves. The voltage can be read at power card connector MK107 pins 8 and 11 with respect to pin 1. The voltage at pins 8 and 11 correspond to the fan's commanded speed: 200 VAC for low speed and 230 VAC for high speed.

If the correct voltage is available but the fan is not running, that fan is defective. If no voltage is available, verify that the fans should be running. If so, the power card is defective. Replace the fan or power card in accordance with the disassembly instructions in Section 7 or 8.

Fan control circuit

To verify that the fan control circuit is receiving appropriate commands from the control card, the signal test board can be used to verify those signals.

1. Remove power from the frequency converter and allow the DC bus to fully discharge.
2. Install the signal test board into power connector MK104.
3. Reapply power to the frequency converter.
4. Connect the negative (-) meter lead of a voltmeter to signal board terminal 4 (common).
5. With a positive (+) meter lead, check the signal at terminal 6 of the signal board. The meter should read zero (0) volts with the fans set to run, 5 VDC if the control card has the fans set to off.
6. Verify sequence of operation of the cooling fans to ensure they should be running. In addition, the signal board contains a fan test switch. When switched on, fans should start and run at high speed.

The signals at terminals 5 and 10 of the signal board determine fan speed. See Section 9 for more on those signals. In addition, if a heatsink overtemperature trip has occurred, the fans will automatically be switched to high speed.

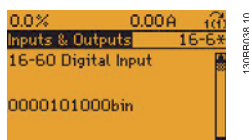
Given the fact that the fans should be running, if the signal at terminal 6 is correct and the fan test switch activates the fan, the control card is defective. Otherwise, the power card is defective. Replace the appropriate assembly in accordance with the disassembly instructions in Section 7 or 8.

6.3.16 Input Terminal Signal Tests

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

Digital inputs

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



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

Verify the control voltage power supply is correct as follows.

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

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

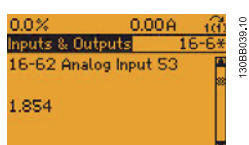
If 24 V is present, proceed with checking the individual inputs as follows

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

The presence of a signal at the desired terminal should correspond to the digital input display readout. A reading of 24 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 and 54 can also be displayed. The voltage or current in mA, depending on the switch setting, is shown in line 2 of the display.



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

Verify the reference voltage power supply is correct as follows.

1. With a voltmeter, measure the voltage at control card terminal 50 with respect to terminal 55. The meter should read between 9.2 and 11.2 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 the (-) negative meter lead to reference terminal 55.
3. Connect the (+) positive meter lead to desired terminal 53 or 54.

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

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

6.4 Initial Start Up or After Repair Drive 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 Table 4-1.
2. Perform static test procedures 6.2.1, 6.2.2 and 6.2.5 for D-frame size units or 6.2.3, 6.2.4 and 6.2.5 for E-frame size units to ensure the frequency converter is safe to start.
3. Disconnect the motor leads from the output terminals (U, V, W) of the frequency converter.
4. Apply AC power to the frequency converter.
5. Give the frequency converter a run command and slowly increase the reference (speed command) to approximately 40 Hz.
6. Using an analog voltmeter or a DVM capable of measuring true RMS, measure phase-to-phase output voltage on all three phases: U to V, U to W, V to W. All voltages must be balanced within 8 volts. If unbalanced voltage is measured, refer to Input Voltage Test (6.3.2).
7. Stop the frequency converter and remove the input power. *Allow 40 minutes for DC capacitors to fully discharge for E-frame size frequency converters or 20 minutes for D-frame size frequency converters.*
8. Reconnect the motor leads to the frequency converter output terminals (U, V, W).
9. Reapply power and restart the frequency converter. Adjust the motor speed to a nominal level.
10. Using a clamp-on style ammeter, measure the output current on each output phase. All currents should be balanced. If unbalanced current is measured, refer to Current Sensor Test (6.3.14).

7 D-Frame Sizes Disassembly and Assembly Instructions

7.1 Electrostatic Discharge (ESD)



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 20 minutes to let the frequency converter capacitors fully discharge. Only a competent technician should carry out service.

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 reduce the life, affect performance, or completely destroy sensitive electronic components.



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



NB!

Frame size is used throughout this manual where ever procedures or components differ between frequency converters based upon the unit's physical size. Refer to the tables in the Introduction Section to determine frame size definitions. See Section 8 for E-frame sizes disassembly and assembly instructions.

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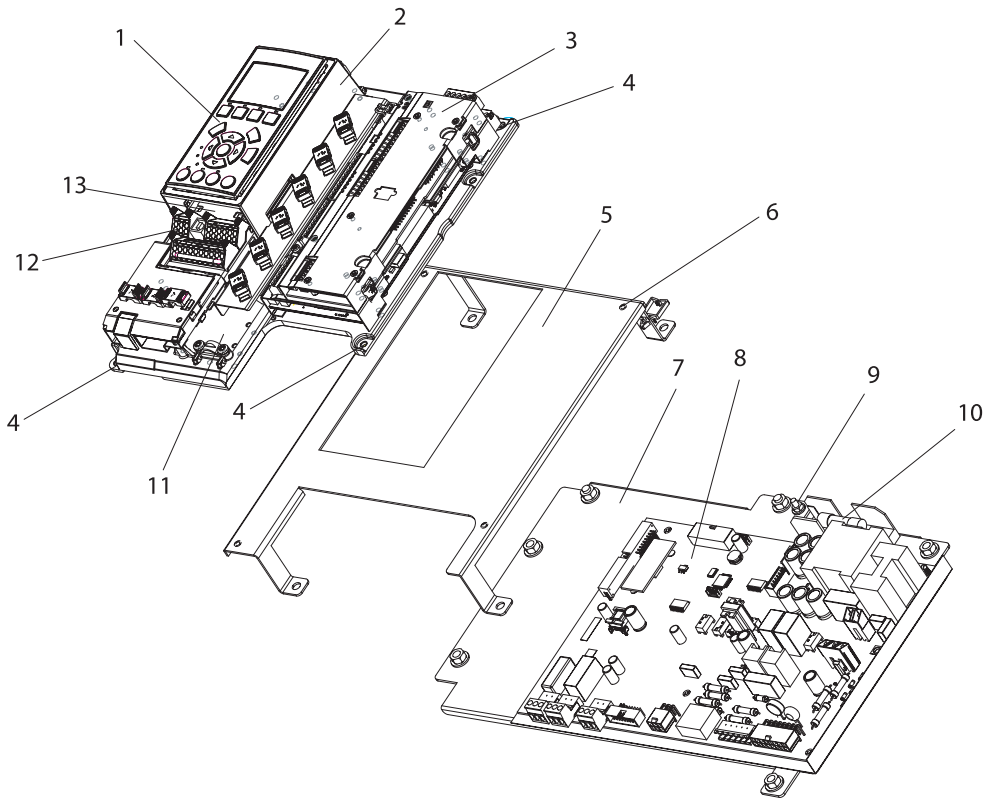
7.2 Instructions

7.2.1 Control Card and Control Card Mounting Plate

1. Open the front panel door or remove the front cover, depending on the unit type.
2. (See Illustration 7-1) Unplug the LCP ribbon cable (not shown) from the control card or remove LCP, depending on unit type. LCP can be removed by hand.
3. Remove the LCP cradle. LCP cradle can be removed by hand.
4. Remove any customer control wiring from the control card terminal blocks.
5. Remove the 4 screws (T20 Torx) securing the control card mounting plate to the control assembly support bracket.
6. Unplug the ribbon cable from the back of the control card.

Reinstall in reverse order of this procedure. The red conductor on the ribbon cable between the control card and the power card should be on the bottom of the connector. Tighten the control card mounting plate screws to 1 Nm (8 in-lb).

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Illustration 7.1: Control Card Access

380–480/500V: Yellow tape on the main SMPS transformer in the upper right corner.

525–690V: White tape on the main SMPS transformer in the upper right corner.

1	Local control panel (LCP) (Step 2)	8	Power card PCA3
2	LCP cradle (Step 3)	9	MK102 ring lug connection
3	C-option (if installed)	10	DC bus fuse
4	Mounting screws (Step 5)	11	Control card mounting plate
5	Control assembly support bracket	12	Control card terminal block
6	Attaching hardware	13	Control card (under LCP)
7	Power card mounting plate		

7.2.2 Control Assembly Support Bracket

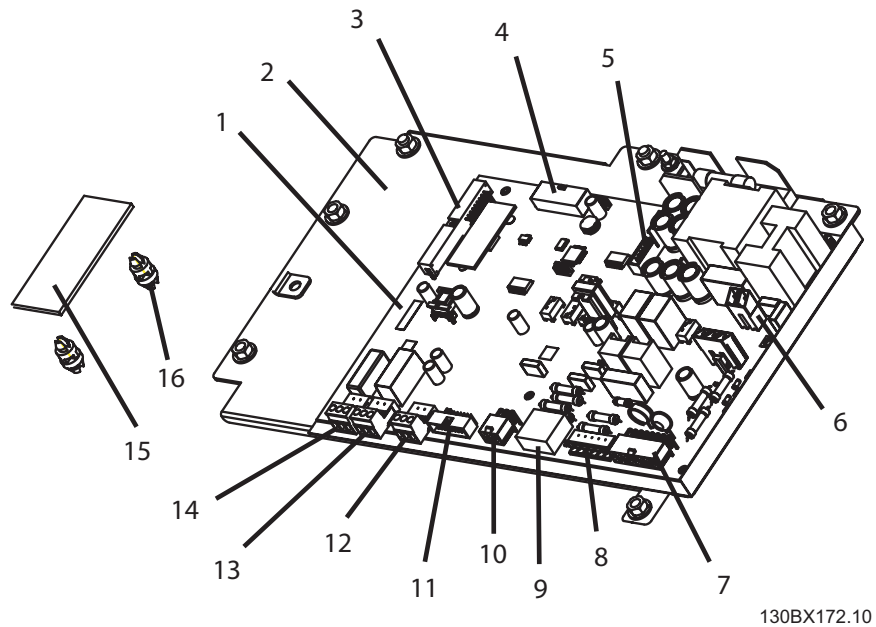
1. Remove the control card mounting plate in accordance with procedure.
2. Remove the 6 mounting nuts (10 mm), see Illustration 7-1.
3. Remove the control assembly support bracket.

Reinstall in reverse order of this procedure. Tighten the mounting screws to 4 Nm (35 in-lbs).

7.2.3 Power Card

1. Remove the control assembly support bracket in accordance with procedure.
2. Unplug power card connectors MK100, MK102, MK105, MK106, MK107 and MK109.
3. If customer connections are present, unplug connectors FK102, FK103, and MK112.
4. Remove the 7 mounting screws (T25 Torx) from the power card.
5. Remove the power card from the plastic standoff at the top right of the power card.
6. Remove the current scaling card from the power card by pushing in the retaining clips on the standoffs. KEEP THIS SCALING CARD FOR FUTURE REINSTALLATION OF ANY REPLACEMENT POWER CARD. The scaling card controls signals operating with this specific frequency converter. The scaling card is not part of the replacement power card.

Reinstall in reverse order of this procedure. When installing the power card, ensure that the insulator sheet is installed behind the power card. Tighten the mounting screws to 2.3 Nm (20 in-lbs).



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Illustration 7.2: Power Card, and Mounting Plate

380–480/500V: Yellow tape on the main SMPS transformer in the upper right corner.

525–690V: White tape on the main SMPS transformer in the upper right corner.

1	Power card PCA3	9	MK106
2	Mounting plate	10	MK100
3	MK110	11	MK109
4	MK102	12	FK102
5	MK104	13	MK112 terminals 4,5,6
6	MK105	14	MK112 terminals 1,2,3
7	MK107	15	Current scaling card PCA4
8	FK103	16	Current scaling card standoff

7.2.4 Power Card Mounting Plate

1. Remove the control assembly mounting bracket in accordance with procedure.
2. The power card mounting plate (see Illustration 7-1) can be removed with the power card still mounted, if so desired. If the power card is to be removed, remove it in accordance with the power card procedure.
3. To remove the power card mounting plate with the power card attached, unplug connectors MK100, MK102, MK105, MK106, MK107, and MK109 (see Illustration 7-2).
4. If customer connections are present, unplug connectors FK102, FK103, and MK112.
5. Remove the nut (7 mm) attaching the MK102 ring lug to the power card mounting plate.
6. Remove the 2 connectors, one on each end of the DC bus fuse holder.
7. Remove the 2 nuts (10 mm) on the right side of the power card mounting plate. (Two nuts that secure the control assembly mounting bracket also secure the left side of the power card mounting bracket.)

Reinstall in reverse order of this procedure. The ring lug for the wire assembly that connects to power card connector MK102 attaches to the right mounting stud on the top of the power card mounting plate. The white wire from the DC bus connects to the left end of the DC bus fuse holder. The white wire from the power card connector MK105 connects to the right end of the DC bus fuse holder. Tighten the 10 mm mounting nuts to 4 Nm (35 in-lbs) and the 7 mm nut to 1 Nm (8 in-lbs).

7.2.5 Soft Charge Card

1. Remove the power card mounting plate in accordance with procedure.
2. Remove the 2 retaining nuts from the soft charge card assembly (10 mm).
3. Slide the assembly part way out to access the cable glands on the card.
4. Disconnect MK1, MK2, MK3, and MK4.
5. Remove the soft charge card assembly.

Reinstall by aligning the soft charge card with fastening clips on the side of the chassis. Reattach the connectors. Slide into place and tighten the mounting screws to 4 Nm (35 in-lbs).

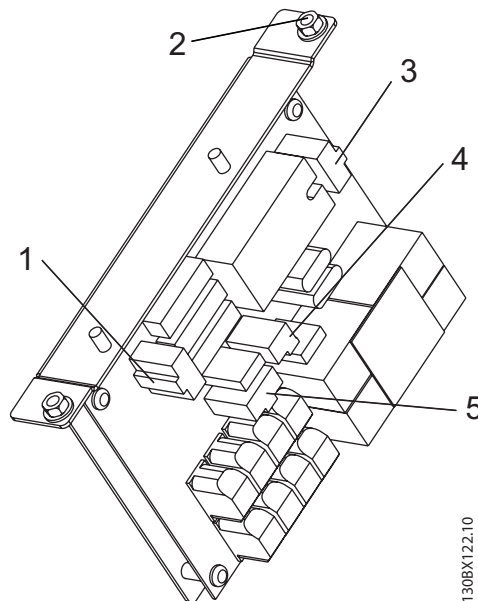


Illustration 7.3: Soft Charge Card Assy

380–480/500V: Blue MOV and 8 PTCs.

525–690V: Red MOV and 6 PTCs.

1	MK1
2	Retaining screw (Step 2)
3	MK2
4	MK4
5	MK3

7.2.6 Gate Drive Card

1. Disconnect the cables from the connectors on gate drive card MK100, MK102, MK103, MK104, MK106, and, if the unit has a brake option, MK105, and, for 380-500 V units with an RFI filter, MK101.
2. Remove the gate drive card by removing the 6 mounting screws (T25 Torx) from the standoffs.

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

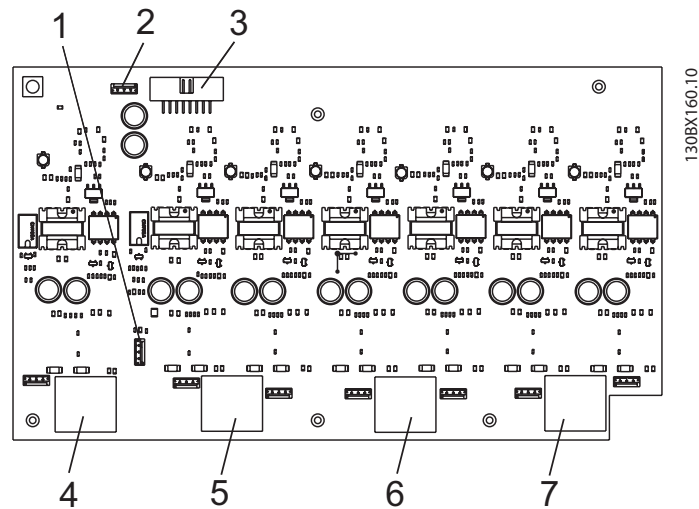


Illustration 7.4: Gate Drive Card

1	MK100 (temperature sensor)
2	MK101 (RFI filter)
3	MK106
4	MK105 (brake option)
5	MK102 (U)
6	MK103 (V)
7	MK104 (W)

7.2.7 Capacitor Bank(s)



Some D2/D4 size units have 2 capacitor bank assemblies mounted one above the other. Separate disassembly instructions are given for upper and lower capacitor banks. For units with one capacitor bank assembly only, disassemble in accordance with instructions for *Single capacitor bank D1/D3 units*.

Upper capacitor bank D2/D4 units

1. Remove the control assembly support bracket in accordance with instructions.
2. Capacitor bank connection to DC bus bars can be seen recessed in the gap between upper and lower cap banks. Remove the 2 nuts (10 mm) furthest from the DC bus bars. A minimum 100 mm (4 in) extension is required.
3. Remove the 4 retaining nuts (10 mm) from the cap bank cover plate and remove the cover plate.
4. Note that the weight of the cap bank is approximately 9 kg (20 lbs). Remove the cap bank by pulling it free from the mounting studs.

Reinstall in reverse order of this procedure. Tighten the mounting screws to 4 Nm (35 in-lbs).

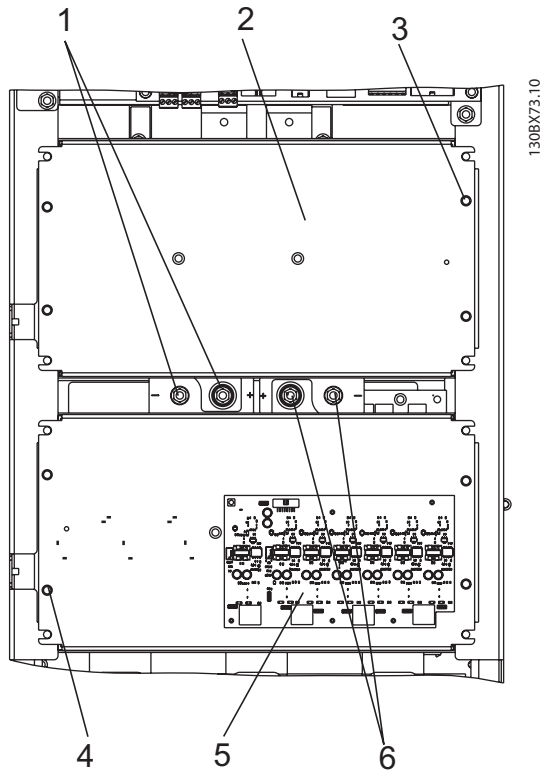


Illustration 7.5: D2/D4 Upper and Lower Capacitor Bank Assemblies

380–480/500V: Blue DC Link Capacitors. 525–690V: Black DC Link Capacitors

1	Upper cap bank assy retaining nuts (step 2)	4	Lower cover plate retaining nut (step 3)
2	Upper cover plate	5	Gate drive card
3	Upper cover plate retaining nut (step 3)	6	Lower cap bank assy retaining nuts (step 1)

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Lower capacitor bank D2/D4 units

1. Capacitor bank connection to DC bus bars can be seen recessed in the gap between upper and lower cap banks. Remove the 2 cap bank retaining nuts (10 mm) furthest to the right from the DC bus bars. A minimum 100 mm (4 in) extension is required.
2. Note that the IGBT gate drive card can remain attached to the cap bank cover plate. Disconnect MK100, MK102, MK103, MK104, and MK106 from the gate drive card. Also remove the MK105, for units with a brake, and MK101 for units with an RFI filter.
3. Remove the 4 retaining nuts (10 mm) from the cap bank cover plate, and remove the plate.
4. Note that the weight of the cap bank is approximately 9 kg (20 lbs). Remove the cap bank by pulling it free from the mounting studs.

Reinstall in reverse order of this procedure. Tighten the mounting screws to 4 Nm (35 in-lbs).

Single capacitor bank D1/D3 units

1. Remove the control assembly support bracket in accordance with instructions.
2. Remove the 2 capacitor bank retaining nuts (10 mm) from the DC bus bars. A minimum 100 mm (4 in) extension is required.
3. Note that the IGBT gate drive card can remain attached to the cap bank cover plate. Disconnect MK100, MK102, MK103, MK104, and MK106 from the gate drive card. Also remove the MK105, for units with a brake, and MK101 for units with an RFI filter.
4. Remove the 4 retaining nuts (10 mm) from the cap bank cover plate, and remove the plate.
5. Note that the weight of the cap bank is approximately 9 kg (20 lbs). Remove the cap bank by pulling it free from the mounting studs.

Reinstall in reverse order of this procedure. Tighten the mounting screws to 4 Nm (35 in-lbs).

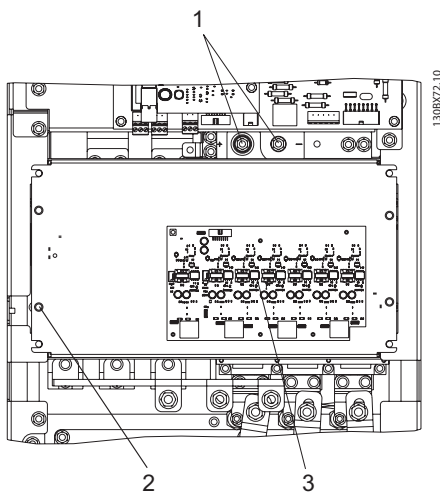


Illustration 7.6: D1/D3 Single Capacitor Bank Assembly

380–480/500V: Blue DC Link Capacitors. 525–690V: Black DC Link Capacitors.

1	Retaining nuts (step 2)
2	Retaining nuts (step 4)
3	Gate drive card (step 3)

7.2.8 Soft Charge (SC) Resistors D2/D4 Units

1. Remove the upper capacitor bank assembly in accordance with procedure.



NB!

On D2/D4 units, only the upper cap bank assembly is removed.

2. The MK4 connector on the soft charge card must be disconnected. Disengage the soft charge card far enough to access the MK4 (see Illustration 7-3) in accordance with steps 1-3 in the soft charge card disassembly procedure.
3. Note that the soft charge resistor is located under the bus bars and held in place by 2 retaining nuts. Bus bars do not need to be removed. Loosen the retaining nut (8 mm) furthest to the right.
4. Remove the 8 mm retaining nut furthest to the left.
5. Lift the left side of the SC resistor and remove the resistor by sliding it to the left and out from under the bus bars.

Reinstall in reverse order of this procedure. Tighten the 8 mm mounting nuts to 2.3 Nm (20 in-lbs). Tighten 10 mm mounting nuts to 4 Nm (35 in-lbs).

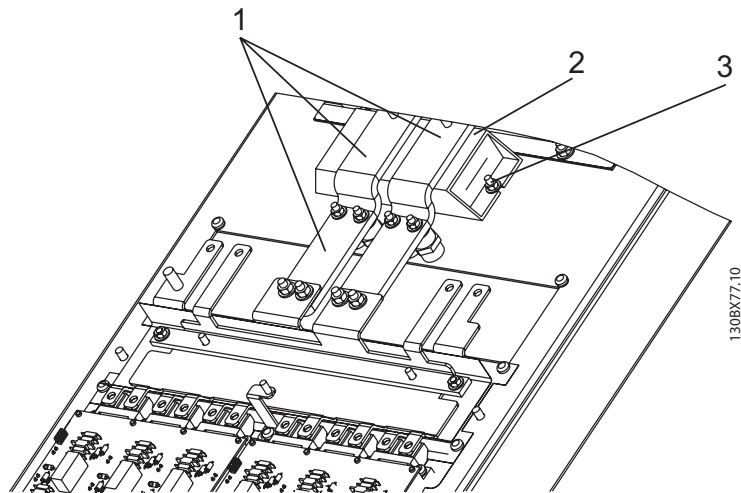


Illustration 7.7: D2/D4 Soft Charge Resistor

380–480/500V: Clear wire leads.

525–690V: Black wire leads.

1	Bus bars BB27 (do not remove)
2	Soft charge resistor
3	Retaining nut (loosen) (Step 3)

7.2.9 Soft Charge (SC) Resistors D1/D3 Units

1. Remove the capacitor bank per instructions.
2. Remove the input terminal mounting plate per instructions.
3. Note the colour coding for each of three wires attached to terminal 1 for each SCR/diode module. Ensure that the correct wire is attached to the applicable stud during reassembly. Remove the wiring from the studs. Remove the retaining screw (T25) from terminal 1 of each of 3 SCR/diode modules and remove the bus bar.

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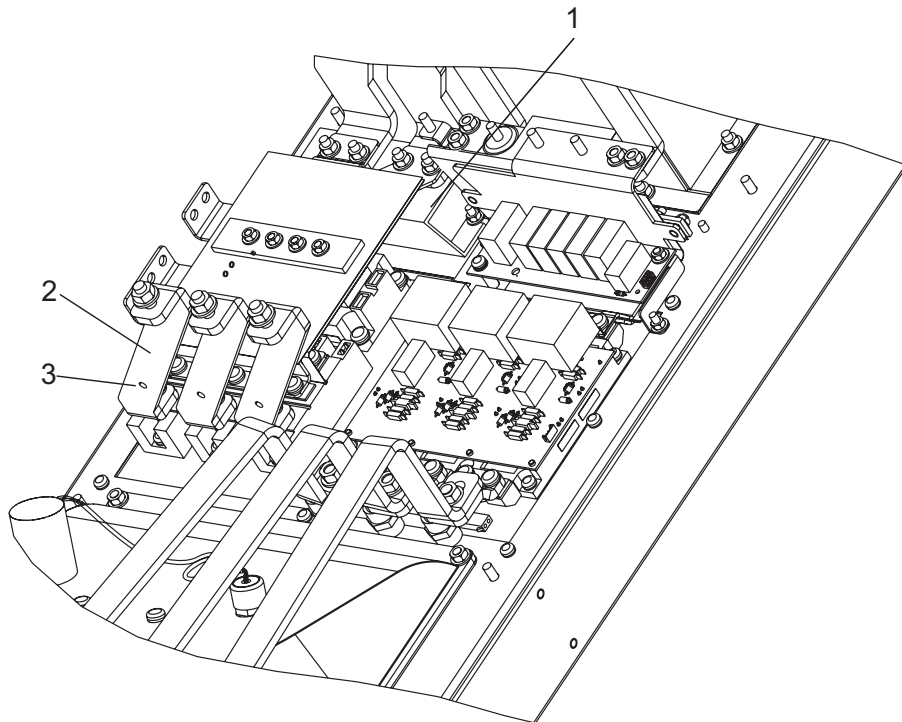


Illustration 7.8: D2/D4 Soft Charge Resistor (1 of 3)

380–480/500V: Clear wire leads.

525–690V: Black wire leads.

1	Soft charge resistor
2	Bus bar BB2 (Step 3)
3	Retaining screw (Step 3)

4. Remove the six retaining screws (T25) from the SCR/diode modules, terminals 2 and 3 in each module.
5. Remove the 4 (10 mm) retaining nuts from the DC inductor input bus bars and the 4 retaining nuts (not shown) from the side mounted bus bars. (Side mounted bus bars are only present on units with load sharing.) Remove the DC input bus assembly.

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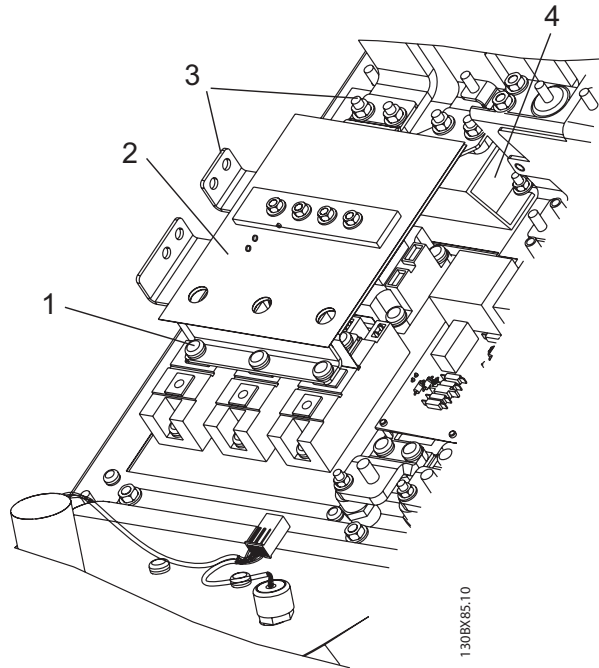


Illustration 7.9: D1/D3 Soft Charge Resistor (2 of 3)

380–480/500V: Clear wire leads.

525–690V: Black wire leads.

1	Retaining screws (Step 4)
2	DC input bus assembly BB3
3	Retaining nuts (Step 5)
4	Soft charge resistor

6. Remove the soft charge resistor by removing the two mounting screws.

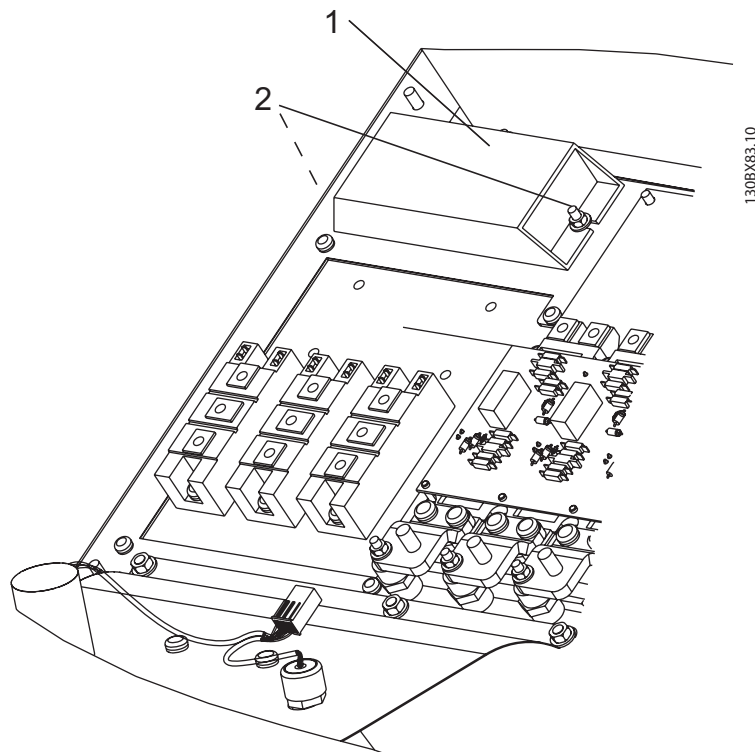


Illustration 7.10: D1/D3 Soft Charge Resistor (3 of 3)

380–480/500V: Clear wire leads.

525–690V: Black wire leads.

1	Soft charge resistor
2	Mounting screws (Step 6)

Reassembly

1. Clean the heatsink surface with a mild solvent or alcohol solution.
2. Reassemble the remaining parts in reverse order of their removal. Tighten the T25 and 8 mm mounting screws to 2.3 Nm (20 in-lbs) and T30 and 10 mm to 4 Nm (35 in-lbs).

7.2.10 Input Terminal Mounting Plate Assembly

1. Disconnect the input power wiring from L1, L2, L3, and earth connection.
2. Remove the upper most bus bar retaining nuts (13 mm) from the AC power input bus bars L1, L2, and L3.
3. Disconnect the fan autotransformer cable at the in-line connector.
4. Remove the 4 or 5 (10 mm) retaining nuts (varies with size) from the mounting plate.



The input terminal mounting plate weighs approximately 7–27 kg (15–60 lbs) depending on the mounted options.

5. Remove the entire assembly from the mounting studs.

Reinstall in reverse order of this procedure. Tighten the 10 mm mounting nuts to 4 Nm (35 in-lbs) and the 13 mm nuts to 9.5 Nm (85 in-lb).

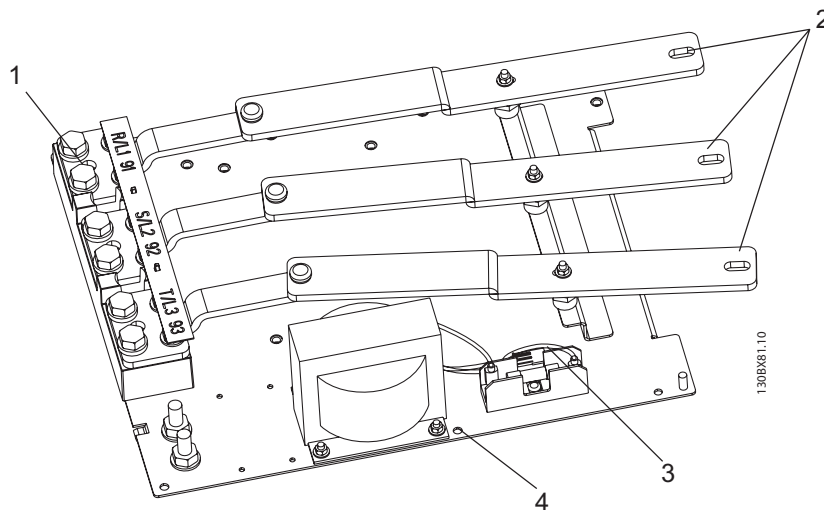


Illustration 7.11: Input Terminal Mounting Plate Assembly (no options shown)

380–480/500V: White label on fan transformer. 525–690V: Orange label on fan transformer.

1	Input power connector (Step 1)
2	Bus bar retaining nuts (shown removed) (Step 2)
3	Transformer connector (Step 3)
4	Retaining nuts (Step 4)

7.2.11 SCR/Diode Module D2/D4 Units

1. Remove the lower DC capacitor bank per instructions.
2. Remove the input terminal plate per instructions.
3. Remove the retaining nuts (8 mm) from the SCR input bus bars, one for each input phase.
4. Note the colour coding for each of the three wires attached to the retaining studs. Ensure that the correct wire is attached to the applicable stud during reassembly. Remove the wiring from the studs.
5. Remove screw (T30) from terminal 1 of each SCR/diode module by accessing the screw through access hole in the SCR/diode input bus bar. Remove the SCR input bus bars.
6. Remove each IGBT output bus bar by removing the nut (13 mm) from the stud. Also remove the retaining screw (T40) at other end of the IGBT output bus bars (not shown).

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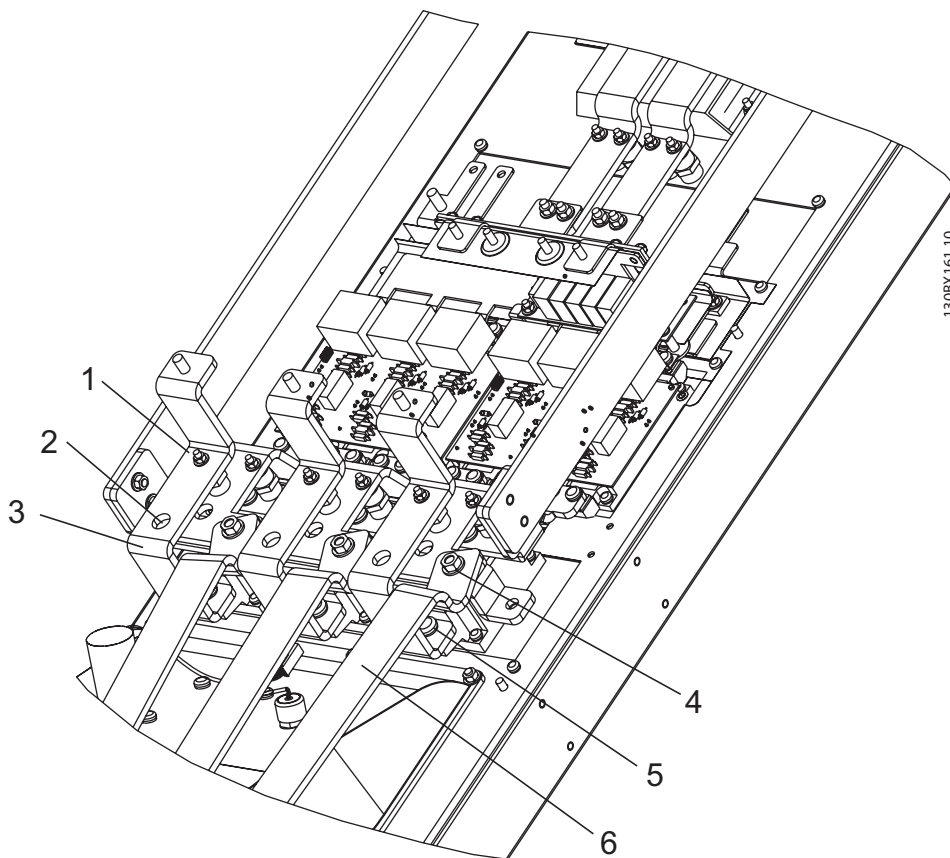


Illustration 7.12: D2/D4 SCR/Diode Module (1 of 4)

1	SCR/diode input bus bar retaining nut and stud (Steps 3 & 4)	4	IGBT output bus bar retaining nut (Step 6)
2	SCR/diode terminal screw (Step 5)	5	SCR/diode terminal screw (Step 5)
3	SCR/diode input bus bar BB21 or BB22 per drive power rating	6	IGBT output bus bar BB32 (Step 6)

7. Remove twelve (T30) screws from the output (lower) side of the IGBT modules.
8. Remove the retaining nut (8 mm) from each intermediate IGBT output bus bar. Remove the intermediate IGBT bus bars.
9. Remove 4 nuts (10 mm), two on either side, connecting the rectifier DC bus bars to the main DC bus bars. These are located to either side of the SCR/diode modules.

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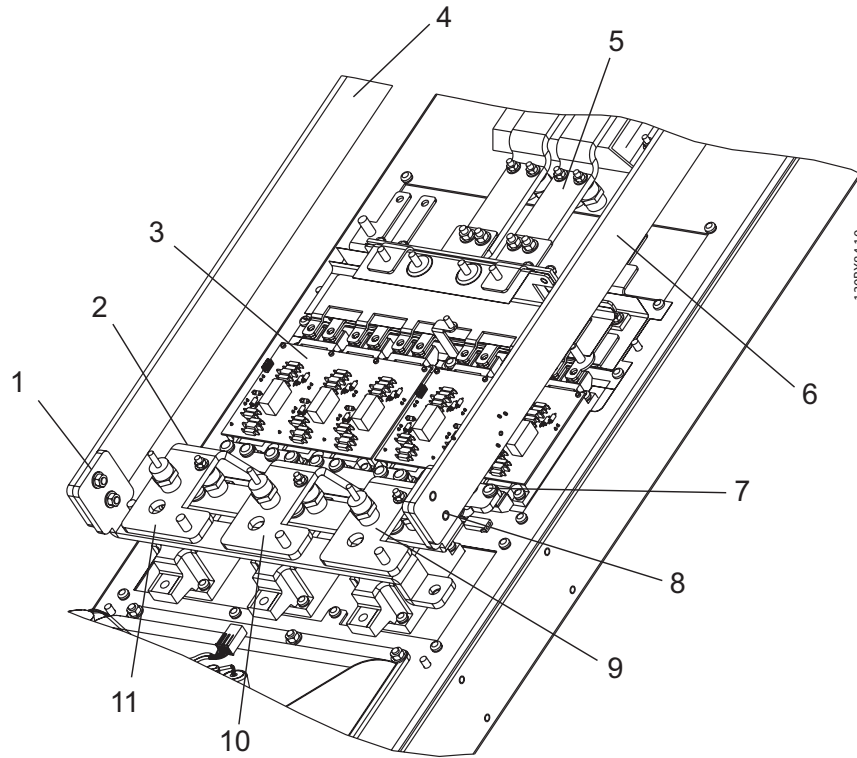


Illustration 7.13: D2/D4 SCR/Diode Module (2 of 4)

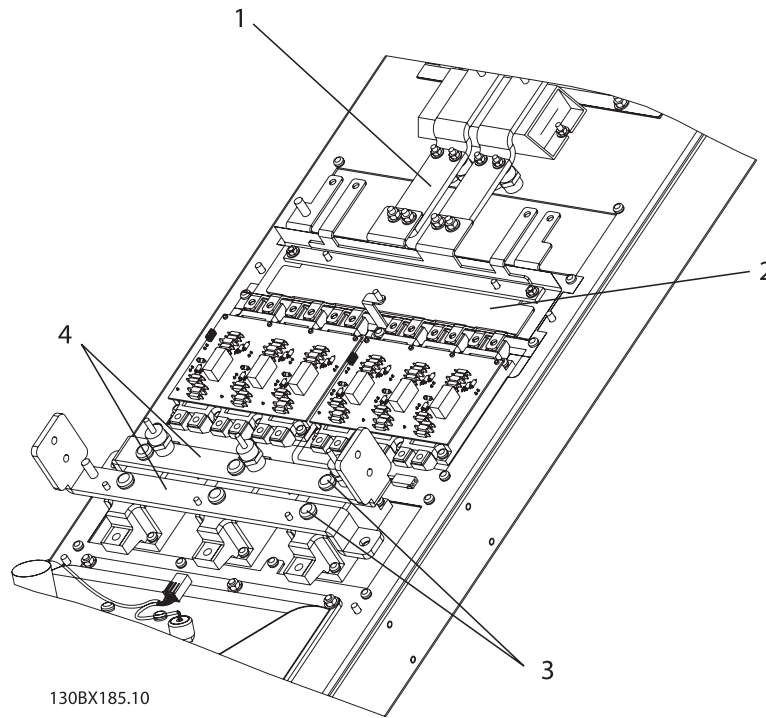
1	Retaining screws (Step 9)	7	IGBT output retaining screws (Step 7)
2	Retaining nut (Step 8)	8	Retaining screws (Step 9)
3	IGBT module	9	Intermediate IGBT output bus bar BB30 (Step 8)
4	Main DC bus bar BB25 (Step 9)	10	Bus bar BB31
5	Bus bar BB27	11	Bus bar BB30
6	Bus bar BB26		



NB!

Note which gate leads are attached to which module to ensure that the leads are reconnected to the correct modules upon reassembly.

10. Remove the rectifier DC bus bars by removing the 3 screws (T25) connecting each rectifier DC bus bar to standoffs on the SCR/diode modules.



1	Bus bar BB27
2	Bus bar BB28
3	Retaining screws (Step 10)
4	Rectifier DC bus bars BB23 or BB24 per drive power rating (Step 10)

11. Remove the SCR gate lead connectors from the modules.
12. Remove the SCR/diode module retaining screws on each module (T30) and remove the SCR/diode modules.

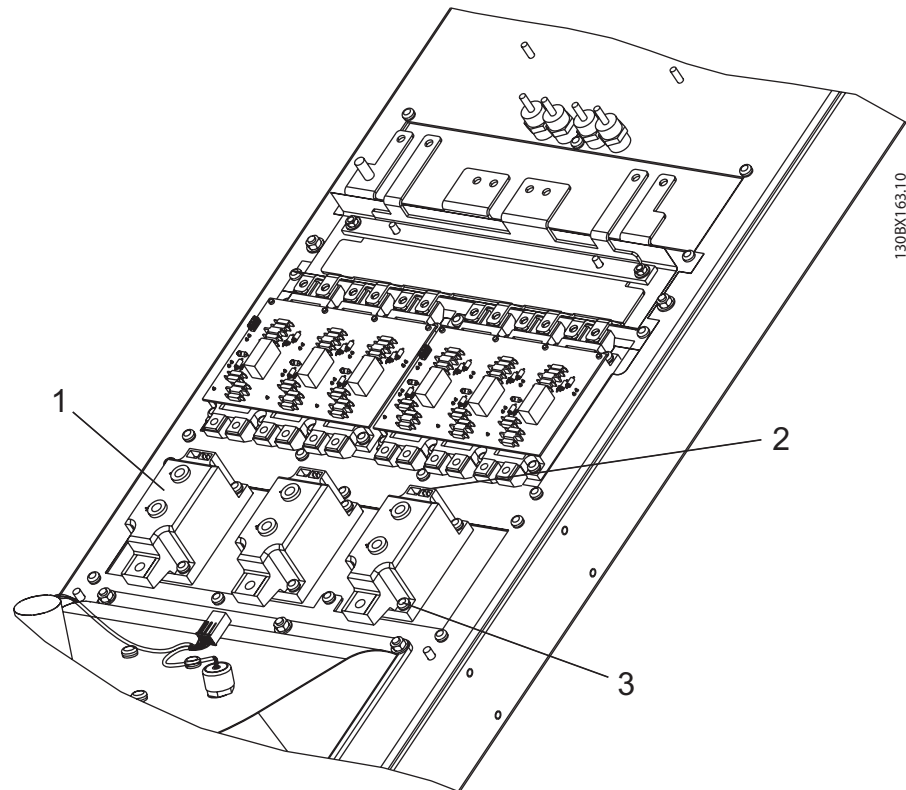


Illustration 7.14: D2/D4 SCR/Diode Module (4 of 4)

1	SCR/diode module (Step 12)
2	SCR gate lead connectors (Step 11)
3	SCR/diode module mounting screws (Step 12)

REASSEMBLY

1. To replace SCR/diode modules, follow the instructions included with the replacement module.
2. Reassemble in reverse order. Tighten the remaining T25 and 8 mm screws to 2.3 Nm (20 in-lbs) and T30 to 4 Nm (35 in-lbs).
3. Be sure to cross the tighten replacement unit with the spare part per instructions.

7.2.12 SCR/Diode Module D1/D3 Units

1. Remove the capacitor bank per instructions.
2. Remove the input terminal mounting plate per instructions.
3. Remove the retaining screw (T25) from terminal 1 of each SCR/diode module.
4. Remove the 8 mm retaining nut from the bus bar holding bracket and remove the bus bar, one for each input phase.

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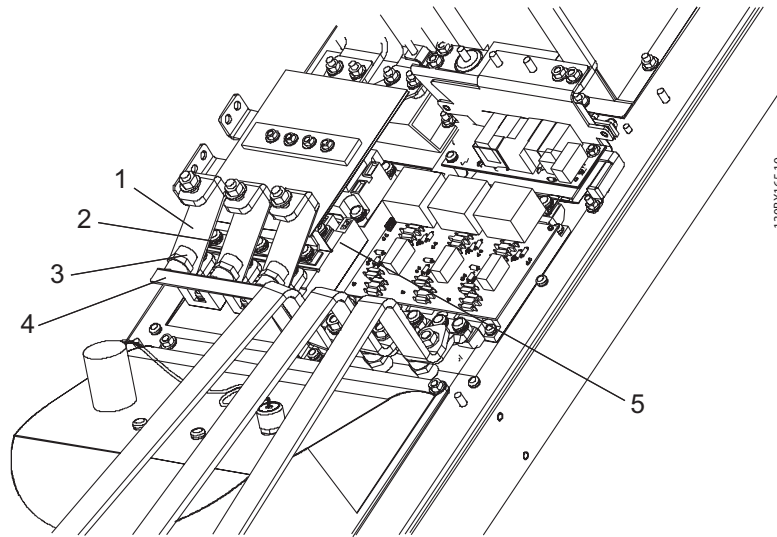


Illustration 7.15: D1/D3 SCR/Diode Module (1 of 3)

1	Bus bar BB2 (Step 4)
2	Retaining screw access (Step 3)
3	Retaining nut (Step 4)
4	Bus bar BB1
5	SCR/diode module

5. Remove the six retaining screws (T25) from the SCR/diode modules, terminals 2 and 3 in each module.
6. Remove the 4 (10 mm) retaining nuts from the DC inductor input bus bars and the 4 retaining nuts (not shown) from the side mounted bus bars. (Side mounted bus bars are only present on units with load sharing.) Remove the DC input bus assembly.

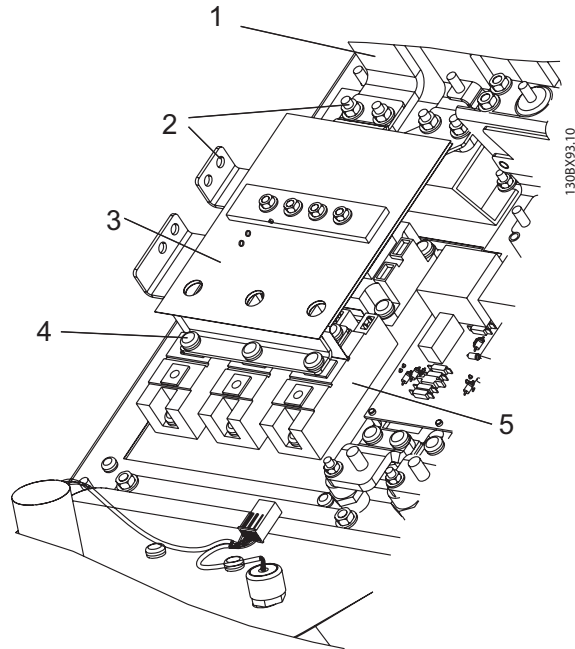


Illustration 7.16: D1/D3 SCR/Diode Module (2 of 3)

1	Bus bar BB4
2	Retaining nuts (Step 6)
3	DC input bus assembly BB3 (Step 6)
4	Retaining screws (Step 5)
5	SCR/diode module

7. Note which gate leads attach to which module for reassembly. Remove the SCR/diode gate lead connectors from the modules (not shown).
8. If the unit is equipped with a brake option, remove the two bus bars attaching the brake IGBT module to the IGBT bus assy. Remove the SCR/diode mounting screws.

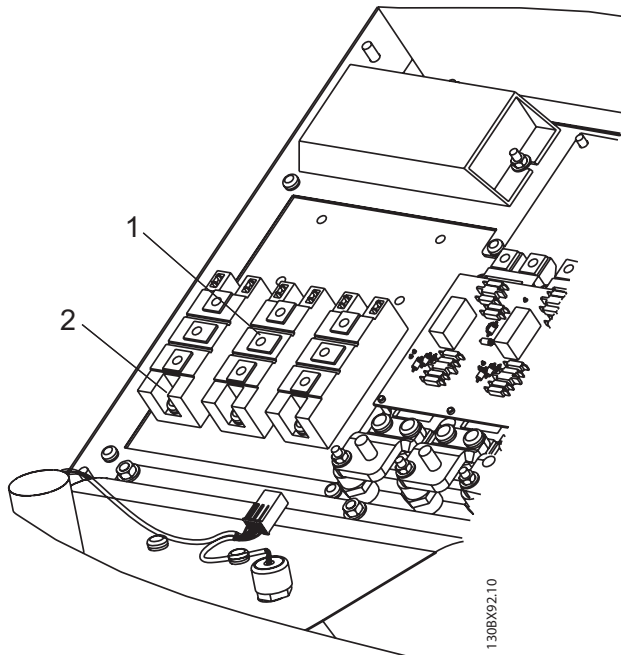


Illustration 7.17: D1/D3 SCR/Diode Module (3 of 3)

1	SCR/diode module
2	Mounting screws (Step 8)

REASSEMBLY

1. To replace SCR/diode modules, follow the instructions included with the replacement module.
2. Reinstall the module and mounting screws. Tighten the remaining T25 and 8 mm screws to 2.3 Nm (20 in-lbs) and T30 and 10 mm to 4 Nm (35 in-lbs).
3. Reassemble the remaining parts in reverse order of their removal.

7.2.13 Current Sensor

1. Remove the motor cabling, as required.
2. Remove the input terminal mounting plate assembly per instructions.
3. Remove terminals U, V, and W by removing the 3 mounting screws. The terminal slides out from under the current sensor.
4. Disconnect the current sensor cable from the current sensor.
5. Note which cables attach to which sensor for reassembly. Remove the 2 (8 mm) retaining nuts from the stud on the chassis base plate and remove the sensor.

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

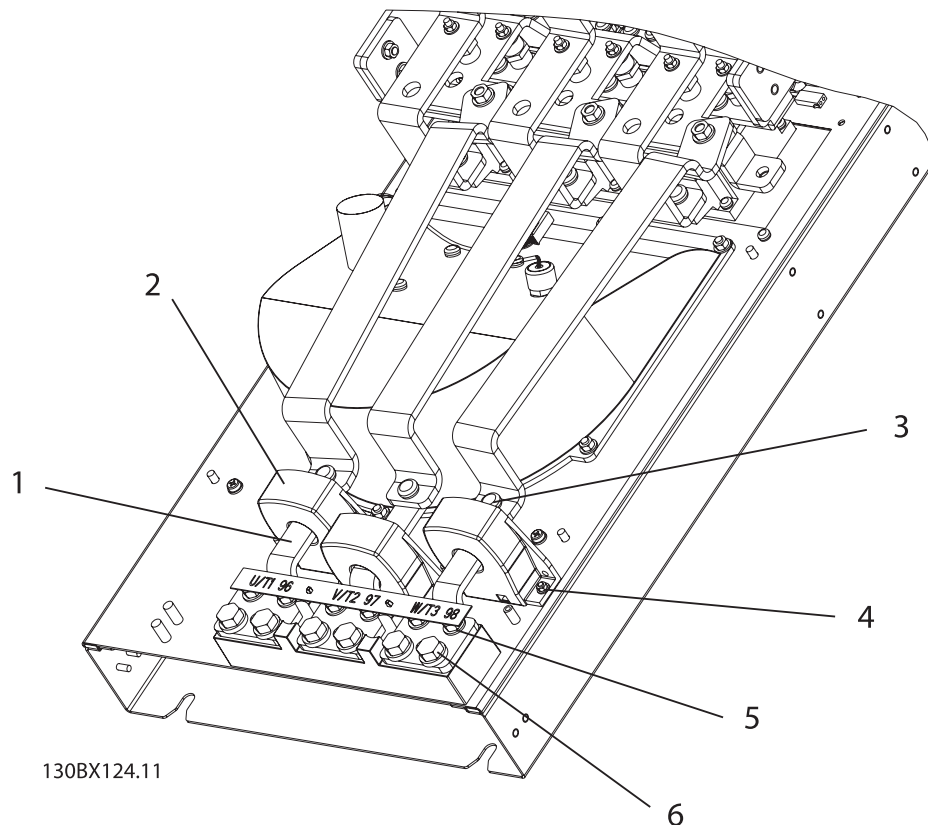


Illustration 7.18: Current Sensors

1	Terminal	4	Current sensor mounting screws (2)
2	Current sensor	5	Terminal mounting screws (2)
3	Terminal mounting screw	6	Output motor cable connection screws (2)

7.2.14 Heatsink Fan Assembly

1. Remove the input terminal mounting plate assembly per instructions.
2. Remove the 3 IGBT output bus bars (see Illustration 7-19) by removing the 6 retaining nuts (8 mm), one from each end, of the IGBT output bus bars. Remove the bus bars.

NB!
Omit steps 3 and 4 for D2/D4 units.

3. Use a 100 mm (4 in) minimum extension and remove terminal 1 from the SCR/diode module.
4. Note the colour coding for each of the three wires attached to the retaining studs. Ensure that the correct wire is attached to the applicable stud during reassembly. Remove the AC power lead to the intermediate SCR input bus bar by removing the nut (8 mm) and remove the bus bar.

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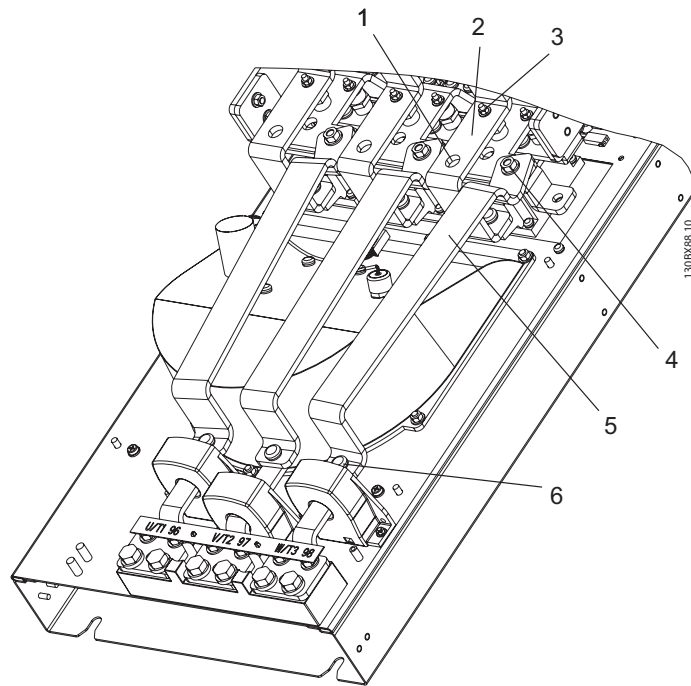


Illustration 7.19: Fan Assembly (1 of 2)

1	Terminal (Step 3)
2	Intermediate SCR input bus bar (Step 3)
3	Retaining nut (Step 4)
4	Retaining nut (Step 2)
5	IGBT output bus bar (Step 2)
6	Retaining nut (Step 2)

5. Disconnect the in-line Molex connector.

6. Remove the fan assy by removing the 6 (8 mm) retaining nuts from the stud. Note that the fan assembly weighs approximately 8 kg (18 lbs).

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

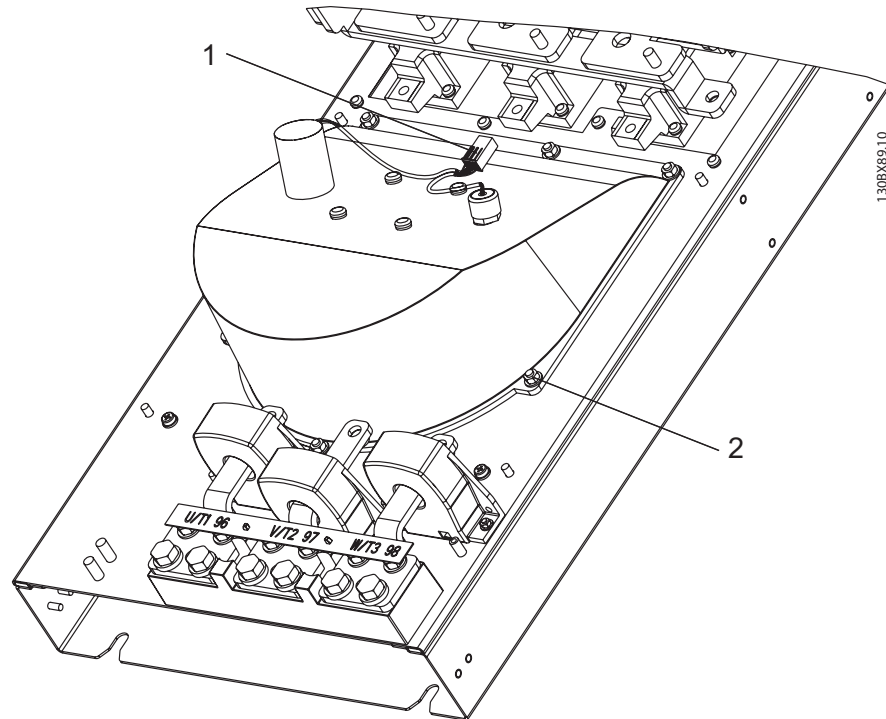


Illustration 7.20: Fan Assembly (2 of 2)

1	Inline Molex connector (Step 5)
2	Retaining nut (Step 6)

7.2.15 AC Input Terminals

1. Remove the AC input power cabling, as required.
2. Remove the R/L1, S/L2, T/L3 terminals by removing the 3 retaining screws.

Reinstall in reverse order of this procedure. Tighten the mounting nuts per specifications in the unit's instruction manual.

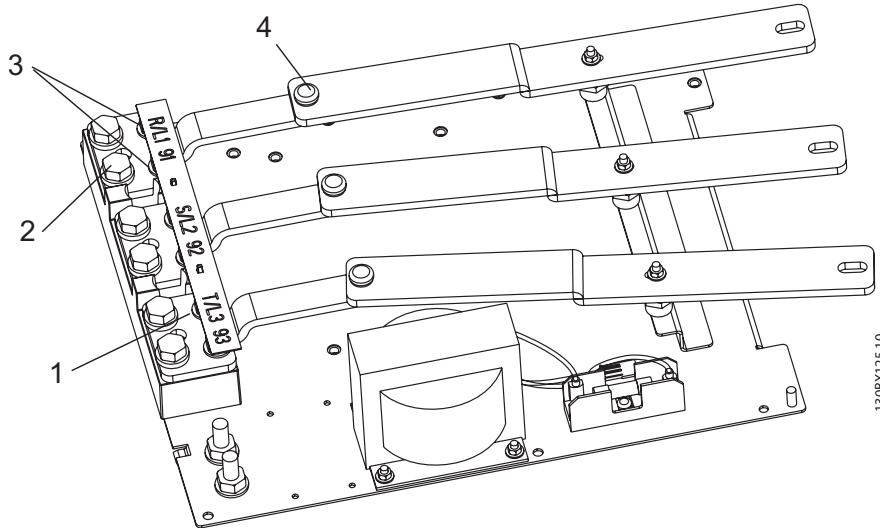


Illustration 7.21: AC Input Terminals (no options shown)

380–480V: White label on fan transformer.

525–690V: Orange label on fan transformer.

1	AC input terminal
2	AC input cable gland (Step 1)
3	Retaining screws (Step 2)
4	Retaining screw (Step 2)

7.2.16 IGBT Modules D2/D4 Units

1. Remove the capacitor banks per instructions.
2. Note the IGBT gate signal cables connected between gate drive card connectors MK100 (temperature sensor), MK102 (U), MK103 (V), and MK104 (W) and IGBTs. These will need to be reconnected in the same locations during reassembly. Units with a brake option will have brake cabling from MK105 in addition. Disconnect the cables at the connectors on the IGBT modules.
3. Remove the retaining nuts (8 mm) from the SCR input bus bars.
4. Note the colour coding for each of the three wires attached to the retaining studs. Ensure that the correct wire is attached to the applicable stud during reassembly. Remove the wiring from the studs.
5. Remove screw (T25) from terminal 1 of each SCR/diode module by accessing the screw through the access hole in the SCR/diode input bus bar. Remove the SCR input bus bars.
6. Remove each IGBT output bus bar by removing the nut (10 mm) from the stud. Also remove retaining screw (T30) at the other end of the IGBT output bus bars (not shown).

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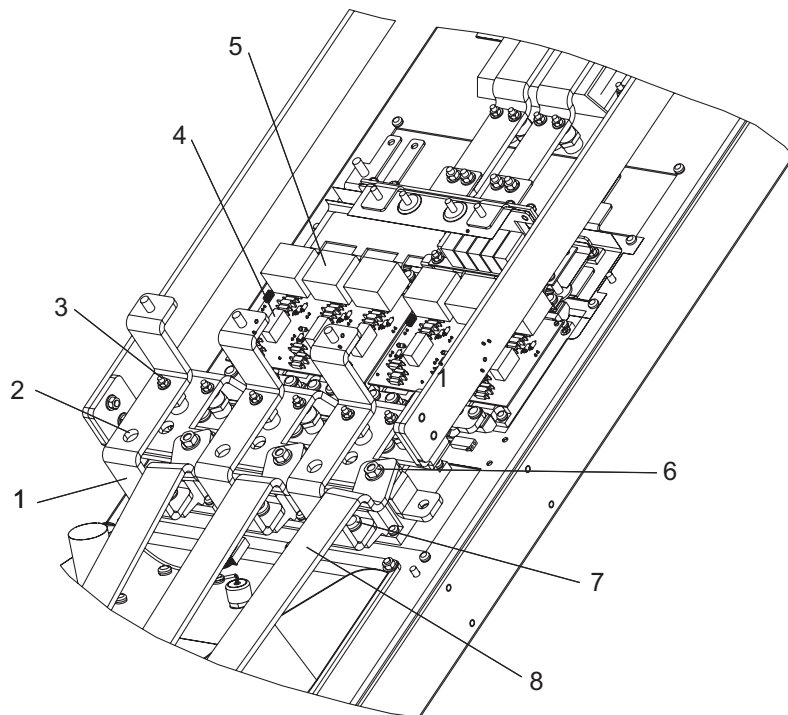


Illustration 7.22: D2/D4 IGBT Modules (1 of 3)

1	SCR/diode input bus bar BB21 or BB22 per drive power rating	5	Snubber capacitor
2	SCR/diode terminal screw (Step 5)	6	IGBT output bus bar retaining nut (Step 6)
3	SCR/diode input bus bar retaining nut and stud (Steps 3 & 4)	7	SCR/diode terminal screw (Step 5)
4	IGBT gate signal input terminal (Step 2)	8	IGBT output bus bar BB32 (Step 6)

7. Remove the 4 (10 mm) retaining nuts at the top of the IGBT bus bar assy.
8. Remove the 12 retaining screws (6 on each module) on the upper portion of the IGBT modules. These screws also attach the snubber capacitors to the IGBT modules (see Illustration 7-22, item 5 for snubber capacitor location). Remove the snubber capacitors.
9. Remove the 10 mm retaining nut from the IGBT bus bar assy.
10. Remove the IGBT bus bar assy.
11. At the bottom end of the IGBT module, remove the 12 retaining screws (4 each for U, V, and W intermediate IGBT output bus bars).
12. Remove the retaining nut (8 mm) from the 3 intermediate IGBT output bus bars. Remove the intermediate IGBT output bus bars.

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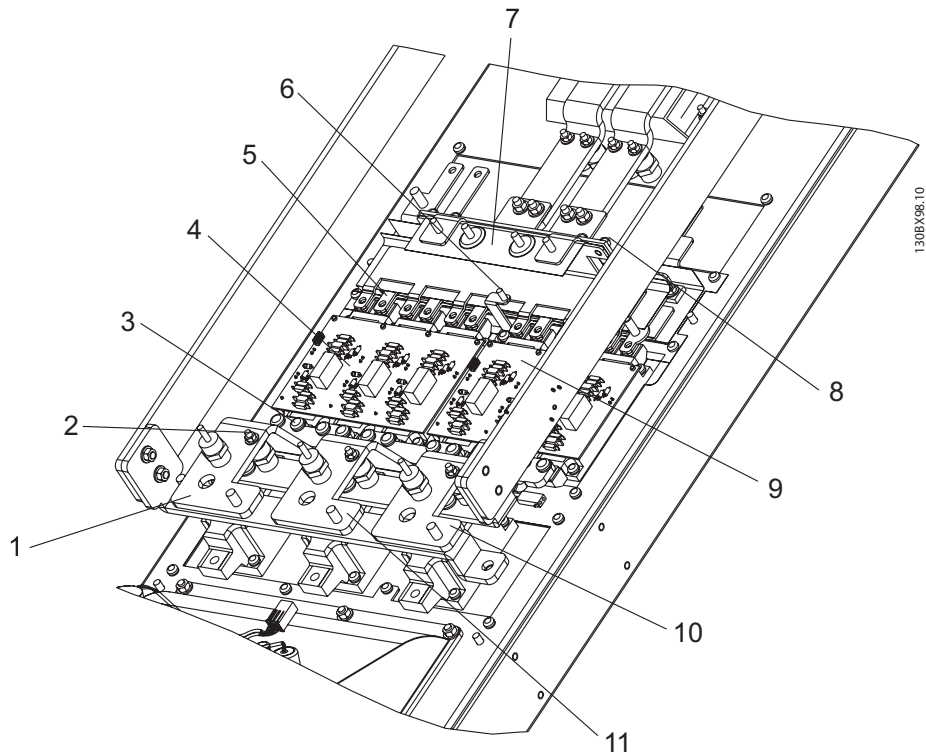


Illustration 7.23: D2/D4 IGBT Modules (2 of 3)

1	Intermediate IGBT output bus bar BB30 (Step 12)	7	IGBT bus bar assembly BB29 (Steps 7 & 10)
2	Retaining nut (Step 12)	8	Retaining nut (Step 7)
3	Retaining screws (Step 11)	9	IGBT module
4	IGBT module	10	BB30
5	Retaining screws (shown removed) (Step 8)	11	BB31
6	Retaining nut (Step 9)		

13. Remove the 2 IGBT modules by removing the 16 retaining screws (8 per module) and sliding the modules free from under the bus bars.
14. Clean the heatsink surface with a mild solvent or alcohol solution.

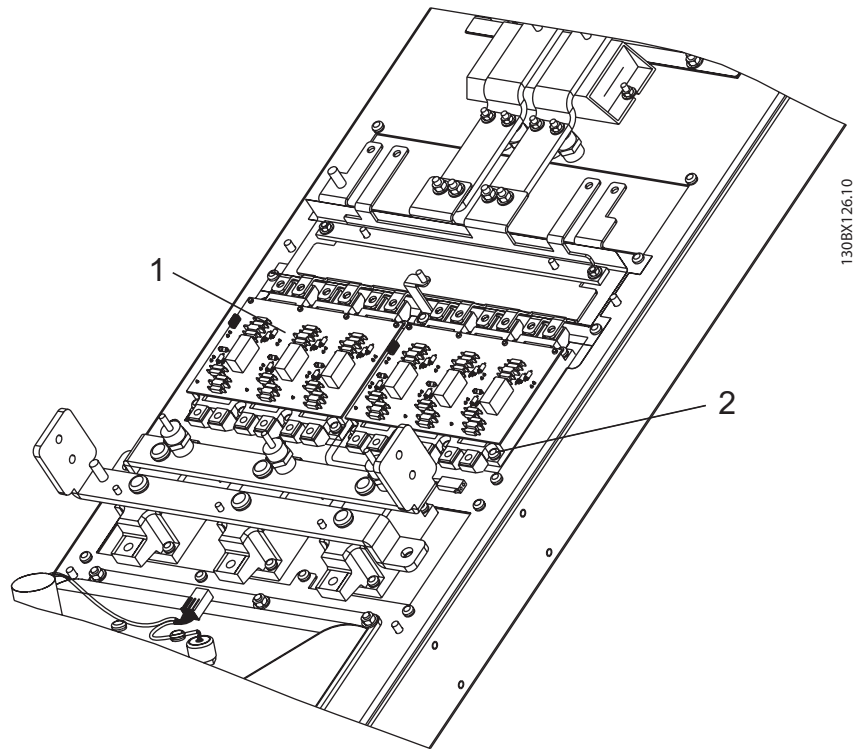


Illustration 7.24: D2/D4 IGBT Modules (3 of 3)

1	IGBT module
2	Retaining screw (Step 13)

REASSEMBLY

1. Replace the IGBT module in accordance with the instructions provided with the replacement unit.
2. Reassemble the remaining parts in reverse order of their removal.
3. Reinstall the module and mounting screws. Tighten the remaining T25 and 8 mm screws to 2.3 Nm (20 in-lbs) and T30 and 10 mm to 4 Nm (35 in-lbs).

7.2.17 IGBT Modules D1/D3 Units

1. Remove the control card cassette per instructions.
2. Remove the input terminal mounting plate per instructions.
3. Note the IGBT gate signal cables connected between the gate drive card connectors MK100 (temperature sensor), MK102 (U), MK103 (V), and MK104 (W) and the IGBT module connectors. These will need to be reconnected in the same locations during re-assembly. Units with a brake option will have brake cabling from MK105 in addition. Remove the capacitor bank per instructions.
4. Disconnect the gate drive cables at the connectors on the IGBT modules.
5. Disconnect the cable connected to connector MK100 on the high frequency card.
6. Remove the high frequency card by removing 2 retaining screws and 1 retaining nut.
 - 6a For units with a brake option, the DC input bus assembly must be removed to access and remove the bus bars between the IGBT bus bar assembly and the brake IGBT. Remove the DC input bus bar assembly per steps 3–5 of SCR/Diode Module Removal (D1 units).
 - 6b For units with brake option, remove the bus bars between the IGBT bus bar assembly and brake IGBT by removing two T25 retaining screws on brake IGBT (not shown) and two 8 mm retaining nuts on the IGBT bus bar assembly (not shown).
7. Remove the 3 IGBT output bus bars by removing the nut (10 mm) from the stud. Also remove retaining screw (T30) at the other end of the IGBT output bus bars (not shown).

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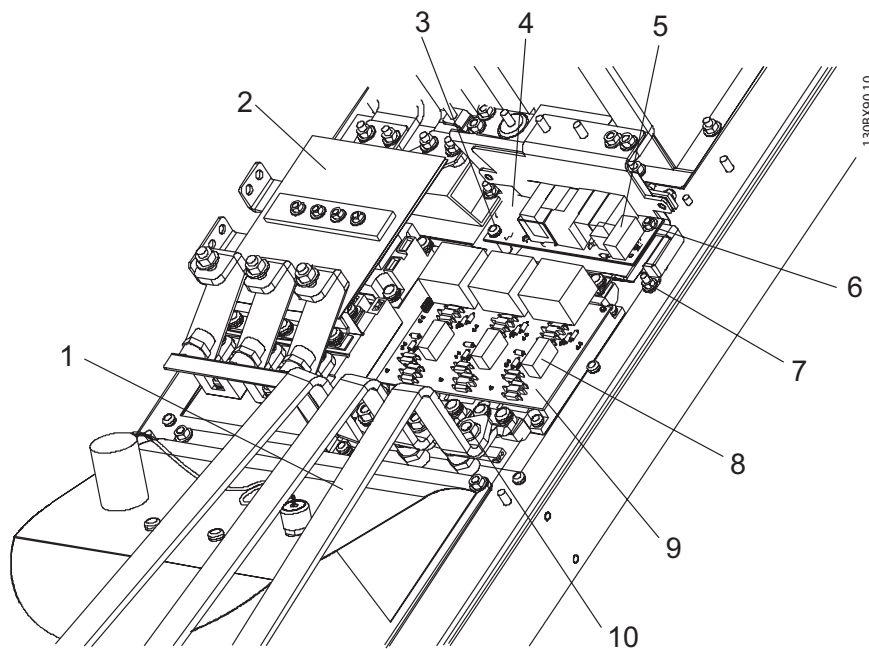


Illustration 7.25: D1/D3 IGBT Module (1 of 2)

1	IGBT output bus bar BB9 (Step 7)	6	Retaining nut (Step 6)
2	DC input bus bar assembly BB3 (Step 6A)	7	Do not remove (Step 6)
3	Retaining screw (Step 6)	8	Gate drive cable glands (Steps 3 & 4)
4	High frequency card	9	IGBT module
5	Connector MK100 (Step 5)	10	IGBT output bus bar retaining nut (Step 7)

8. Remove the 4 (10 mm) retaining nuts at the top of the IGBT bus bar assy.
9. Remove the 6 retaining screws on the upper portion of the IGBT modules. These screws also attach the snubber capacitors to the IGBT modules. Remove the 3 snubber capacitors.
10. Remove the IGBT bus bar assy.
11. At the bottom end of a IGBT module, remove the 6 retaining screws (2 each for U, V, and W intermediate IGBT output bus bars).
12. Remove the retaining nut (8 mm) from the 3 intermediate IGBT output bus bars. Remove the intermediate IGBT output bus bars.
13. Remove the IGBT module.
14. Clean the heatsink surface with a mild solvent or alcohol solution.

REASSEMBLY

1. Replace the IGBT module in accordance with the instructions enclosed with the replacement module.
2. Tighten the remaining T25 and 8 mm screws to 2.3 Nm (20 in-lbs) and T30 and 10 mm to 4 Nm (35 in-lbs).
3. Reassemble the frequency converter in reverse order of disassembly and tighten the attachment hardware in accordance with the torque tables.

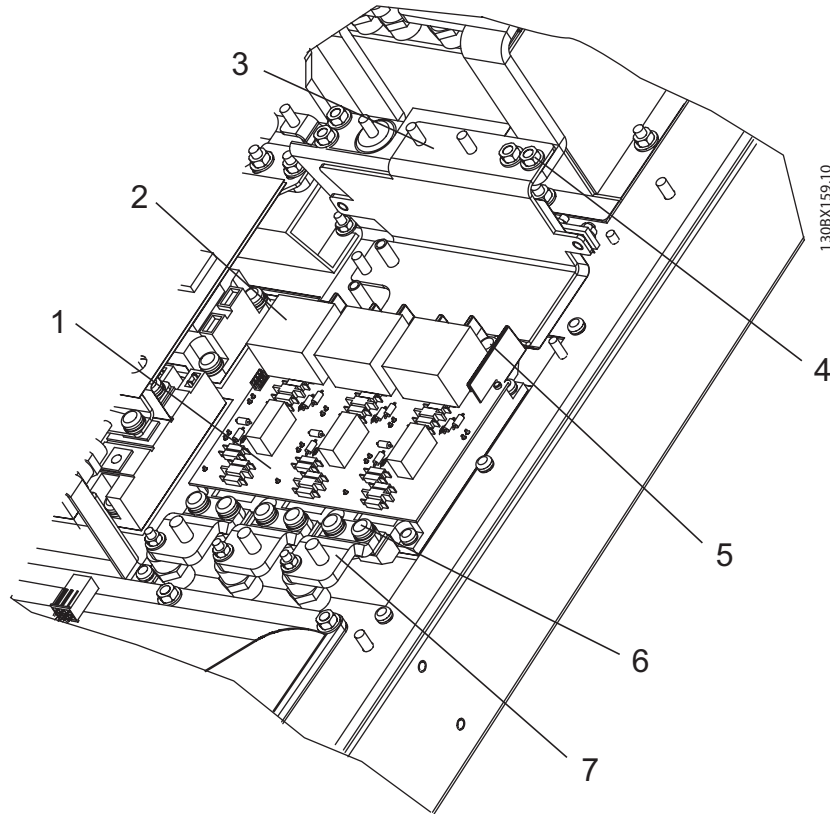


Illustration 7.26: D1/D3 IGBT Module (2 of 2)

1	IGBT module	5	Retaining screw (Step 9)
2	Snubber capacitor (Step 9)	6	Retaining nut (Step 11)
3	IGBT bus bar assembly (Step 8)	7	Intermediate IGBT output bus bar (Step 11)
4	Retaining nut (Step 8)		



8 E-Frame Sizes Disassembly and Assembly Instructions

8.1 Electrostatic Discharge (ESD)



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.

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 reduce the life, affect performance, or completely destroy sensitive electronic components.



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



NB!

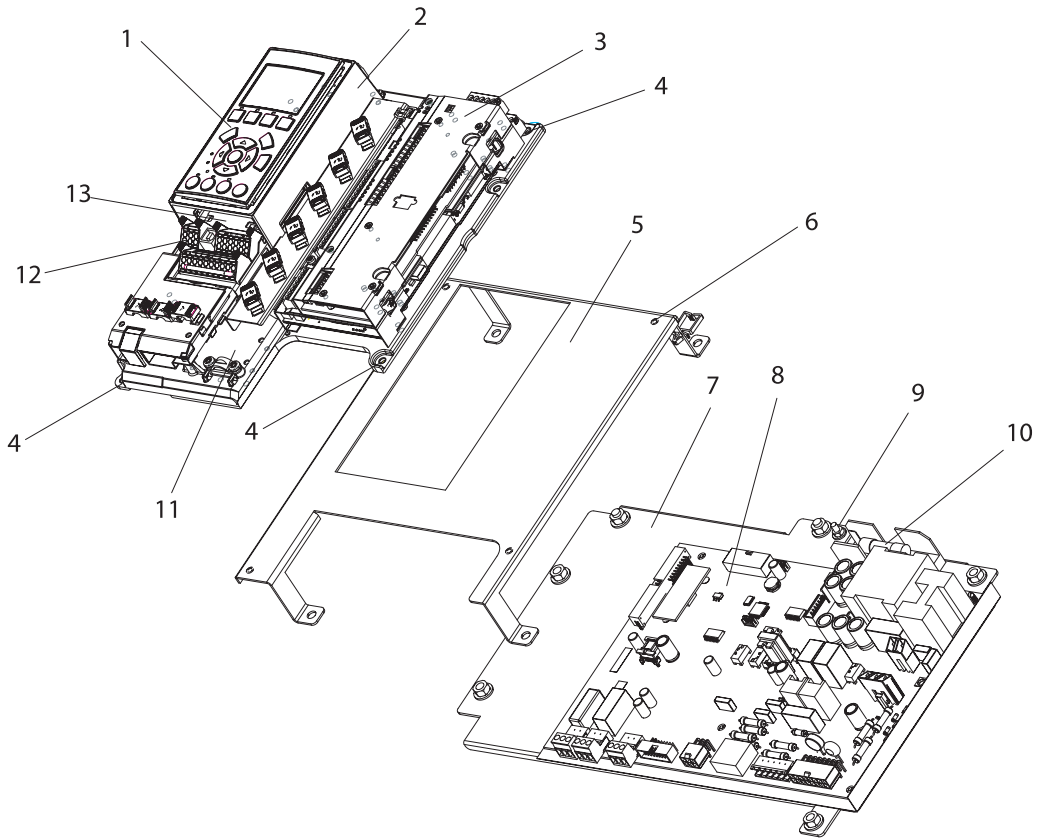
Frame size is used throughout this manual where ever procedures or components differ between frequency converters based upon the unit's physical size. Refer to the tables in the Introduction section to determine E-frame size definitions.

8.2 Instructions

8.2.1 Control Card and Control Card Mounting Plate

1. Open the front panel door or remove the front cover, depending on the unit type.
2. (See Illustration 8-1) Unplug the LCP ribbon cable (not shown) from the control card or remove the LCP, depending on the unit type. The LCP can be removed by hand.
3. Remove the LCP cradle. LCP cradle can be removed by hand.
4. Remove any customer control wiring from the control card terminal blocks.
5. Remove the 4 screws (T20 Torx) securing the control card mounting plate to the control assembly support bracket.
6. Unplug the ribbon cable from the back of the control card.

Reinstall in reverse order of this procedure. The red conductor on the ribbon cable between the control card and the power card should be on the bottom of the connector. Tighten the control card mounting plate screws to 1 Nm (8 in-lb).



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Illustration 8.1: Control Card Access

380–480/500V: Yellow tape on the main SMPS transformer in the upper right corner.

525–690V: White tape on the main SMPS transformer in the upper right corner.

1	Local control panel (LCP) (Step 2)	8	Power card PCA3
2	LCP cradle (Step 3)	9	MK102 ring lug connection
3	C-option (if installed)	10	DC bus fuse
4	Mounting screws (Step 5)	11	Control card mounting plate
5	Control assembly support bracket	12	Control card terminal block
6	Attaching hardware	13	Control card (under LCP)
7	Power card mounting plate		

8.2.2 Control Assembly Support Bracket

1. Remove the control card mounting plate in accordance with procedure.
2. Remove the 6 mounting nuts (10 mm), see Illustration 8-1.
3. Remove the control assembly support bracket.

Reinstall in reverse order of this procedure. Tighten the mounting screws to 4 Nm (35 in-lbs).

8.2.3 Power Card

1. Remove the control assembly support bracket in accordance with procedure.
2. Unplug power card connectors MK100, MK102, MK105, MK106, MK107 and MK109.
3. If customer connections are present, unplug connectors FK102, FK103, and MK112.
4. Remove the 7 mounting screws (T25 Torx) from the power card.
5. Remove the power card from the plastic standoff at the top right of the power card.
6. Remove the current scaling card from the power card by pushing in the retaining clips on the standoffs. KEEP THIS SCALING CARD FOR FUTURE REINSTALLATION OF ANY REPLACEMENT POWER CARD. The scaling card controls signals operating with this specific frequency converter. The scaling card is not part of the replacement power card.

Reinstall in reverse order of this procedure. When installing the power card, ensure that the insulator sheet is installed behind the power card. Tighten the mounting screws to 2.3 Nm (20 in-lbs).

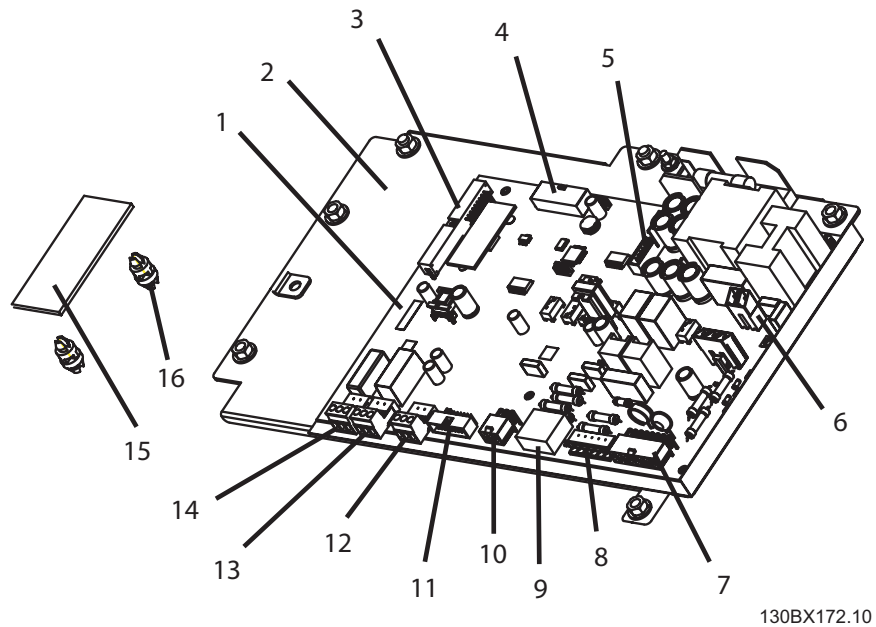


Illustration 8.1: Power Card, and Mounting Plate

380–480/500V: Yellow tape on the main SMPS transformer in the upper right corner.

525–690V: White tape on the main SMPS transformer in the upper right corner.

1	Power card PCA3	9	MK106
2	Mounting plate	10	MK100
3	MK110	11	MK109
4	MK102	12	FK102
5	MK104	13	MK112 terminals 4,5,6
6	MK105	14	MK112 terminals 1,2,3
7	MK107	15	Current scaling card PCA4
8	FK103	16	Current scaling card standoff

8.2.4 Soft Charge Card

1. Disconnect MK1, MK2, MK3, and MK4.
2. Remove the 4 mounting screws (T25) from the standoffs.
3. Remove the soft charge card. Note the insulation sheet below the soft charge card. Remove and keep the insulation with the card for reinstallation.

Reinstall by mounting the insulation onto the standoffs. Mount the soft charge card and tighten the mounting screws to 2.3 Nm (20 in-lbs).

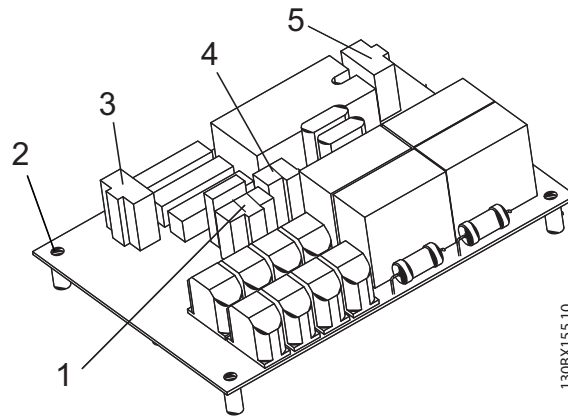


Illustration 8.1: Soft Charge Card

380–480/500V: Blue MOV and 8 PTCs.

525–690V: Red MOV and 6 PTCs.

1	MK3	4	MK4
2	Mounting screw (Step 2)	5	MK2
3	MK1		

8.2.5 Gate Drive Card

1. Disconnect the cables from connectors on the gate drive card MK100, MK102, MK103, MK104, MK106, and, if unit has a brake option, MK105, and, for 380–500 V units with an RFI filter, MK101.
2. Remove the gate drive card by removing the 6 mounting screws (T25 Torx) from the standoffs.

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

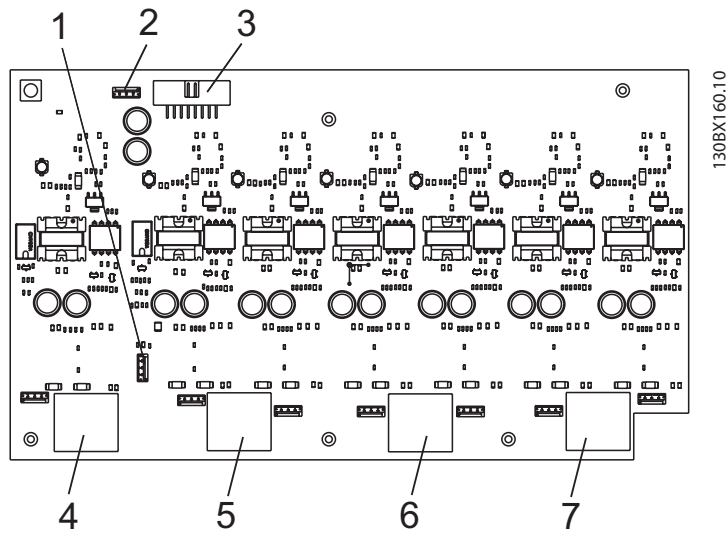


Illustration 8.1: Gate Drive Card.

1	MK100	5	MK102 (U)
2	MK101 (RFI filter)	6	MK103 (V)
3	MK106	7	MK104 (W)
4	MK105 (brake option)		

8.2.6 Capacitor Banks

Upper Capacitor Banks

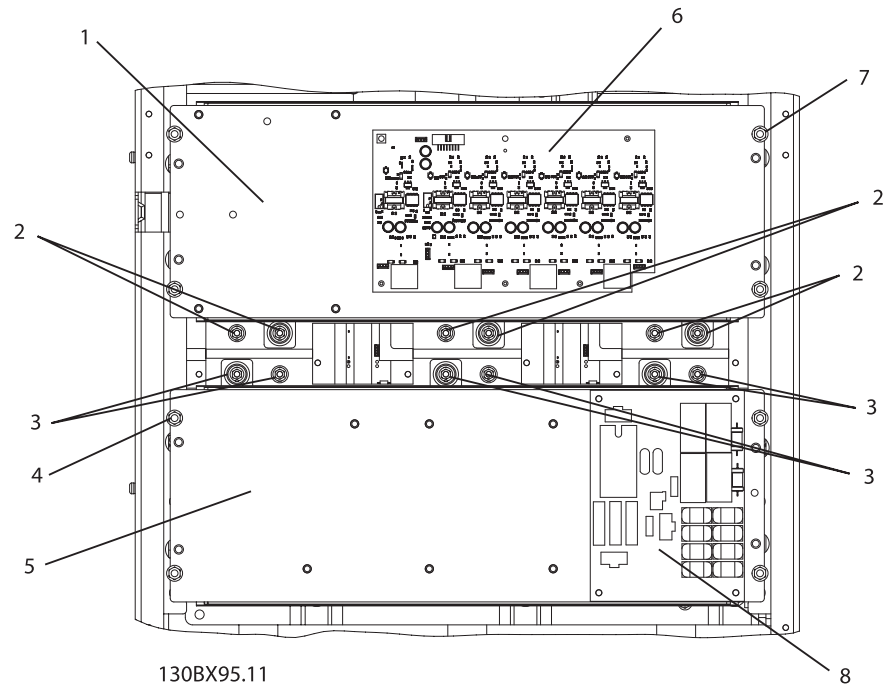
1. Remove the control assembly support bracket and the gate drive card in accordance with the instructions.
2. The capacitor bank connection to the DC bus bars can be seen recessed in the gap between the upper and the lower capacitor banks. A minimum extension of 6 inches (150 mm) is required. Remove the 6 electrical connection nuts (8 mm) for the upper capacitor bank on the DC bus bars.
3. Remove the 4 retaining nuts (10 mm) from the capacitor bank and remove the air dam.
4. Note that the weight of the capacitor bank is approximately 20 pounds (9 kg). Remove the capacitor bank by pulling free from the mounting studs.

Reinstall in reverse order of this procedure. Tighten the electrical connection nuts (8 mm) to 2.3 Nm (20 in-lbs) and the mechanical connection nuts (10 mm) to 4 Nm (35 in-lbs).

Lower Capacitor Banks

1. Remove the soft charge card in accordance with procedures.
2. The capacitor bank connection to the DC bus bars can be seen recessed in the gap between the upper and the lower capacitor banks. A minimum extension of 150 mm (6 in) is required. Remove the 6 electrical connection nuts (8 mm) for the lower capacitor bank from the DC bus bars.
3. Remove the 4 retaining nuts (10 mm) from the capacitor bank.
4. Note that the weight of the capacitor bank is approximately 9 kg (20 lbs). Remove the capacitor bank by pulling free from the mounting studs.

Reinstall in reverse order of this procedure. Note: DO NOT overtorque. Tighten the electrical connection nuts (8 mm) to 2.3 Nm (20 in-lbs) and the mechanical connection nuts (10 mm) to 4 Nm (35 in-lbs).



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Illustration 8.1: Upper and Lower Capacitor Bank Assemblies

1*	Upper capacitor bank assy	5*	Lower capacitor bank assy
2	Upper cap bank assy electrical connection nuts (Step 2)	6	Gate drive card
3	Lower cap bank assy electrical connection nuts (Step 2)		Upper cap bank assy retaining nut (Step 4)
4	Lower cap bank assy retaining nut (Step 3)	8**	Soft charge card

*380–480/500V: Blue DC Link Capacitors.

525–690V: Black DC Link Capacitors.

**380–480/500V: Blue MOV and 8 PTCs.

525–690V: Red MOV and 6 PTCs.

8.2.7 Input Terminal Mounting Plate Assy Option

The frequency converter has component options that can be mounted on the input mounting plate. This results in differing unit configurations. These options include input terminal blocks, input disconnect, RFI filter, input fuses, and an additional cooling fan. These options may need to be removed from the mounting plate assembly to reduce the weight of the assembly for ease of removal.

1. Disconnect the input power wiring from terminals L1, L2, L3, and earth connector.
2. Remove the upper most bus bar retaining nut (17 mm) from each of three terminals.
3. If a disconnect (not shown) is mounted, remove the disconnect from the terminal plate assembly to reduce the weight of the terminal plate as follows.
 - 3a Loosen the connection nut (17 mm) between the fuse and disconnect.
 - 3b Remove the 4 mounting screws (T40) from the disconnect.
 - 3c Note that the weight of the disconnect can be up to 16 kg (35 lbs). Slide disconnect down to clear fuses and remove.
4. If a cooling fan is mounted, disconnect the fan cable.
5. If an RFI filter is mounted, disconnect the RFI cable.
6. Note that the weight of the terminal plate without the disconnect can be up to 20 kg (44 lbs). To remove the terminal plate, remove the 8 retaining nuts (10 mm) from the terminal plate and lift the entire assembly from the mounting studs.

Reinstall in reverse order of this procedure. Tighten the 10 mm mounting nuts to 4 Nm (35 in-lbs), 17 mm connection nuts to 19 Nm (170 in-lbs) and T40 mounting screws to 9.5 Nm (85 in-lbs).

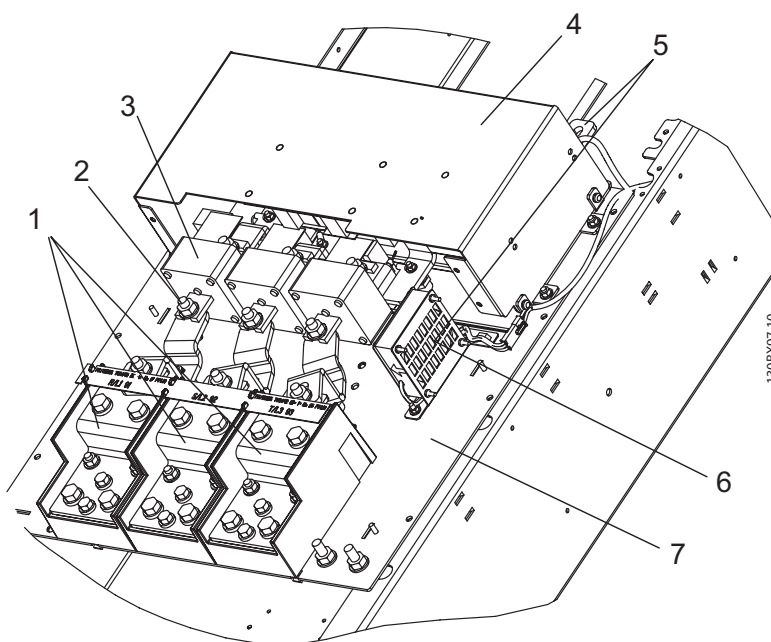


Illustration 8.1: Input Terminal Mounting Plate Assy (shown with RFI and mains fuse options)

1	Input terminals (Step 1)	5	Retaining nut (Step 2)
2	Connection nut (Step 3a)	6	Cooling fan (Step 4)
3	Fuse	7	Input terminal mounting plate
4	RFI filter assembly		

8.2.8 Soft Charge Resistor

1. Remove the input terminal plate assembly in accordance with procedure.
2. Disconnect the MK4 connector on the soft charge card.
3. Loosen top retaining nut (8 mm) on soft charge resistor.
4. Remove bottom retaining nut (8 mm) on the soft charge resistor.
5. Lift the bottom of the soft charge resistor and remove the resistor by sliding it down.

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

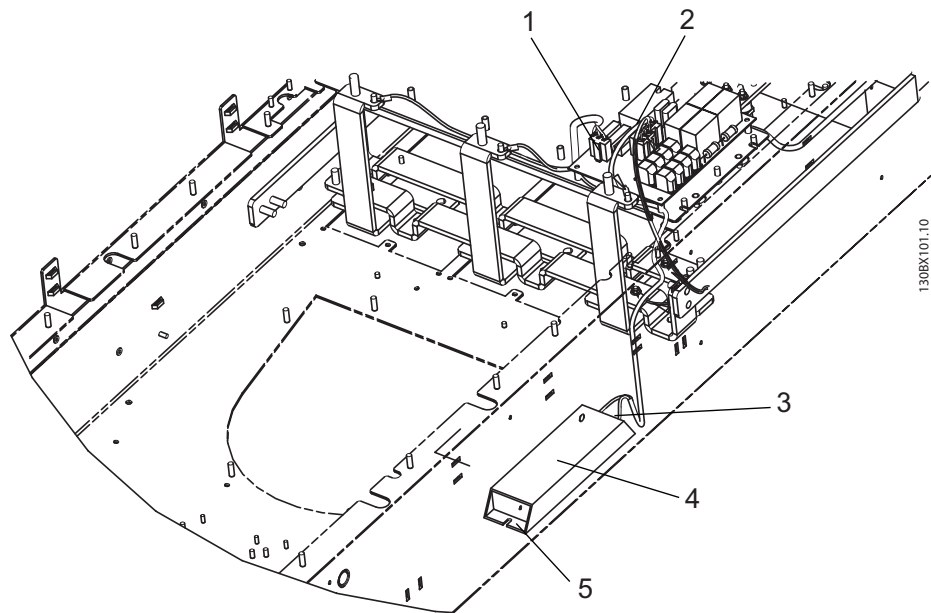


Illustration 8.1: Soft Charge Resistor

1	Soft charge card	4*	Soft charge resistor
2	MK4 connector (Step 2)	5	Bottom retaining nut (Step 4)
3	Top retaining nut (Step 3)		

*380–480/500V: Clear wire leads.

525–690V: Black wire leads.

8.2.9 SCR and Diode Modules

1. Remove the lower DC capacitor bank in accordance with procedure.
2. Remove the input terminal plate in accordance with procedure.
3. Remove the wire retaining nut (10 mm) from each of the 3 SCR input bus bars (BB41).
4. Note colour coding for each of the 3 wires attached to the retaining studs. Ensure that the correct wire is attached to the applicable stud upon reassembly. Remove the wiring from the studs.
5. Remove the wire retaining nut (8 mm) from the SCR output bus bars (BB42). One from the (+) DC bus bar and one from the (-) DC bus bar.
6. Note colour coding for each wire attached to the retaining studs. Ensure that the correct wire is attached to the applicable stud upon reassembly. Remove the wiring from the studs.
7. Remove the 4 retaining nuts (13 mm) on the side of the bus bars, 2 on each bus bar.

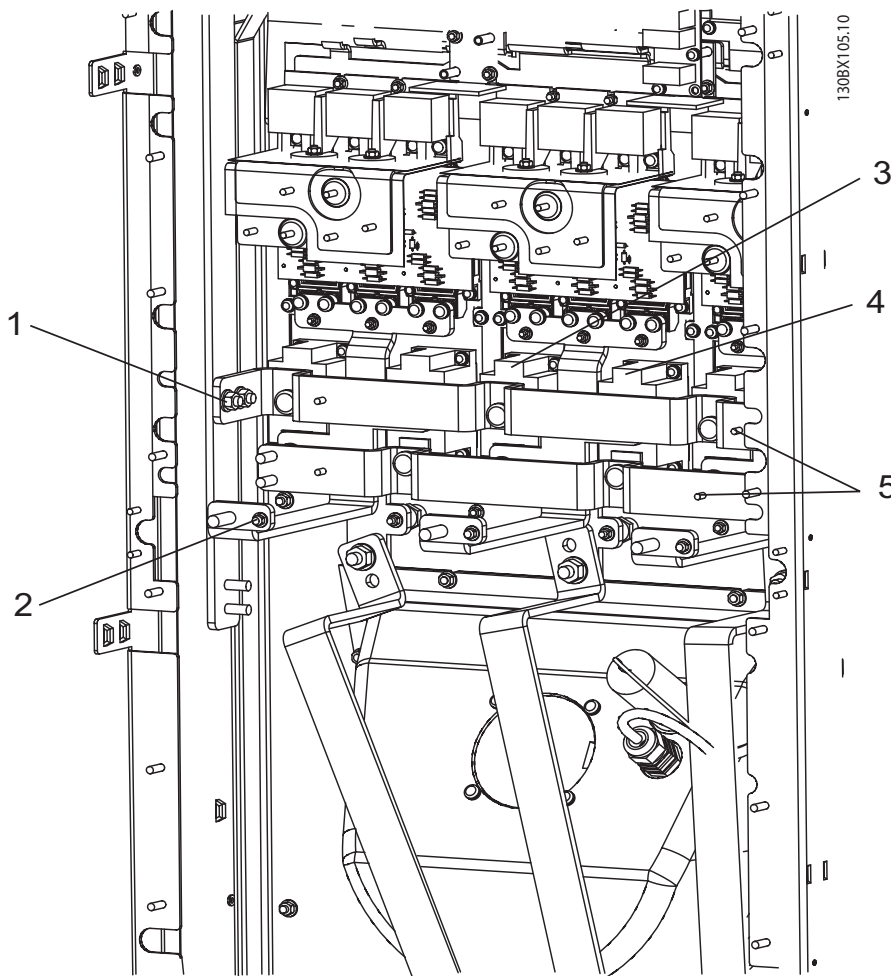


Illustration 8.1: SCR and Diode Modules (1 of 3)

1	Retaining nuts (Step 7)	4	Diode module
2	Wire retaining nut on bus bar BB41 (Step 3)	5	Wire retaining nuts for output bus bars BB42 (Steps 5 & 6)
3	SCR module		

8. If the unit is not equipped with the load sharing option, proceed to step 9. If the unit is equipped with load sharing, the load share minus (-) bus bar must be removed as follows.
 - 8a. Remove the 2 retaining nuts (13 mm) connecting the load share bus bar to the SCR output bus bar.
 - 8b. Remove the retaining nut (17 mm) connecting the load share bus bar to the load share terminal on the opposite end of the bus bar (not shown).
 - 8c. Remove the load share bus bar.
9. Remove both positive (+) and negative (-) SCR output bus bars by removing the 6 connection screws (T50). There are 3 screws per bus bar.
10. Remove the three SCR and diode input bus bars by removing the 6 connection screws (T50). There are 2 screws per bus bar.

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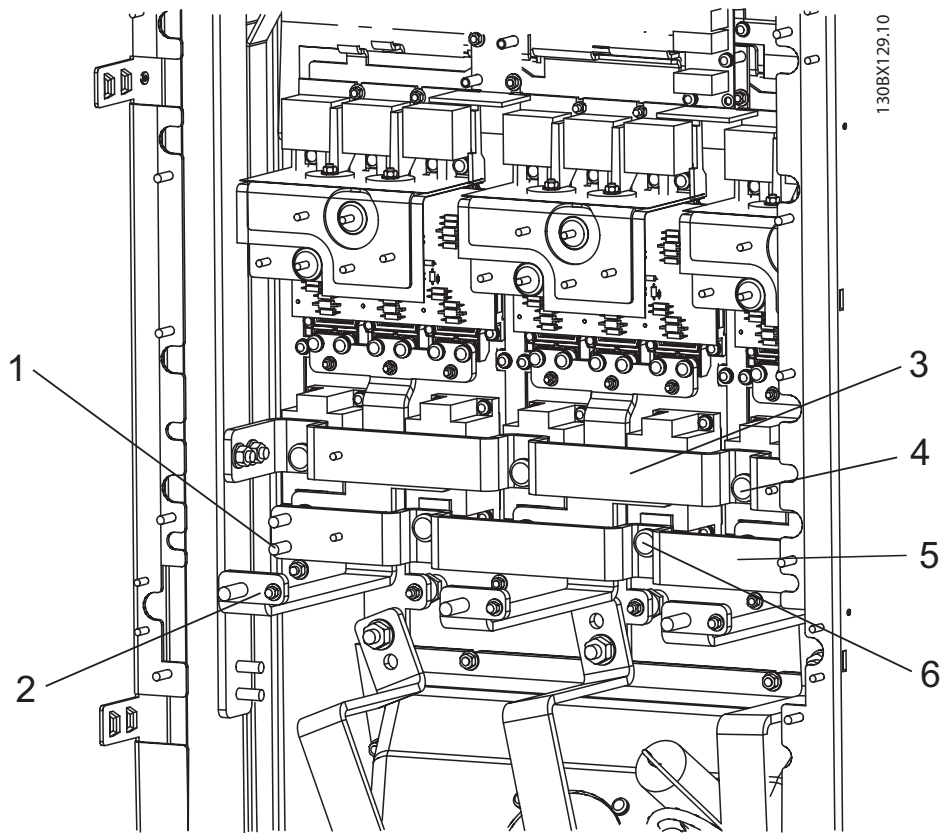


Illustration 8.1: SCR and Diode Modules (2 of 3)

1	Load sharing option retaining stud (Step 8)	4	Positive (+) output bus bar connecting screw (Step 9)
2	SCR and diode input bus bar BB41 (Step 10)	5	Negative (-) output bus bar BB42 (Step 9)
3	Positive (+) output bus bar BB42 (Step 9)	6	Negative (-) output bus bar connecting screw (Step 9)

11. Note which gate lead connects to which SCR module. Ensure that the correct wire is attached to the applicable SCR upon reassembly. Remove the wiring from each SCR module. The connector is keyed for proper reinstallation. DO NOT force the connection.
12. Remove the SCR or diode module by removing the 4 retaining screws (T25) from each module.

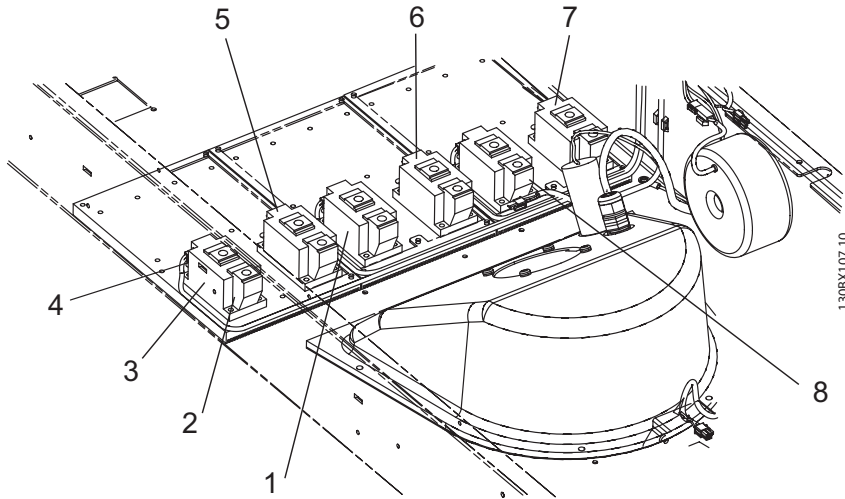




Illustration 8.1: SCR and Diode Modules (3 of 3)

1	SCR module SCR2	5	Diode module D1
2	Retaining screw (Step 12)	6	Diode module D2
3	SCR module SCR1	7	Diode module D3
4	SCR gate lead connection (Step 11)	8	SCR module SCR3

REASSEMBLY

 **Equipment Damage!**
Do not reverse the SCR and diode modules during installation. Reversing the SCR and diode modules can result in equipment damage.

 **NB!**
For each AC input phase, there is one SCR module and one diode module. The SCR is on the left, the diode on the right (as seen facing the upright unit). There are three pairs. Only the SCR module has a connection pin for the gate signals.

1. Replace SCR and diode modules in accordance with the instructions included with the replacement modules.
2. Reassemble in reverse order.

Attaching Hardware	Tightening Torque
T50	Per spare part instruction
T25	Per spare part instruction
17 mm	19 Nm (170 in-lbs)
13 mm	9.5 Nm (85 in-lbs)
10 mm	4 Nm (35 in-lbs)
8 mm	2.3 Nm (20 in-lbs)

8.2.10 Current Sensor

1. Remove the input terminal plate in accordance with procedure.
2. Remove the retaining nut (17 mm) connecting the current sensor bus bar to the motor terminal bus bar.
3. Remove the retaining nut (17 mm) or T50 screw, depending on unit type, connecting the current sensor bus bar to the IGBT via the fan bus bar.
4. Note which cable is attached to the current sensor. Ensure that the correct cable is attached upon reassembly. Unplug the cable from the current sensor being removed.
5. Remove the 2 retaining nuts (size varies with model) from the stud on the base plate, and remove the sensor.

Reinstall in reverse order of this procedure. Tighten the 17 mm retaining nuts or T50 screw to 19 Nm (170 in-lbs).

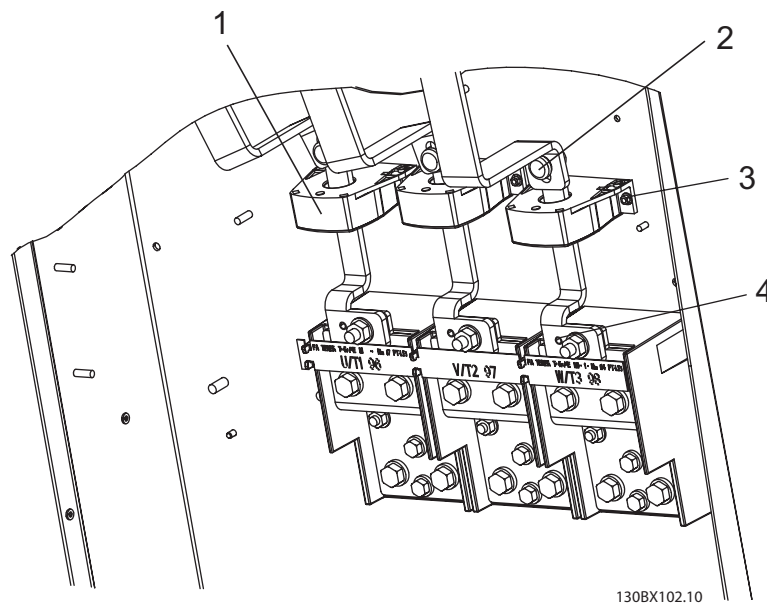


Illustration 8.1: Current Sensors

1	Current sensor	3	Current sensor mounting screws (2) (Step 5)
2	IGBT terminal bus bar mounting screw (Step 3)	4	Output motor terminal bus bar retaining nut (Step 2)

8.2.11 Heatsink Fan Assembly

1. Remove the input terminal plate in accordance with procedure.
2. Remove the retaining nut (17 mm) or T50 Torx screw, depending on the unit type, connecting each of the 3 IGBT over-fan bus bars to the 3 current sensor bus bars.
3. Remove the retaining nut (17 mm) connecting each of three IGBT over-fan bus bars to three IGBT output bus bars.
4. Disconnect the in-line Molex connector in the fan wiring. Cut the tie wrap to free the wiring from frame.
5. Remove the fan assembly by removing the 6 retaining nuts (10 mm). Note that the fan assembly weighs approximately 11 kg (25 pounds).

Reinstall in reverse order of this procedure. Tighten the 10 mm retaining nuts to 4 Nm (35 in-lbs) and the 17 mm connecting nuts or T50 screw to 19 Nm (170 in-lbs).

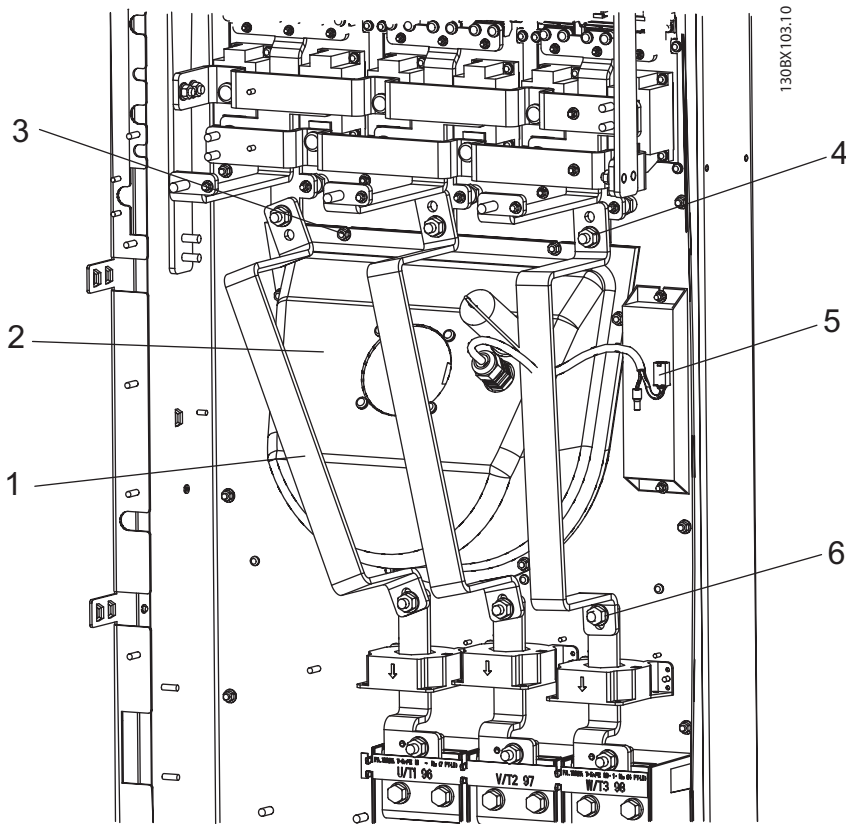


Illustration 8.1: Fan Assembly

1	IGBT output bus bar BB49	4	Retaining nut (Step 3)
2	Fan housing	5	Molex connector (Step 4)
3	Retaining nut (Step 5)	6	Retaining nut (Step 2)

8.2.12 AC Input, Motor, Load Sharing or Regen Terminals

1. Remove the external wiring from the terminals as required.
2. Remove the retaining nut (17 mm) connecting the terminal bus bar to other bus bar assemblies.
3. Remove the 2 retaining nuts (13 mm) attaching the terminal bus bar to the terminal block insulation. Slide the terminal bus bar out.
4. If the terminal block is attached to the input terminal plate (not shown), remove the retaining screw (T40) attaching the terminal block insulation, otherwise go to step 5.
5. If the terminal block is not attached to the input terminal plate, remove the retaining nut (13 mm) attaching the terminal block insulation.

Reinstall in reverse order of this procedure. Tighten the 17 mm connecting nuts to 19 Nm (170 in-lbs) and the 13 mm or T40 Torx screw to 9.5 Nm (85 in-lbs).

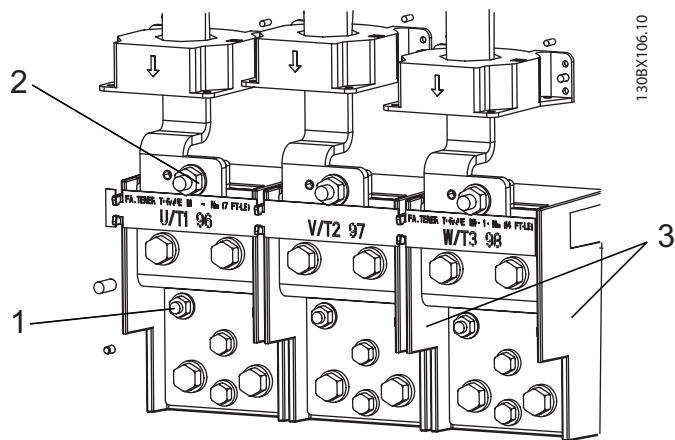


Illustration 8.1: Terminal Blocks

1	Retaining nuts (Step 3)	3	Terminal block insulation (Step 4 or 5)
2	Retaining nut (Step 2)		

8.2.13 IGBT Modules

1. Remove both DC capacitor banks in accordance with the procedure.
2. Remove the Input Terminal Plate in accordance with procedure.
3. Remove the wire retaining nut (10 mm) from each of the 3 SCR input bus bars.
4. Note colour coding for each of the 3 wires attached to the retaining studs. Ensure that the correct wire is attached to the applicable stud upon reassembly. Remove the wiring from the studs.
5. Remove the wire retaining nut (8 mm) from the SCR output bus bars. One from the (+) DC bus bar and one from the (-) DC bus bar.
6. Note colour coding for each wire attached to the retaining studs. Ensure that the correct wire is attached to the applicable stud upon reassembly. Remove the wiring from the studs.
7. Remove the 4 retaining nuts (13 mm) on the side of the bus bars, 2 on each bus bar.

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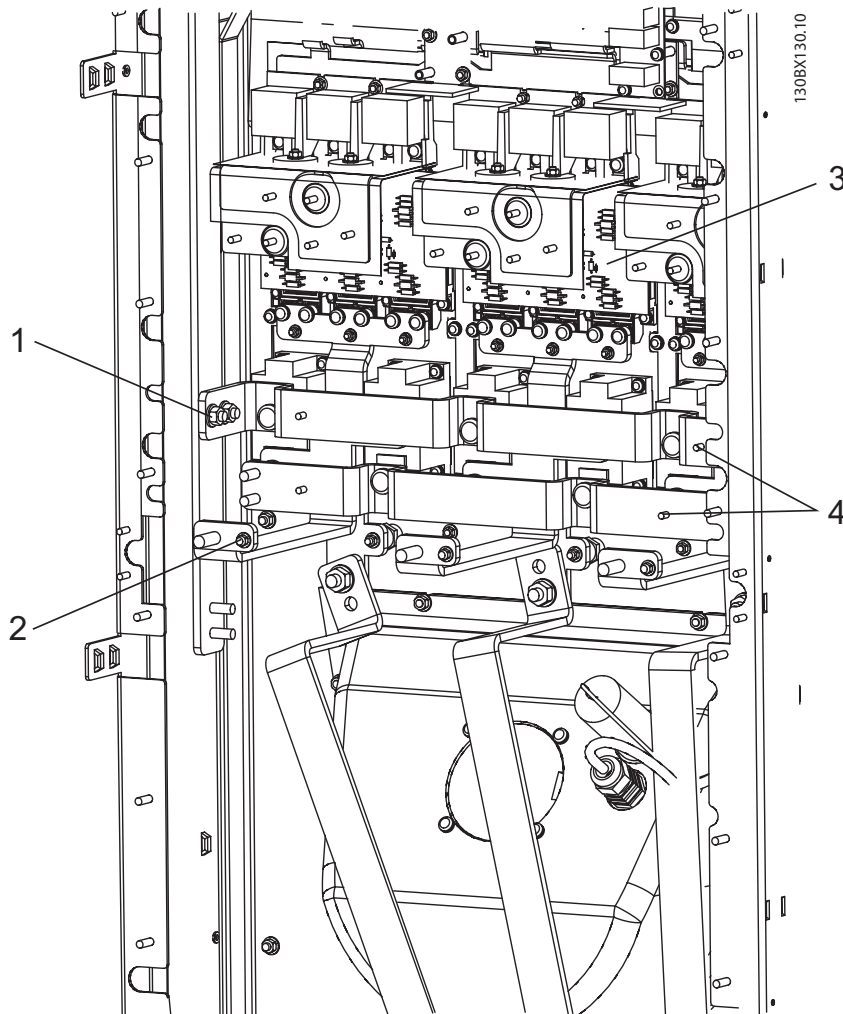


Illustration 8.1: IGBT Modules (1 of 4)

1	Retaining nuts (Step 7)	3	IGBT board
2	Wire retaining nut on bus bar BB41 (Step 3)	4	Wire retaining nuts for output bus bars BB42 (Steps 5 & 6)

8. If the unit is not equipped with the load sharing option, proceed to step 9. If the unit is equipped with load sharing, the load share minus (-) bus bar must be removed as follows.
 - 8a. Remove the 2 retaining nuts (13 mm) connecting the load share bus bar to the SCR output bus bar.
 - 8b. Remove the retaining nut (17 mm) connecting the load share bus bar to the load share terminal on the opposite end of the bus bar (not shown).
 - 8c. Remove the load share bus bar.
9. Remove both positive (+) and negative (-) SCR output bus bars by removing the 6 connection screws (T50). There are 3 screws per bus bar.
10. Remove the three SCR and diode input bus bars by removing the 6 connection screws (T50). There are 2 screws per bus bar.

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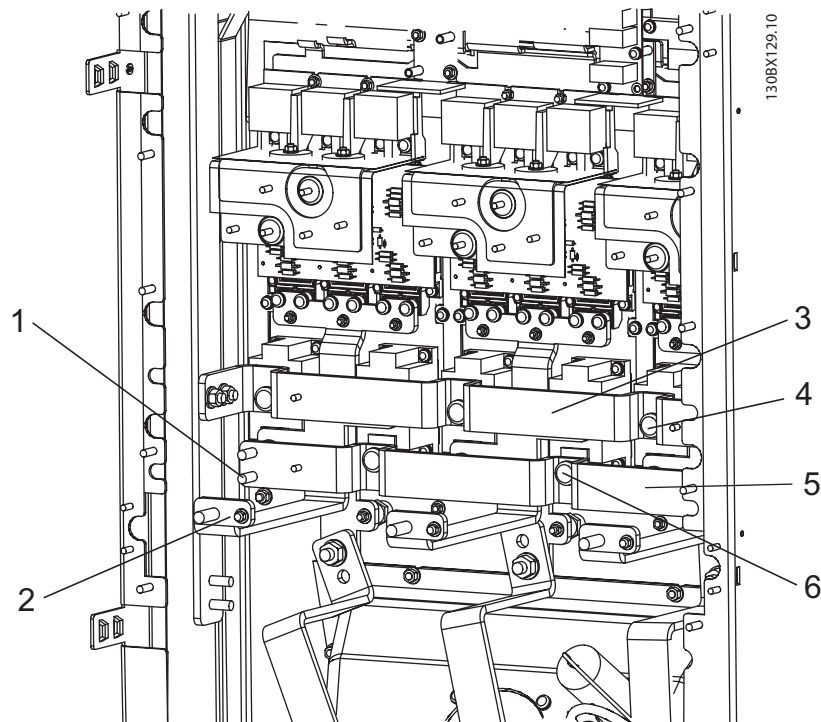


Illustration 8.1: IGBT Modules (2 of 4)

1	Load sharing option retaining studs (Step 8)	4	Positive (+) output bus bar connecting screw (Step 9)
2	SCR and diode input bus bar BB41 (Step 10)	5	Negative (-) output bus bar BB42 (Step 9)
3	Positive (+) output bus bar BB42 (Step 9)	6	Negative (-) output bus bar connecting screw (Step 9)

11. Remove the 6 retaining screws (T30) connecting each IGBT module output to the IGBT output bus bars.
12. Remove the retaining nut (17 mm) connecting the IGBT output bus bar to IGBT over-fan bus bar. Note that there is one for each of three phases.
13. Remove the retaining nut (17 mm) or T50 Torx screw, depending on the unit type, connecting to IGBT over-fan bus bar to current sensor bus bar.
14. Remove the 3 retaining nuts (17 mm) at top and one retaining nut (8 mm) at bottom attaching IGBT output bus bar to standoffs. Remove the IGBT output bus bar.

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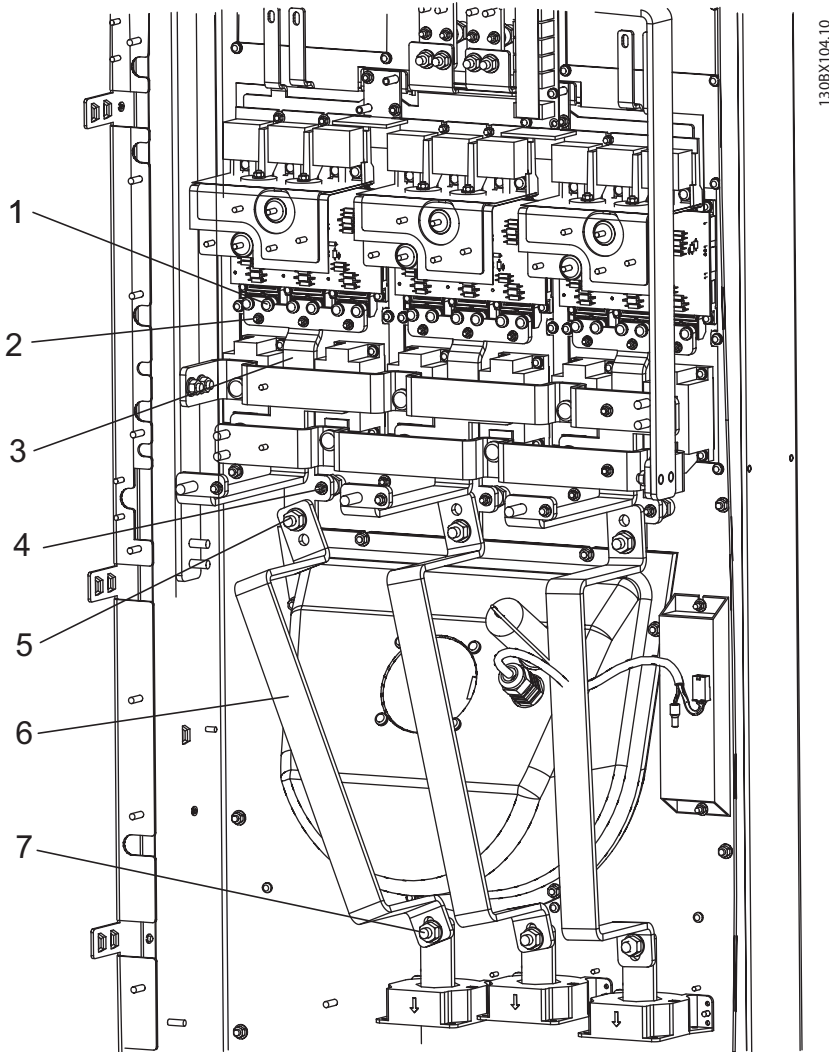


Illustration 8.1: IGBT Modules (3 of 4)

1	Retaining screw (Step 11)	5	Retaining nut (Step 12)
2	Retaining nut (Step 14)	6	Over-fan bus bar
3	Output bus bar	7	Retaining nut (Step 13)
4	Retaining nut (Step 14)		

15. Remove the 18 retaining screws (T30) on the IGBT input terminals. Note snubber capacitors come off when screws are removed. There are 6 screws for each IGBT module.
16. Remove the 2 retaining nuts (8 mm) connecting each IGBT-cap bus bar assembly to the IGBT-Ind bus bar assembly and remove the IGBT-cap bus bar assembly. There are three IGBT-cap bus bar assemblies.
17. Remove the retaining nut (8 mm) from the high frequency board.
18. Remove the 2 retaining screws (T25) from the high frequency board.
19. Disconnect the wire assembly from the high frequency board and remove the board.
20. If the unit has Brake IGBTs, remove the 4 retaining screws (T30) connecting the IGBT-Ind bus bar assembly to the Brake IGBT. Note that there are 2 screws per Brake IGBT module.
21. Remove the 4 retaining nuts (13 mm) connecting the IGBT-Ind bus bar assembly to two DC bus bars from the inductor. Remove the IGBT-Ind bus bar assembly.
22. Remove the 8 retaining screws (T25) mounting each IGBT module.

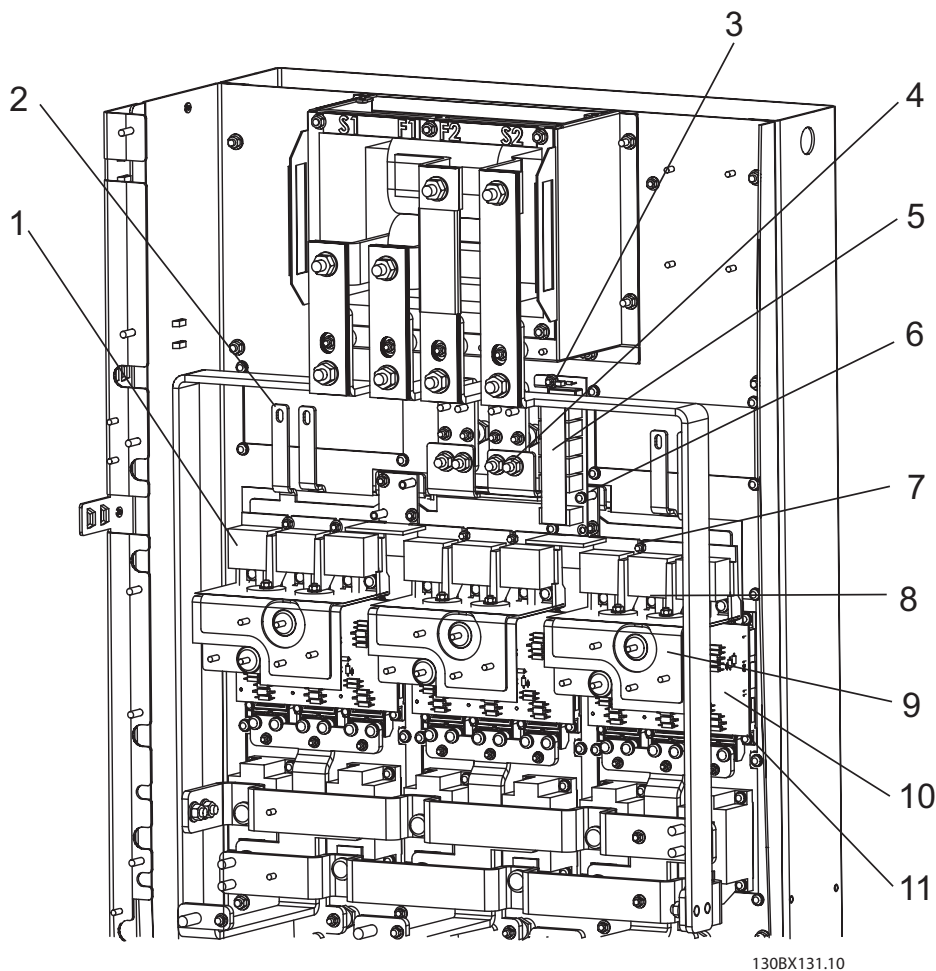


Illustration 8.1: IGBT Modules (4 of 4)

1	Snubber capacitor	7	Retaining screw (Step 16)
2	Retaining screw (Brake IGBT option) (Step 20)	8	Retaining screw (Step 15)
3	Retaining nut (Step 17)	9	IGBT-Cap bus bar BB47
4	Retaining nut (Step 21)	10	IGBT board
5	High Frequency board	11	IGBT retaining screw (Step 22)
6	Retaining screw (Step 18)		

REASSEMBLY

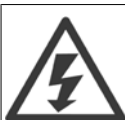
1. Replace the IGBT modules in accordance with instructions included with the replacement modules.
2. Reassemble in reverse order.

Attaching Hardware	Tightening Torque
8 mm/T25	2.3 Nm (20 in-lbs)
10 mm/T30	4 Nm (35 in-lbs)
13 mm	9.5 Nm (85 in-lbs)
17 mm/T50	19 Nm (170 in-lbs)

9 Special Test Equipment

9.1 Test Equipment

Test tools have been developed to aid in troubleshooting these products. It is highly recommended for repair and servicing this equipment that these tools be available to the technician. Without them, some troubleshooting procedures described in this manual cannot be carried out. Although some test points can be found inside the 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 Danfoss.



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.

9.1.1 Test Cables and SCR Shorting Plug Kit p/n 176F8439

This tool provides the ability to power up the Switch Mode Power Supplies (SMPS) and activate all the control functions of the frequency converter without having the DC bus capacitors charged. It provides protection for troubleshooting gate drive signals and other important control signals within the frequency converter.

The test kit includes the shorting plug and connector cables. The cable is connected between the soft charge card and the power card. The SCR shorting plug shorts the gates of the SCRs to ensure they do not fire and add a charge to the DC bus.

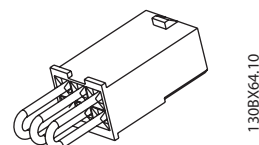


Illustration 9.1: SCR Shorting Plug



Illustration 9.2: Two-pin D-frame Test Cable



Illustration 9.3: Three-pin E-frame Test Cable

To install the cable, first make sure the frequency converter is powered down and the DC bus is fully discharged.

1. For D-frame size units, follow the procedure in Section 7 for soft charge card removal and disengage the soft charge card far enough to disconnect the cable plugged into the MK3.
2. For all frame sizes, disconnect the cable from the MK3 connector on the soft charge card and connect one end of the test cable into the MK3.
3. For D-frame size units, reinstall the soft charge card.
4. For all frame sizes, disconnect connectors MK100 and MK105 on the power card.
5. For all frame sizes, connect the free end of the test cable into MK105.
6. For all frame sizes, connect the SCR gate shorting plug into the cable that was removed from MK100.

When reapplying main input power to the frequency converter, the soft charge rectifier provides DC power to the power card. Testing with the use of the gate signal board and the signal test board can now be carried out without the presence of DC bus voltage.

9.1.2 Signal Test Board (p/n 176F8437)

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 power card connector MK104. 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. Section 6 of this manual describes when these tests would be called for and what the signal should be at that given test point.

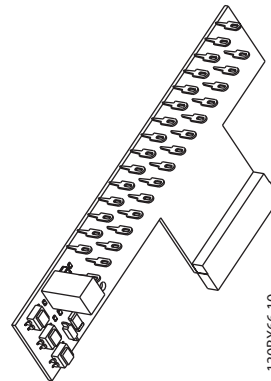
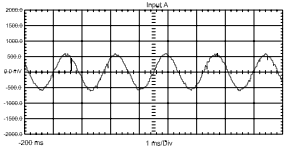
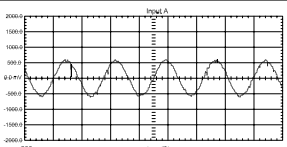
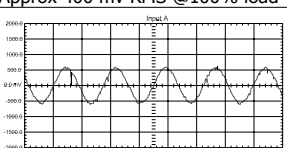
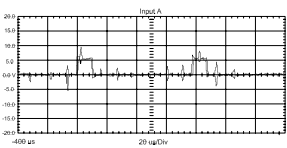
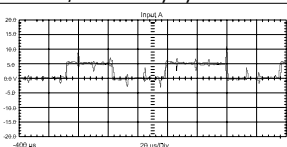
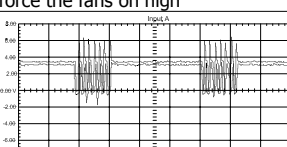


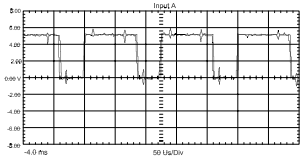
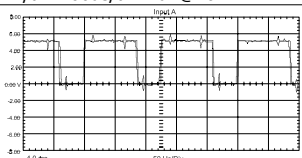
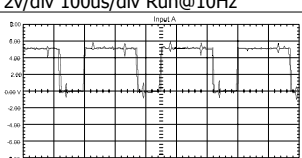
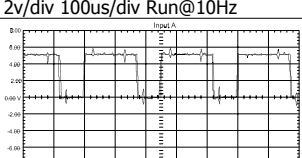
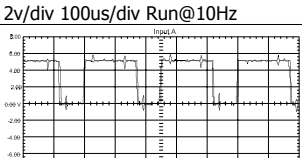
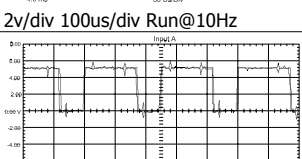
Illustration 9.4: Signal Test Board

9.1.3 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 Section 6 of this manual. Other than power supply measurements, most of the signals being measured are made up of waveforms.

Although in some cases, a digital voltmeter can be used to verify the presence of such signals, it cannot be relied upon to verify that the waveform is correct. An oscilloscope is the instrument preferred. 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	 <p>Approx 400 mv RMS @100% load</p>	.937 VACpeak @ 165% of CT current rating. AC waveform @ output frequency of the frequency converter.
2	IV1	Current sensed, V phase, not conditioned	 <p>Approx 400 mv RMS @100% load</p>	.937 VACpeak @ 165% of CT current rating. AC waveform @ output frequency of the frequency converter.
3	IW1	Current sensed, W phase, not conditioned	 <p>Approx 400 mv RMS @100% load</p>	.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	 <p>Varies w/ brake duty cycle</p>	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.	 <p>Varies w/ brake duty cycle</p>	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.	 <p>7 trigger pulses at 3Khz</p>	5VDC - fans off

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_DISS	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_DISS	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



10 Spare Parts List

10.1 Spare Parts List

10.1.1 General Notes

General Notes:

All spare parts are suitable for conformal coated frequency converters and can be used in either coated or non-conformal coated frequency converters.

Bus bars used in some units are aluminum. Spare part bus bars are always plated copper. Plated copper bus bars are useable for all units.

For the latest spare parts list, visit the Danfoss website at www.danfossdrives.com



10.1.2 Spare Parts Lists

Block Diagram Designator	Spare Part Number	Spare Part Name	Comments	380-480 VAC/380-500 VAC														
				D1/D3	D2/D4				E1/E2									
				P110	P132	P160	P200	P250	P315	P355	P400	P450						
				FC 202	P110	P132	P160	P200	P250	P315	P355	P400						
				FC 302	P90K	P110	P132	P160	P200	P250	P315	P355	P400					
		PCA																
PCA3	176F8652	Spare, power card, pdefc-xxxP110T4xxxxxUxC	Power card, conformal coated, does not include scaling card	102														
PCA3	176F8653	Spare, power card, pdefc-xxxP132T4xxxxxUxC	Power card, conformal coated, does not include scaling card		102													
PCA3	176F8654	Spare, power card, pdefc-xxxP160T4xxxxxUxC	Power card, conformal coated, does not include scaling card			102												
PCA3	176F8655	Spare, power card, pdefc-xxxP200T4xxxxxUxC	Power card, conformal coated, does not include scaling card				102											
PCA3	176F8656	Spare, power card, pdefc-xxxP250T4xxxxxUxC	Power card, conformal coated, does not include scaling card					102										
PCA3	176F8657	Spare, power card, pdefc-xxxP315T4xxxxxUxC	Power card, conformal coated, does not include scaling card						102									
PCA3	176F8658	Spare, power card, pdefc-xxxP355T4xxxxxUxC	Power card, conformal coated, does not include scaling card							102								
PCA3	176F8659	Spare, power card, pdefc-xxxP400T4xxxxxUxC	Power card, conformal coated, does not include scaling card								102							
PCA3	176F8660	Spare, power card, pdefc-xxxP450T4xxxxxUxC	Power card, conformal coated, does not include scaling card									102						
PCA3	176F8652	Spare, power card, pdefc-xxxP110T4xxxxxUxC	Power card, conformal coated, does not include scaling card	202														
PCA3	176F8653	Spare, power card, pdefc-xxxP132T4xxxxxUxC	Power card, conformal coated, does not include scaling card		202													
PCA3	176F8654	Spare, power card, pdefc-xxxP160T4xxxxxUxC	Power card, conformal coated, does not include scaling card			202												
PCA3	176F8655	Spare, power card, pdefc-xxxP200T4xxxxxUxC	Power card, conformal coated, does not include scaling card				202											
PCA3	176F8656	Spare, power card, pdefc-xxxP250T4xxxxxUxC	Power card, conformal coated, does not include scaling card					202										
PCA3	176F8657	Spare, power card, pdefc-xxxP315T4xxxxxUxC	Power card, conformal coated, does not include scaling card						202									
PCA3	176F8658	Spare, power card, pdefc-xxxP355T4xxxxxUxC	Power card, conformal coated, does not include scaling card							202								
PCA3	176F8659	Spare, power card, pdefc-xxxP400T4xxxxxUxC	Power card, conformal coated, does not include scaling card								202							
PCA3	176F8660	Spare, power card, pdefc-xxxP450T4xxxxxUxC	Power card, conformal coated, does not include scaling card									202						
PCA3	176F8643	Spare, power card, pdefc-xxxP110T5xxxxxUxC	Power card, conformal coated, does not include scaling card	302														
PCA3	176F8644	Spare, power card, pdefc-xxxP132T5xxxxxUxC	Power card, conformal coated, does not include scaling card		302													
PCA3	176F8645	Spare, power card, pdefc-xxxP160T5xxxxxUxC	Power card, conformal coated, does not include scaling card			302												
PCA3	176F8646	Spare, power card, pdefc-xxxP200T5xxxxxUxC	Power card, conformal coated, does not include scaling card				302											
PCA3	176F8647	Spare, power card, pdefc-xxxP250T5xxxxxUxC	Power card, conformal coated, does not include scaling card					302										
PCA3	176F8648	Spare, power card, pdefc-xxxP315T5xxxxxUxC	Power card, conformal coated, does not include scaling card						302									
PCA3	176F8649	Spare, power card, pdefc-xxxP355T5xxxxxUxC	Power card, conformal coated, does not include scaling card							302								
PCA3	176F8650	Spare, power card, pdefc-xxxP400T5xxxxxUxC	Power card, conformal coated, does not include scaling card								302							
PCA3	176F8651	Spare, power card, pdefc-xxxP450T5xxxxxUxC	Power card, conformal coated, does not include scaling card									302						
PCA4	176F8308	Spare, Current Scaling PCA, 4.54 Ohm	Installs on the Power Card	1														
PCA4	176F8309	Spare, Current Scaling PCA, 3.79 Ohm	Installs on the Power Card		1													
PCA4	176F8310	Spare, Current Scaling PCA, 3.10 Ohm	Installs on the Power Card			1												
PCA4	176F8311	Spare, Current Scaling PCA, 2.56 Ohm	Installs on the Power Card				1											
PCA4	176F8312	Spare, Current Scaling PCA, 5.10 Ohm	Installs on the Power Card					1										
PCA4	176F8554	Spare, Current Scaling PCA, 4.21 Ohm	Installs on the Power Card						1									
PCA4	176F8627	Spare, Current Scaling PCA, 2.32 Ohm	Installs on the Power Card															
PCA5	176F8626	Spare, FC Gate Drive PCA, CC, D&E Frame	Gate Drive Board	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PCA8	176F8307	Spare, HF PCA, T5, D&E Frame	High Frequency Board	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PCA11	176F8306	Spare, Soft-charge PCA, CC, T5, D Frame	Soft charge Board, Includes mounting bracket	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PCA11	176F8555	Spare, Soft-charge PCA, CC, T5, E Frame	Soft charge Board	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PCA9	176F8510	Spare, Balance PCA, T5, D&E Frame	Capacitor Bank Balance Card, included with spare Cap Bank	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2

Table 10.1: Spare Parts List PCA3, PCA4, PCA5, PCA8 and PCA11

380–480 VAC/380–500 VAC												
	D1/D3			D2/D4			E1/E2					
	P110	P132	P160	P110	P132	P160	P200	P250	P315	P355	P400	P450
Semiconductors												
IGBT1, 2	1	---	2	2	---	---	---	---	---	---	---	---
IGBT1,2	---	1	---	---	---	2	---	---	---	---	---	---
IGBT1,2,3	---	---	---	---	---	---	---	3	---	---	---	---
IGBT1,2,3	1	1	2	2	2	2	2	2	2	2	2	2
IGBT1,4,5	---	---	3	---	---	---	---	---	---	---	---	---
SCR1,2,3	---	---	---	---	---	---	---	---	---	---	---	---
SCR1,2,3	---	---	---	3	---	---	---	---	---	---	---	---
SCR1,2,3	---	---	---	---	---	---	3	---	---	---	---	---
SCR1,2,3	---	---	---	---	---	---	---	---	---	---	---	---
SCR1,2,3	---	---	---	---	---	---	---	---	3	---	---	---
DI,2,3	---	---	---	---	---	---	---	---	---	3	---	---
Resistors												
R1	1	1	1	1	1	1	1	1	---	---	---	---
R1	---	---	---	---	---	---	---	---	1	1	1	1
Capacitors												
C2, 3, 4, 5, 6, 7, 8, 9, 10	3	3	3	6	6	6	6	6	9	9	9	9
CBANK1,2	1	---	---	2	1	---	---	---	---	---	---	---
CBANK1,2	---	1	1	---	1	---	---	---	---	---	---	---
CBANK1,2	---	---	---	---	---	---	---	---	2	1	---	---
CBANK1,2	---	---	---	---	---	---	---	---	---	---	1	2
Fans												
F1+C1	1	1	1	1	1	1	1	1	---	---	---	---
F1+C1	---	---	---	---	---	---	---	---	1	---	---	---
F1+C1	---	---	---	---	---	---	---	---	---	1	1	1
F2,3	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54
F4	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54	21/54
F2	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00
F2,3	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00	IP00
F5	---	---	---	---	---	---	---	---	---	---	---	---

Table 10.2: Spare Parts List Semiconductors, Resistors, Capacitors and Fans

Block Designator	Diagram	Spare Part Number	Spare Part Name	Comments	380-480 VAC/380-500 VAC											
					D1/D3	D2/D4	E1/E2	P110	P132	P160	P200	P250	P315	P355	P400	P450
Fuses																
FU1,2,3		176F8334	Spare, Fuse, Main, 350A	Mains Fuse. 1 fuse per kit	3	3	---	---	---	---	---	---	---	---	---	---
FU1,2,3		176F8335	Spare, Fuse, Main, 630A	Mains Fuse. 1 fuse per kit	---	---	3	3	---	---	---	---	---	---	---	---
FU1,2,3		176F8591	Spare, Fuse, Main, 700A	Mains Fuse. 1 fuse per kit	---	---	---	---	---	3	---	---	---	---	---	---
FU1,2,3		176F8592	Spare, Fuse, Main, 900A	Mains Fuse. 1 fuse per kit	---	---	---	---	---	---	---	3	---	---	---	---
FU5		176F8336	Spare, Fuse, Soft charge, 20A, PKG3, D&E Frame	Soft charge fuse. Package of 3	1	1	1	1	1	1	1	1	1	1	1	1
FU4		176F8440	Spare, Fuse, 4A, PKG3, Power PCA, Fan	Power Card Fuse, 4 amp. Package of 3	1	1	1	1	1	1	1	1	1	1	1	1
FU4		176F8440	Spare, Fuse, 4A, PKG3, Power PCA, Fan	Fan Transformer Fuse, 4 amp. Package of 3	1	1	1	1	1	1	1	1	1	1	1	1
FU4		176F8609	Spare, Fuse, 15A, PKG3, Fan, E Frame	Fan Transformer Fuse, 15 amp. Package of 3	---	---	---	---	---	---	---	---	---	---	---	---
Inductors and Current Sensors																
L1		176F8337	Spare, Bus Inductor, 200uH	DC Link Coil, Small D Frame	1	---	---	---	---	---	---	---	---	---	---	---
L1		176F8338	Spare, Bus Inductor, 157uH	DC Link Coil, Small D Frame	---	1	---	---	---	---	---	---	---	---	---	---
L1		176F8339	Spare, Bus Inductor, 136uH	DC Link Coil, Large D Frame	---	---	1	---	---	---	---	---	---	---	---	---
L1		176F8340	Spare, Bus Inductor, 109uH	DC Link Coil, Large D Frame	---	---	---	1	---	---	---	---	---	---	---	---
L1		176F8341	Spare, Bus Inductor, 87uH	DC Link Coil, Large D Frame	---	---	---	---	1	---	---	---	---	---	---	---
L1		176F8564	Spare, Bus Inductor, 62uH, E Frame	DC Link Coil, E Frame	---	---	---	---	---	---	1	---	---	---	---	---
L1		176F8565	Spare, Bus Inductor, 51uH, E Frame	DC Link Coil, E Frame	---	---	---	---	---	---	---	---	1	---	---	---
L2,3,4		176F8342	Spare, Current Sensor, 300A	Motor Current Sensor, 1 sensor per kit	3	3	3	3	---	---	---	---	---	---	---	---
L2,3,4		176F8343	Spare, Current Sensor, 500A	Motor Current Sensor, 1 sensor per kit	---	---	---	---	3	---	---	---	---	---	---	---
L2,3,4		176F8563	Spare, Current Sensor, 1000A	Motor Current Sensor, 1 sensor per kit	---	---	---	---	---	---	---	---	3	---	---	---
TR1		176F8344	Spare, Fan Transformer Assy, 500V	Fan Transformer. Includes cables and plug	1	1	1	1	1	---	---	---	---	---	---	---
TR1		176F8566	Spare, Fan Transformer Assy, 5352T5	Fan Transformer. Includes cables and plug	---	---	---	---	---	---	---	---	---	1	---	---
TR1		176F8567	Spare, Fan Transformer Assy, 1500VA	Fan Transformer. Includes cables and plug	---	---	---	---	---	---	---	---	---	---	1	---
L5		176F8577	Spare, Heatsink Fan Inductor, E Frame	Fan Inductor	---	---	---	---	---	---	---	---	---	---	1	---
Disconnects																
SW1		176F8345	Spare, Disconnect SW, 200A, D Frame	Disconnect Switch	1	1	---	---	---	---	---	---	---	---	---	---
SW1		176F8347	Spare, Disconnect SW, 400A, D Frame	Disconnect Switch	---	---	---	1	1	---	---	---	---	---	---	---
SW1		176F8593	Spare, Disconnect SW, 600A, E Frame	Disconnect Switch	---	---	---	---	---	---	---	---	1	---	---	---
SW1		176F8594	Spare, Disconnect SW, 800A, E Frame	Disconnect Switch	---	---	---	---	---	---	---	---	---	---	1	---
		176F8346	Spare, Disconnect Handle, Rod, D Frame	Disconnect Handle	1	1	---	---	---	---	---	---	---	---	---	---
		176F8348	Spare, Disconnect Handle, Rod, D2&E Frame	Disconnect Handle	---	---	---	1	1	1	1	1	1	1	1	1

Table 10.3: Spare Parts List Fuses, Inductors & Current Sensors and Disconnects

Block Designator	Di-Spare Parts Number	Spare Parts Name	Comments	380–480 VAC/380–500 VAC											
				D1/D3			D2/D4			E1/E2					
				P110	P132	P160	P200	P250	P315	P355	P400	P450			
				FC 202	P110	P132	P160	P200	P250	P315	P355	P400	P450		
				FC 302	P90K	P110	P132	P160	P200	P250	P315	P355	P400		
Cables															
CBL1	176F8640	Spare, Cable, FC LCP, D Frame, IP54	ribbon cable from the LCP to the control card, IP54 enclosure	IP54	IP54	IP54	IP54	IP54	IP54	---	---	---	---		
CBL1	176F85861 76F8586	Spare, Cable, LCP, E Frame	ribbon cable from LCP to control card	---	---	---	---	---	---	1	1	1	1		
CBL2	176F8641	Spare, Cable, Control PCA, 44pin, D&E Frame	ribbon cable from control card to power card	1	1	1	1	1	1	1	1	1	1		
CBL5	176F8541	Spare, Cable, FC Current Sensor, D2 Frame	wire harness from power card to current sensors	1	1	---	---	---	---	---	---	---	---		
CBL5	176F8349	Spare, Cable, FC Current Sensor, D Frame	wire harness from power card to current sensors	---	---	1	1	1	1	---	---	---	---		
CBL5	176F8568	Spare, Cable, FC I-Sensor, small E Frame	wire harness from power card to current sensors	---	---	---	---	---	---	1	---	---	---		
CBL5	176F8569	Spare, Cable, FC I-Sensor, large E Frame	wire harness from power card to current sensors	---	---	---	---	---	---	---	1	---	---		
CBL8	176F8542	Spare, Cable, HS Fan, D1 Frame	wire harness from the power card to the fan transformer	1	1	---	---	---	---	---	---	---	---		
CBL8	176F8359	Spare, Cable, HS Fan, D2 Frame	wire harness from the power card to the fan transformer	---	---	1	1	1	1	---	---	---	---		
CBL8	176F8571	Spare, Cable, Fan, IP00, small E Frame	wire harness for all AC fans on IP00 units	---	---	---	---	---	---	IP00	---	---	---		
CBL8	176F8572	Spare, Cable, Fan, IP21/54, small E Frame	wire harness for all AC fans on IP21 and IP54 units	---	---	---	---	---	---	---	21/54	---	---		
CBL8	176F8573	Spare, Cable, Fan, IP00, large E Frame	wire harness for all AC fans on IP00 units	---	---	---	---	---	---	---	IP00	IP00	IP00		
CBL8	176F8574	Spare, Cable, Fan, IP21/54, large E Frame	wire harness for all AC fans on IP21 and IP54 units	---	---	---	---	---	---	---	---	21/54	21/54		
CBL9	176F8354	Spare, Cable, Softchg RST prime, D Frame	wire harness from soft charge to power card	1	1	1	1	1	1	---	---	---	---		
CBL9	176F8570	Spare, Cable, Softchg RST prime, E Frame	wire harness from soft charge to power card	---	---	---	---	---	---	---	---	---	---		
CBL12	176F8358	Spare, Cable, Door Fan, D Frame	wire harness for AC door fans	21/54	21/54	21/54	21/54	21/54	21/54	---	---	---	---		
CBL13	176F8544	Spare, Cable, FC SCR, D1 Frame	wire harness from power card to SCR	1	1	---	---	---	---	---	---	---	---		
CBL13	176F8357	Spare, Cable, FC SCR, D2 Frame	wire harness from power card to SCR	---	---	1	1	1	1	---	---	---	---		
CBL13	176F8575	Spare, Cable, FC SCR, E Frame	wire harness from power card to SCR	---	---	---	---	---	---	1	1	1	1		
CBL14	176F8356	Spare, Cable, DC to Power PCA, DFrame	voltage from DC bus to power card	1	1	1	1	1	1	---	---	---	---		
CBL14	176F85761 76F8576	Spare, Cable, DC to Power PCA, E Frame	voltage from DC bus to power card	---	---	---	---	---	---	1	1	1	1		
CBL15	176F8830	Spare, Cable, RFI Switch, D Frame	wire from gate drive card to RFI filter	1	1	1	1	1	1	---	---	---	---		
CBL15	176F8580	Spare, Cable, RFI Switch, E Frame	wire from gate drive card to RFI filter	---	---	---	---	---	---	1	1	1	1		
CBL16	176F8363	Spare, Cable, FC Gate Drive, 16pin, D1 Frame	ribbon cable from power card to gate drive card	1	1	---	---	---	---	---	---	---	---		
CBL16	176F8350	Spare, Cable, FC Gate Drive, 16pin, D2 Frame	ribbon cable from power card to gate drive card	---	---	1	1	1	1	---	---	---	---		
CBL16	176F8581	Spare, Cable, FC Gate Drive, 16pin, E Frame	ribbon cable from power card to gate drive card	---	---	---	---	---	---	1	1	1	1		
CBL17,18,19	176F8364	Spare, Cable, IGBT Gate, D1 Frame	wire harness from gate drive card to IGBT module (1 per kit)	3	3	---	---	---	---	---	---	---	---		
CBL17,18,19	176F8351	Spare, Cable, IGBT Gate, D2 Frame	wire harness from gate drive card to IGBT module (1 per kit)	---	---	3	3	3	3	---	---	---	---		
CBL17,18,19	176F8582	Spare, Cable, IGBT Gate, E1 Frame	wire harness from gate drive card to IGBT module (1 per kit)	---	---	---	---	---	---	3	3	3	3		
CBL20	176F8352	Spare, Cable, IGBT Temperature	temperature connection from IGBT module to gate drive card	1	1	1	1	1	1	1	1	1	1		
CBL21	176F8365	Spare, Cable, Brake IGBT, D2 Frame	wire harness from gate drive card to brake IGBT module	1	1	---	---	---	---	---	---	---	---		
CBL21	176F8368	Spare, Cable, Brake IGBT, D Frame	wire harness from gate drive card to brake IGBT module	---	---	1	1	1	1	---	---	---	---		
CBL21	176F8583	Spare, Cable, Brake IGBT, E Frame	wire harness from gate drive card to brake IGBT module	---	---	---	---	---	---	1	1	1	1		

Table 10.4: Spare Parts List Cables

Block Diagram Designator	Spare Parts Number	Spare Parts Name	Comments	380-480 VAC/380-500 VAC											
				D1/D3			D2/D4			E1/E2					
				P110	P132	P160	P160	P200	P250	P315	P355	P400	P450	P450	P400
				FC 202	P110	P132	P160	P160	P200	P250	P315	P355	P400	P450	
				FC 302	P90K	P110	P132	P160	P200	P250	P315	P355	P400	P400	
		Cables													
CBL22	176F8366	Spare, Cable, Brake Power Plus, D1 Frame	cable from brake IGBT to brake plus terminal		1	1	---	---	---	---	---	---	---	---	---
CBL22	176F8369	Spare, Cable, Brake Power Plus, D2 Frame	cable from brake IGBT to brake plus terminal		---	---	1	1	1	---	---	---	---	---	---
CBL23	176F8367	Spare, Cable, Brake Power Minus, D1 Frame	cable from brake IGBT to brake minus terminal		1	1	---	---	---	---	---	---	---	---	---
CBL23	176F8370	Spare, Cable, Brake Power Minus, D2 Frame	cable from brake IGBT to brake minus terminal		---	---	1	1	1	---	---	---	---	---	---
CBL24	176F8543	Spare, Cable, Softchg RST, D1 Frame	wire harness from input power to soft charge board		1	1	---	---	---	---	---	---	---	---	---
CBL24	176F8353	Spare, Cable, Softchg RST, D2 Frame	wire harness from input power to soft charge board		---	---	1	1	1	---	---	---	---	---	---
CBL24	176F8584	Spare, Cable, Softchg RST, E Frame	wire harness from input power to soft charge board		---	---	---	---	---	1	1	1	1	1	1
CBL25	176F8355	Spare, Cable, Softchg to DC bus, D Frame	wire harness from soft charge to DC bus		1	1	1	1	1	---	---	---	---	---	---
CBL25	176F8585	Spare, Cable, Softchg to DC bus, E Frame	wire harness from soft charge to DC bus		---	---	---	---	---	1	1	1	1	1	1
CBL26	176F8613	Spare, Cable, FC Fuse Fan, E Frame	cable from power card to fan fuse		---	---	---	---	---	---	1	1	1	1	1

Table 10.5: Spare Parts List Cables

Block Diagram Designator	Spare Parts Number	Spare Parts Name	Comments	380-480 VAC/380-500 VAC																					
				D1/D3	D2/D4			E1/E2																	
		Terminals, Labels, Insulators																							
TB1	176F8374	Spare, BB, Terminals, Mains, Motor, D Frame	mains terminal bus bar (1 per kit)																						
TB1	176F8375	Spare, BB, Terminals, Mains, Motor, D Frame	mains terminal bus bar (1 per kit)																						
TB1	176F8587	Spare, BB, Terminal Block, E Frame	mains terminal stepped bus bar (1 per kit)																						
TB2	176F8374	Spare, BB, Terminals, Mains, Motor, D Frame	motor terminal bus bar (1 per kit)																						
TB2	176F8375	Spare, BB, Terminals, Mains, Motor, D Frame	motor terminal bus bar (1 per kit)																						
TB2	176F8587	Spare, BB, Terminal Block, E Frame	motor terminal stepped bus bar (1 per kit)																						
TB3	176F83956	Spare, BB, Terminal, LS, BK, D Frame	brake terminal bus bar (1 per kit)																						
	KAF6H8395																								
TB3	176F8399	Spare, BB, Terminal, LS, LT, D Frame	left brake terminal bus bar																						
TB3	176F8404	Spare, BB, Load Share, 2, D Frame	right brake terminal bus bar																						
TB4	176F8395	Spare, BB, Terminal, LS, BK, D Frame	load share terminal bus bar (1 per kit)																						
TB4	176F8399	Spare, BB, Terminal, LS, LT, D Frame	left load share terminal bus bar																						
TB4	176F8404	Spare, BB, Load Share, 2, D Frame	right load share terminal bus bar																						
TB4	176F8587	Spare, BB, Terminal Block, E Frame	load share terminal stepped bus bar (1 per kit)																						
TB1	176F8371	Spare, Terminal, Insul., mains, motor, D Frame	mains terminal insulation block																						
TB1	176F8588	Spare, Insul, Terminal Block, E Frame	mains terminal insulation block (1 per kit)																						
TB2	176F8371	Spare, Terminal, Insul., mains, motor, D Frame	motor terminal insulation block																						
TB2	176F8588	Spare, Insul, Terminal Block, E Frame	motor terminal insulation block (1 per kit)																						
TB3	176F8372	Spare, Terminal, Insul., Brk, LD Shr, D Frame	brake terminal insulation block																						
TB4	176F8372	Spare, Terminal, Insul., Brk, LD Shr, D Frame	load share terminal insulation block																						
TB4	176F8588	Spare, Insul, Terminal Block, E Frame	load share terminal insulation block (1 per kit)																						
TB4	176F8373	Spare, Label Set, Terminal Blk, D Frame	terminal block label set includes mains, motor, brake, load share																						
	176F85896	Spare, Label Set, Terminal, EFrame	terminal block label set includes mains, motor, brake, load share																						
	KAF6H8589																								
	176F8545	Spare, Insul, Mylar, IGBT, Bus, D1 Frame	insulation under IGBT input bus bar assemblies																						
	176F8421	Spare, Insul, Mylar, IGBT, Bus, D2 Frame	insulation under IGBT input bus bar assemblies																						
	176F8590	Spare, Insul, IGBT-Chassis, E Frame	insulation under IGBT input bus bar assemblies																						
	176F8547	Spare, Insul, IGBT snubber cap support	mounts between IGBT and snubber capacitors (1 per kit)																						
	176F8546	Spare, Insul, between mains fuse, T6/7	insulator between mains fuses																						
	176F8410	Spare, BB Stand Off, PKG10	bus bar mounting standoff (10 per kit)																						
	176F8610	Spare, IGBT Output Standoff, PKG9, E Frame	IGBT output bus bar mounting standoff (9 per kit)																						

Table 10.6: Spare parts list: Terminals, Labels, Insulators

Block gram nator	Dia- Spare Desig- Parts Number	Spare Parts Name	Comments	380-480 VAC/380-500 VAC											
				D1/D3	D2/D4			E1/E2							
				P110 FC 202 FC 302	P132 P160 P132	P160 P200 P160	P200 P250 P200	P250 P315 P250	P315 P355 P250	P400 P450 P315	P400 P450 P355	P450 P400 P400			
Bus Bars															
176F8380	Spare, BB, SCR, R\N\T, D Frame	connects input plate bus bar to SCR input (1 per kit)		3	3										
176F8548	Spare, Brikt, SCR BB Support, D Frame	SCR input bus bar support		1	1										
176F8394	Spare, BB, SCR, Input, D Frame	connects input plate bus bar to SCR input (1 per kit)			3										
176F8387	Spare, BB, SCR, Plus, 1, E Frame	connects input plate bus bar to SCR input (1 per kit)				3									
176F8595	Spare, BB, SCR/DI Input, D Frame	from input plate to SCR and diode (1 per kit)					3								
176F8379	Spare, BB Assy, SCR, D Frame	connects to SCR outputs, sandwich assembly		1	1										
176F8381	Spare, BB, SCR, Minus, D Frame	connects DC coil inputs to SCR output bus bar assembly (1 per kit)		2	2										
176F8393	Spare, BB, SCR, DC, VLT5202	connects to SCR outputs (1 per kit)				2									
176F8385	Spare, BB, SCR, Minus, 1, D Frame	connects to SCR outputs (1 per kit)					2								
176F83861	Spare, BB, SCR, Minus, 2, D Frame	connects to DC coil + input, left side of frequency converter						1	1						
176F8386	Spare, BB, SCR, Plus, 2, D Frame	connects to DC coil - input, right side of frequency converter								1	1				
176F8596	Spare, BB, SCR/DI Output, E Frame	attaches to the SCR and diode on the DC side (1 per kit)										2	2	2	2
176F8597	Spare, BB, DC Bus Plus, Before Coil, E Frame	DC Plus to DC Coils												1	1
176F8598	Spare, BB, DC Bus Minus, Before Coil, E Frame	DC Minus to DC Coils													1
176F8549	Spare, BB, DC Link, Plus, D Frame	connects DC Plus coil output to IGBT input bus bar assembly		1	1										
176F8391	Spare, BB, DC Link, Plus, D Frame	connects DC Minus coil output to IGBT input bus bar assembly		1	1										
176F8382	Spare, BB, DC Link, Minus, D Frame	connects DC coil output to IGBT input bus bar assembly (1 per kit)				2	2	2	2						
176F8599	Space, BB, DC Bus, After Coil, E Frame	from DC Coil output to IGBT sandwich (1 per kit)												2	2
176F83761	Spare, BB Assy, IGBT, D Frame	connects capacitor bank and IGBT inputs, sandwich assembly		1	1										
76F8376	Spare, BB Assy, IGBT-Ind, D Frame	lower IGBT input bus bar sandwich assembly						1	1	1					
176F8378	Spare, BB Assy, IGBT-Cap, D Frame	upper IGBT input bus bar sandwich assembly						1	1	1					
176F8600	Spare, BB Assy, IGBT-Ind, E Frame	DC Bus sandwich, connects to the IGBT input												1	1
176F8601	Spare, BB Assy, IGBT-Cap, D Frame	connects the capacitor bank to the IGBT input (1 per kit)												3	3
176F8390	Spare, BB, IGBT, UV\W, E Frame	connects IGBT output to long bus bar over the fan (1 per kit)		3	3										
176F8392	Spare, BB, Motor, 2, D Frame	long output bus bar over the fan (1 per kit)		3	3										
176F8383	Spare, BB, Motor, U\W, D Frame	connects to IGBT output, for phase U or W (1 per kit)				2	2	2	2						
176F8384	Spare, BB, Motor, V, D Frame	connects to IGBT output, for phase V (1 per kit)						1	1	1					
176F8389	Spare, BB, I-Sensor, D Frame	long output bus bar over the fan (1 per kit)						3	3	3					
176F8602	Spare, BB, IGBT Output, E Frame	from IGBT output between SCR and diode (1 per kit)												3	3
176F8603	Spare, BB, Over Fan Box, E Frame	output over the fan box (1 per kit)												3	3
176F8604	Spare, BB, Current Sensor 5352, E	goes through the current sensor (1 per kit)													
176F8605	Spare, BB, Current Sensor 5452-5502, E	goes through the current sensor (1 per kit)												3	3
176F8397	Spare, BB, Brake, Plus, D Frame	connects DC Plus to brake IGBT		1	1										
176F8398	Spare, BB, Brake, Minus, D Frame	connects DC Minus to brake IGBT		1	1										
176F8396	Spare, BB, Brake, D Frame	connects the two brake IGBT together						1	1	1					
176F8606	Spare, BB, Brake Assy, E Frame	collection of brake bus bars, does not include terminal bus bars												1	1

Table 10.7: Spare parts lists: Bus Bars (tabel 1)

		380-480 VAC/380-500 VAC															
Block Diagram Designator	Spare Parts Number	Spare Parts Name	Comments	D1/D3			D2/D4			E1/E2							
				P110	P132	P160	P110	P132	P160	P250	P315	P355	P400	P450			
		Bus Bars															
	176F8401	Spare, BB, LS, Plus, D Frame	connects plus load share terminal to SCR output bus bar assembly	1	1												
	176F8400	Spare, BB, LS, Minus, D Frame	connects minus load share terminal to SCR output bus bar assembly	1	1												
	176F8403	Spare, BB, LS, Plus, D Frame	connects SCR bus bar to plus load share terminal			1	1	1									
	176F8402	Spare, BB, LS, Minus, D Frame	connects SCR bus bar to minus load share terminal			1	1	1									
	176F8607	Spare, BB, Load Share Plus, E Frame	load share plus bus bar									1	1	1			
	176F8608	Spare, BB, Load Share Minus, E Frame	load share minus bus bar									1	1	1			
	176F8405	Spare, BB, SCR, Input 2, D Frame	located on input plate (1 per kit)	3	3												
	176F8406	Spare, BB, SCR, T, 1, D Frame	located on input plate (1 per kit)			3	3	3									
	176F8407	Spare, BB, Disc, D Frame	located on input plate (1 per kit)	3	3												
	176F8408	Spare, BB, Disc, R, S, D Frame	located on input plate (1 per kit)			2	2	2									
	176F8409	Spare, BB, Disc, T, D Frame	located on input plate (1 per kit)			1	1	1									

Table 10.8: Spare parts list: Bus Bars (table 2)

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Block gram nator	Dia- Spare Desig- Parts Number	Spare Parts Name	380-480 VAC/380-500 VAC													
			D1/D3	D2/D4	E1/E2											
		Comments	P110	P132	P160	P200	P250	P315	P355	P400	P450					
	FC 202		P110	P132	P160	P200	P250	P315	P355	P400	P450					
	FC 302		P90K	P110	P132	P160	P200	P250	P315	P355	P400					
		Enclosure														
	176F8430	Spare, Cable Clamp, 60 mm														
	176F8490	Spare, Brkt, HF, board, gnd, D Frame	1	1												
	176F8491	Spare, Brkt, HF, board, gnd, D Frame														
	176F8427	IP00, D3, Side Panel				1	1	1								
	176F84286	IP00, D4, Side Panel	IP00	IP00												
	KAF6H8428															

Table 10.9: Spare parts list: Enclosure

Block Diagram Designator	Spare Part Number	Spare Part Name	Comments	525-690 VAC																				
				D1/D3				D2/D4				E1/E2												
				P132	P160	P200	P250	P315	P400	P450	P500	P560	P630	P132	P160	P200	P250	P315	P400	P450	P500	P560	P630	
PCA4	176F8308	Spare, Current Scaling PCA, 4.54 Ohm	Installs on the Power Card																					
PCA4	176F8309	Spare, Current Scaling PCA, 3.79 Ohm	Installs on the Power Card																					
PCA4	176F8310	Spare, Current Scaling PCA, 3.10 Ohm	Installs on the Power Card																					
PCA4	176F8311	Spare, Current Scaling PCA, 2.56 Ohm	Installs on the Power Card																					
PCA4	176F8312	Spare, Current Scaling PCA, 5.10 Ohm	Installs on the Power Card																					
PCA4	176F8525	Spare, Current Scaling PCA, 5.85 Ohm	Installs on the Power Card																					
PCA5	176F8626	Spare, FC Gate Drive PCA, CC, D&E Frame	Gate Drive Board																					
PCA8	176F8523	Spare, HF PCA, T7, D&E Frame	High Frequency Board																					
PCA11	176F8522	Spare, Soft charge PCA, CC, T7, D Frame	Soft charge Board, Includes mounting bracket																					
PCA11	176F8466	Spare, Soft charge PCA, CC, T7, E Frame	Soft charge Board																					
PCA9	176F8526	Spare, Balance, PCA, T7, D&E Frame	Capacitor Bank Balance Card, included with spare Cap Bank																					

Table 10.10: Spare Parts List PCA3-11

Block Diagram	Dia-Part	Spare Part Number	Spare Part Name	Comments	525–690 VAC											
					D1/D3	D2/D4			E1/E2							
					FC 102	P132	P160	P200	P250	P315	P400	P450	P500	P560	P630	
			Semiconductors													
	IGBT1,2	176F8632	Spare, FC IGBT kit, 300A, T7, D Frame	1 IGBT per kit	1	---	2	2	---	---	---	---	---	---	---	
	IGBT1,2	176F8633	Spare, FC IGBT kit, 450A, T7, D Frame	1 IGBT per kit	---	1	---	2	2	---	---	---	---	---	---	
	IGBT1,2,3	176F8634	Spare, FC IGBT kit, 300A, T7, E Frame	1 IGBT per kit	---	---	---	---	---	3	3	---	---	---	---	
	IGBT1,2,3	176F8635	Spare, FC IGBT kit, 450A, T7, E Frame	1 IGBT per kit	---	---	---	---	---	---	---	---	---	---	---	
	IGBT1,2,3	176F8636	Spare, Brake IGBT kit, D&E Frame	1 IGBT per kit	1	1	2	2	2	2	2	2	2	2	2	
	SCR1,2,3	176F8529	Spare, SCR/diode kit, 160A, T7, D Frame	1 SCR and diode per kit	3	3	3	3	---	---	---	---	---	---	---	
	SCR1,2,3	176F8530	Spare, SCR/diode kit, 280A, T7, D Frame	1 SCR and diode per kit	---	---	---	3	3	3	---	---	---	---	---	
	SCR1,2,3	176F8434	Spare, SCR kit, 430A, T7, E Frame	1 SCR per kit	---	---	---	---	---	3	3	3	3	3	3	
	DI,2,3	176F8435	Spare, diode kit, 540A, T7, E Frame	1 diode per kit	---	---	---	---	---	3	3	3	3	3	3	
			Resistors													
	R1	176F8531	Spare, Soft charge Resistor, 68 Ohm, 110W	Soft charge resistor assembly	1	1	1	1	1	1	---	---	---	---	---	
	R1	176F8467	Spare, Soft charge Resistor, 68 Ohm, 155W	Soft charge resistor assembly	---	---	---	---	---	---	1	1	1	1	1	
			Capacitors													
	C2, 3, 4, 5, 6, 7, 8, 9, 10	176F8534	Spare, CAP, IGBT Snubber, 1250V, 1uF	IGBT snubber caps mounted on the IGBT modules	3	3	6	6	6	6	6	6	6	6	9	
	CBANK1,2	176F8532	Spare, CAP Bank, D Frame, 4cap, T7	Capacitor bank, includes balance card	1	---	2	2	1	---	---	---	---	---	---	
	CBANK1,2	176F8533	Spare, CAP Bank, D Frame, 6cap, T7	Capacitor bank, includes balance card	---	1	---	---	1	2	---	---	---	---	---	
	CBANK1,2	176F8638	Spare, CAP Bank, E Frame, 8cap, T7	Capacitor bank, includes balance card	---	---	---	---	---	---	2	2	2	2	2	
			Fans													
	F1+C1	176F8329	Spare, Heatsink Fan Assy, D Frame	Heatsink Fan. Includes fan, fan box, capacitor, gasket, cables	1	1	1	1	1	1	---	---	---	---	---	
	F1+C1	176F8578	Spare, Heatsink Fan Assy, small E Frame	Heatsink Fan. Includes fan, fan box, capacitor, gasket, cables	---	---	---	---	---	---	1	1	---	---	---	
	F1+C1	176F8579	Spare, Heatsink Fan Assy, large E Frame	Heatsink Fan. Includes fan, fan box, capacitor, gasket, cables	---	---	---	---	---	---	---	---	---	---	1	
	F2,3	176F8330	Spare, Door Fan Kit, D&E Frame	Door Fan Kit. Includes fan, grills, support, fasteners (1 fan per kit)	21/54	21/54	21/5	21/54	21/54	21/54	21/54	21/54	21/54	21/5	21/54	
	F4	176F8331	Spare, Door Vent Kit, D&E Frame	Door Vent Kit. Includes grill, support, fasteners (1 vent per kit)	21/54	21/54	21/5	21/5	21/54	21/54	21/54	21/54	21/54	21/5	21/54	
	F4	176F8332	Spare, Door Fan Filter, PKG10, D&E Frame	Door Filters, Package of 10												
	F2	176F8333	Spare, FC DC Top Fan, IP00 D Frame	IP00 Top Fan, Fan Only (1 fan per kit)	IP54	IP54	IP54	IP54	IP54	IP54	IP54	IP54	IP54	IP54	IP54	
	F2,3	176F8333	Spare, Door/Top AC Fan, D&E Frame	IP00 Top Fan, Fan Only (1 fan per kit)	IP00	IP00	IP00	IP00	IP00	IP00	---	---	---	---	---	
	F2,3	176F8333	Spare, Door/Top AC Fan, D&E Frame	IP21/IP54 Door Fan, Fan Only (1 fan per kit)	21/54	21/54	21/5	21/5	21/54	21/54	21/54	21/54	21/54	21/5	21/54	

Table 10.11: Spare Parts List Semiconductors, Resistors, Capacitors and Fans

		525-690 VAC															
		D1/D3			D2/D4			E1/E2									
Block Designator	Diagram Part Number	Spare Part Name	Comments	FC 102	FC 202	FC 302	P132	P160	P200	P250	P315	P400	P450	P500	P560	P630	P560
Fuses																	
FU1,2,3	176F8334	Spare, Fuse, Main, 350A	Mains Fuse. 1 fuse per kit			3											
FU1,2,3	176F8591	Spare, Fuse, Main, 700A	Mains Fuse. 1 fuse per kit										3	3	3		
FU1,2,3	176F8592	Spare, Fuse, Main, 900A	Mains Fuse. 1 fuse per kit														3
FU1,2,3	176F8540	Spare, Fuse, Main, 550A	Mains Fuse. 1 fuse per kit					3	3	3	3						
FU5	176F8336	Spare, Fuse, Soft charge, 20A, PKG3, D&E Frame	Soft charge fuse. Package of 3	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg	1 pkg
FU4	176F8440	Spare, Fuse, 4A, PKG3, Power PCA, Fan	Power Card Fuse, 4 amp. Package of 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FU4	176F8440	Spare, Fuse, 4A, PKG3, Power PCA, Fan	Fan Transformer Fuse, 4 amp. Package of 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FU4	176F8609	Spare, Fuse, 15A, PKG3, Fan, E Frame	Fan Transformer Fuse, 15 amp. Package of 3														1
Inductors and Current Sensors																	
L1	176F8339	Spare, Bus Inductor, 136uH	DC Link Coil, Large D Frame								1						
L1	176F8340	Spare, Bus Inductor, 109uH	DC Link Coil, Large D Frame									1					
L1	176F8536	Spare, Bus Inductor, 350uH	DC Link Coil, Small D Frame	1													
L1	176F8537	Spare, Bus Inductor, 250uH	DC Link Coil, Small D Frame		1												
L1	176F8538	Spare, Bus Inductor, 195uH	DC Link Coil, Large D Frame					1	1								
L1	176F8469	Spare, Bus Inductor, 73uH, E Frame	DC Link Coil, E Frame											1	1	1	1
L2,3,4	176F8342	Spare, Current Sensor, 300A	Motor Current Sensor, 1 sensor per kit	3	3	3	3	3	3	3	3						
L2,3,4	176F8343	Spare, Current Sensor, 500A	Motor Current Sensor, 1 sensor per kit									3	3	3	3		
L2,3,4	176F8563	Spare, Current Sensor, 1000A	Motor Current Sensor, 1 sensor per kit														3
TR1	176F8535	Spare, Fan Transformer Assy, 690V, 400VA	Fan Transformer. Includes cables and plug	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TR1	176F8471	Spare, Fan Transformer Assy, E1, T7	Fan Transformer. Includes cables and plug														1
L5	176F8577	Spare, Heatsink Fan Inductor, E Frame	Fan Inductor														1
Disconnects																	
SW1	176F8345	Spare, Disconnect SW, 200A, D Frame	Disconnect Switch	1	1	1											
SW1	176F8347	Spare, Disconnect SW, 400A, D Frame	Disconnect Switch					1	1	1	1	1	1	1	1	1	1
SW1	176F8593	Spare, Disconnect SW, 600A, E Frame	Disconnect Switch														1
	176F8346	Spare, Disconnect Handle, Rod, D Frame	Disconnect Handle	1	1	1											
	176F8348	Spare, Disconnect Handle, Rod, D&E Frame	Disconnect Handle						1	1	1	1	1	1	1	1	1

Table 10.12: Spare Parts List Fuses, Inductors & Current Sensors and Disconnects

Block Diagram Ignator	Dia- Spare Part Number	Spare Part Name	Comments	525–690 VAC											
				D1/D3			D2/D4			E1/E2					
				FC 102	P132	P160	P200	P250	P315	P400	P450	P500	P560	P630	
		Cables													
CB11	176F8640	Spare, Cable, FC LCP, D Frame, IP54	ribbon cable from LCP to control card, IP 54 enclosure												
CB11	176F8586	Spare, Cable, LCP, E Frame	ribbon cable from LCP to control card												
CB12	176F8641	Spare, Cable, Control PCA, 44pin, D&E Frame	ribbon cable from control card to power card												
CB15	176F8541	Spare, Cable, FC Current Sensor, D Frame	wire harness from power card to current sensors												
CB15	176F8349	Spare, Cable, FC Current Sensor, D2 Frame	wire harness from power card to current sensors												
CB15	176F8568	Spare, Cable, FC I-Sensor, small E Frame	wire harness from power card to current sensors												
CB15	176F8569	Spare, Cable, FC I-Sensor, large E Frame	wire harness from power card to current sensors												
CB18	176F8542	Spare, Cable, HS Fan, D1 Frame	wire harness from the power card to the fan transformer												
CB18	176F8359	Spare, Cable, HS Fan, D2 Frame	wire harness from the power card to the fan transformer												
CB18	176F8571	Spare, Cable, Fan, IP00, small E Frame	wire harness for all AC fans on IP00 units												
CB18	176F8572	Spare, Cable, Fan, IP21/54, small E Frame	wire harness for all AC fans on IP21 and IP54 units												
CB18	176F8573	Spare, Cable, Fan, IP00, large E Frame	wire harness for all AC fans on IP00 units												
CB18	176F8574	Spare, Cable, Fan, IP21/54, large E Frame	wire harness for all AC fans on IP21 and IP54 units												
CB19	176F8354	Spare, Cable, Softchng RST prime, D Frame	wire harness from soft charge to power card												
CB19	176F8570	Spare, Cable, Softchng RST prime, E Frame	wire harness from soft charge to power card												
CB112	176F8358	Spare, Cable, Door Fan, D Frame	wire harness for AC door fans												
CB113	176F8544	Spare, Cable, FC SCR, D1 Frame	wire harness from power card to SCR												
CB113	176F8357	Spare, Cable, FC SCR, D2 Frame	wire harness from power card to SCR												
CB113	176F8575	Spare, Cable, FC SCR, E Frame	wire harness from power card to SCR												
CB114	176F8356	Spare, Cable, DC to Power PCA, D Frame	voltage from DC bus to power card												
CB114	176F8576	Spare, Cable, DC to Power PCA, E Frame	voltage from DC bus to power card												
CB116	176F8363	Spare, Cable, FC Gate Drive, 16pin, D1 Frame	ribbon cable from power card to gate drive card												
CB116	176F8350	Spare, Cable, FC Gate Drive, 16pin, D2 Frame	ribbon cable from power card to gate drive card												
CB116	176F8581	Spare, Cable, FC Gate Drive, 16pin, E Frame	ribbon cable from power card to gate drive card												
CB117,18,19	176F8364	Spare, Cable, IGBT Gate, D1 Frame	wire harness from gate drive card to IGBT module (1 per kit)												
CB117,18,19	176F8351	Spare, Cable, IGBT Gate, D2 Frame	wire harness from gate drive card to IGBT module (1 per kit)												
CB117,18,19	176F8582	Spare, Cable, IGBT Gate, E1 Frame	wire harness from gate drive card to IGBT module (1 per kit)												
CB120	176F8352	Spare, Cable, IGBT Temperature	temperature connection from IGBT module to gate drive card												
CB121	176F8365	Spare, Cable, Brake IGBT, D1 Frame	wire harness from gate drive card to brake IGBT module												
CB121	176F8368	Spare, Cable, Brake IGBT, D2 Frame	wire harness from gate drive card to brake IGBT module												
CB121	176F8583	Spare, Cable, Brake IGBT, E Frame	wire harness from gate drive card to brake IGBT module												
CB122	176F8366	Spare, Cable, Brake Power Plus, D1 Frame	cable from brake IGBT to brake plus terminal												
CB122	176F8369	Spare, Cable, Brake Power Plus, D2 Frame	cable from brake IGBT to brake plus terminal												
CB123	176F8367	Spare, Cable, Brake Power Minus, D1 Frame	cable from brake IGBT to brake minus terminal												
CB123	176F8370	Spare, Cable, Brake Power Minus, D2 Frame	cable from brake IGBT to brake minus terminal												
CB124	176F8543	Spare, Cable, Softchng RST, D1 Frame	wire harness from input power to soft charge board												
CB124	176F8353	Spare, Cable, Softchng RST, D2 Frame	wire harness from input power to soft charge board												
CB124	176F8584	Spare, Cable, Softchng RST, E Frame	wire harness from input power to soft charge board												
CB125	176F8355	Spare, Cable, Softchng to DC bus, D Frame	wire harness from input power to soft charge board												
CB125	176F8585	Spare, Cable, Softchng to DC bus, E Frame	wire harness from input power to soft charge board												
CB126	176F8613	Spare, Cable, FC Fuse Fan, E Frame	wire harness from soft charge to DC bus cable from power card to fan fuse												

Table 10.13: Spare Parts List Cables

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Block Diagram Designation	Di-	Spare Part Number	Spare Part Name	Comments	525-690 VAC																
					D1/D3	D2/D4	E1/E2	FC 102	FC 202	FC 302	P132	P160	P200	P250	P315	P400	P450	P500	P560	P630	
			Terminals, Labels, Insulators																		
TB1		176F8374	Spare, BB, Terminals, Mains, Motor, D Frame	mains terminal bus bar (1 per kit)	3	3															
TB1		176F8375	Spare, BB, Terminals, Mains, Motor, D Frame	mains terminal bus bar (1 per kit)			3	3	3												
TB1		176F8587	Spare, BB, Terminal Block, E Frame	mains terminal stepped bus bar (1 per kit)						3	3										
TB2		176F8374	Spare, BB, Terminals, Mains, Motor, D Frame	motor terminal bus bar (1 per kit)	3	3															
TB2		176F8375	Spare, BB, Terminals, Mains, Motor, D Frame	motor terminal bus bar (1 per kit)						3	3	3									
TB2		176F8587	Spare, BB, Terminal Block, E Frame	motor terminal stepped bus bar (1 per kit)																	
TB3		176F8395	Spare, BB, Terminal, LS, BK, D Frame	brake terminal bus bar (1 per kit)	2	2	2	2	2												
TB3		176F8399	Spare, BB, Terminal, LS, LT, D Frame	left brake terminal bus bar																	
TB3		176F8404	Spare, BB, Load Share, 2, D Frame	right brake terminal bus bar																	
TB4		176F8395	Spare, BB, Terminal, LS, BK, D Frame	load share terminal bus bar (1 per kit)	2	2															
TB4		176F8399	Spare, BB, Terminal, LS, LT, D Frame	left load share terminal bus bar						1	1	1									
TB4		176F8404	Spare, BB, Load Share, 2, D Frame	right load share terminal bus bar																	
TB4		176F8587	Spare, BB, Terminal Block, E Frame	load share terminal stepped bus bar (1 per kit)																	
TB1		176F8371	Spare, Terminal Insul, mains, motor, D Frame	mains terminal insulation block	1	1	1	1	1												
TB1		176F8588	Spare, Insul, Terminal Block, E Frame	mains terminal insulation block (1 per kit)																	
TB2		176F8371	Spare, Terminal Insul, mains, motor, D Frame	mains terminal insulation block	1	1	1	1	1												
TB2		176F8588	Spare, Insul, Terminal Block, E Frame	motor terminal insulation block (1 per kit)																	
TB3		176F8372	Spare, Terminal Insul, Brk, LD Shr, D Frame	brake terminal insulation block	1	1	1	1	1												
TB4		176F8372	Spare, Terminal Insul, Brk, LD Shr, D Frame	load share terminal insulation block	1	1	1	1	1												
TB4		176F8588	Spare, Insul, Terminal Block, E Frame	load share terminal insulation block (1 per kit)																	
		176F8373	Spare, Label Set, Terminal Blk, D Frame	terminal block label set includes mains, motor, brake, load share	1	1	1	1	1												
		176F8589	Spare, Label Set, Terminal, E Frame	terminal block label set includes mains, motor, brake, load share																	
		176F8545	Spare, Insul, Mylar, IGBT, Bus, D1 Frame	insulation under IGBT input bus bar assemblies	1	1															
		176F8421	Spare, Insul, Mylar, IGBT, Bus, D2 Frame	insulation under IGBT input bus bar assemblies																	
		176F8590	Spare, Insul, IGBT-Chassis, E Frame	insulation under IGBT input bus bar assemblies																	
		176F8547	Spare, Insul, IGBT snubber cap support	mounts between IGBT and snubber capacitors (1 per kit)	1	1	2	2	2	2	2	2									
		176F8546	Spare, Insul, between mains fuse, T6/7	insulator between mains fuses																	
		176F8410	Spare, BB Stand Off, PKG10	bus bar mounting standoff (10 per kit)	12	12	17	17	17	17	17	17									
		176F8610	Spare, IGBT Output Standoff, PKG9, E Frame	IGBT output bus bar mounting standoff (9 per kit)																	

Table 10.14: Spare Parts List terminals, Labels, Insulators

Block Diagram Designator	Spare Part Number	Spare Part Name	Comments	525-690 VAC											
				D1/D3	D2/D4	E1/E2	FC 102	P132	P160	P200	P250	P315	P400	P450	P50
				FC 202	P132	P160	P200	P250	P315	P400	P450	P50	P560	P630	
				FC 302	P110	P132	P160	P200	P250	P315	P355	P40	P500	P560	
		Bus Bars													
	176F8380	Spare, BB, SCR, R(S/T, D Frame	connects input plate bus bar to SCR input (1 per kit)		3	3									
	176F8548	Spare, Brkt., SCR BB Support, D Frame	SCR input bus bar support		1	1									
	176F8394	Spare, BB, SCR, Input, D Frame	connects input plate bus bar to SCR input (1 per kit)				3								
	176F8387	Spare, BB, SCR, Plus, 1, D Frame	connects input plate bus bar to SCR input (1 per kit)					3	3	3					
	176F8700	Spare, BB, SCR/Di Input, T7, E Frame	from input plate to SCR and diode (1 per kit)												
	176F8379	Spare, BB Assy, SCR, D Frame	connects to SCR outputs, sandwich assembly		1	1									
	176F8381	Spare, BB, SCR, Minus, D Frame	connects DC coil inputs to SCR output bus bar assembly (1 per kit)		2	2									
	176F8393	Spare, BB, SCR, DC, VLT5202	connects to SCR outputs (1 per kit)				2	2	2						
	176F8385	Spare, BB, SCR, Minus, 1, D Frame	connects to SCR outputs (1 per kit)												
	176F8386	Spare, BB, SCR, Minus, 2, D Frame	connects to DC coil + input, left side of frequency converter				1	1	1						
	176F8388	Spare, BB, SCR, Plus, 2, D Frame	connects to DC coil - input, right side of frequency converter				1	1	1						
	176F8701	Spare, BB, SCR/Di Output, T7, E Frame	attaches to the SCR and diode on the DC side (1 per kit)									2	2	2	2
	176F8597	Spare, BB, DC Bus Plus, Before Coil, E Frame	DC Plus to DC Coils									1	1	1	1
	176F8598	Spare, BB, DC Bus Minus, Before Coil, E Frame	DC Minus to DC Coils									1	1	1	1
	176F8549	Spare, BB, DC Link, Plus, D Frame	connects DC Plus coil output to IGBT input bus bar assembly		1	1									
	176F8391	Spare, BB, DC Link, Plus, D Frame	connects DC Minus coil output to IGBT input bus bar assembly		1	1									
	176F8382	Spare, BB, DC Link, Minus, D Frame	connects DC coil output to IGBT input bus bar assembly (1 per kit)				2	2	2	2					
	176F8599	Spare, BB, DC Bus, After Coil, E Frame	from DC Coil output to IGBT sandwich (1 per kit)									2	2	2	2
	176F8376	Spare, BB Assy, IGBT, D Frame	connects capacitor bank and IGBT inputs, sandwich assembly		1	1									
	176F8377	Spare, BB Assy, IGBT-Ind, D Frame	lower IGBT input bus bar sandwich assembly				1	1	1						
	176F8378	Spare, BB Assy, IGBT-Cap, D Frame	upper IGBT input bus bar sandwich assembly				1	1	1	1					
	176F8600	Spare, BB Assy, IGBT-Ind, E Frame	DC Bus sandwich, connects to the IGBT input									1	1	1	1
	176F8601	Spare, BB Assy, IGBT-Cap, E Frame	connects the capacitor bank to the IGBT input (1 per kit)									3	3	3	3
	176F8390	Spare, BB, IGBT, U/V/W, D Frame	connects IGBT output to long bus bar over the fan (1 per kit)		3	3									
	176F8392	Spare, BB, Motor, 2, D Frame	long output bus bar over the fan (1 per kit)		3	3									
	176F8378	Spare, BB, Motor, U/W, D Frame	connects to IGBT output, for phase U or W (1 per kit)				2	2	2	2					
	176F8384	Spare, BB, Motor, V, D Frame	connects to IGBT output, for phase V (1 per kit)				1	1	1	1					
	176F8389	Spare, BB, I-Sensor, D Frame	long output bus bar over the fan (1 per kit)				3	3	3	3					
	176F8602	Spare, BB, IGBT Output, E Frame	from IGBT output between SCR and diode (1 per kit)									3	3	3	3
	176F8603	Spare, BB, Over Fan Box, E Frame	output over the fan box (1 per kit)									3	3	3	3
	176F8604	Spare, BB, Current Sensor 5352, E	goes through the current sensor (1 per kit)									3	3	3	3
	176F8605	Spare, BB, Current Sensor 5452-5502, E	goes through the current sensor (1 per kit)									3	3	3	3
	176F8607	Spare, BB, Brake, Plus, D Frame	connects DC Plus to brake IGBT												
	176F8397	Spare, BB, Brake, Minus, D Frame	connects DC Minus to brake IGBT		1	1									
	176F8398	Spare, BB, Brake, Minus, D Frame	connects the two brake IGBT together		1	1									
	176F8396	Spare, BB, Brake, D Frame					1	1	1	1					
	176F8606	Spare, BB, Brake Assy, E Frame	collection of brake bus bars, does not include terminal bus bars									1	1	1	1



Block Diagram Designator	Spare Part Number	Spare Part Name	Comments	525-690 VAC														
				D1/D3	D2/D4	E1/E2												
	FC 102	P132 P160 P200 P250 P315 P400 P450		P50	P560	P630												
	FC 202	P132 P160 P200 P250 P315 P400 P450		P50	P560	P630												
	FC 302	P110 P132 P160 P200 P250 P315 P355		P40	P500	P560												
Bus Bars																		
176F8401	Spare, BB, LS, Plus, D Frame		connects plus load share terminal to SCR output bus bar assembly	1	1													
176F8400	Spare, BB, LS, Minus, D Frame		connects minus load share terminal to SCR output bus bar assembly	1	1													
176F8403	Spare, BB, LS, Plus, D Frame		connects SCR bus bar to plus load share terminal			1	1	1	1									
176F8402	Spare, BB, LS, Minus, D Frame		connects SCR bus bar to minus load share terminal			1	1	1	1									
176F8607	Spare, BB, Load Share Plus, E Frame		load share plus bus bar															
176F8702	Spare, BB, Load Share Minus, T7, E Frame		load share minus bus bar															
176F8405	Spare, BB, SCR, Input 2, D Frame		located on input plate (1 per kit)	3	3													
176F8406	Spare, BB, SCR, T, 1, D Frame		located on input plate (1 per kit)			3	3	3	3									
176F8407	Spare, BB, Disc, D Frame		located on input plate (1 per kit)	3	3													
176F8408	Spare, BB, Disc, R, S, D Frame		located on input plate (1 per kit)			2	2	2	2									
176F8409	Spare, BB, Disc, T, D Frame		located on input plate (1 per kit)			1	1	1	1									

Table 10.15: Spare Parts List Bus Bars

		525-690 VAC									
Block Diagram Designator	Spare Part Number	Spare Part Name	Comments	D1/D3	D2/D4	E1/E2					
		Enclosure									
	176F8430	Spare, Cable Clamp, 60 mm	60 mm power cable clamp								
	176F8490	Spare, Brkt, HF, board, grd, D Frame	mounting bracket for high frequency board	1	1						
	176F8491	Spare, Brkt, HF, board, grd, D Frame	mounting bracket for high frequency board								
	176F8427	IP00, D3, Side Panel		IP00	IP00						
	176F8428	IP00, D4, Side Panel		IP00	IP00						

Table 10.16: Spare Parts List Enclosure

Block Diagram Des-ignator		Spare Part Number	Spare Part Name	Comments	FC 102	FC 202	FC 302	P45K	P45K	P45K	P55K	P55K	P75K	P75K	P90K	P90K	P110	P110
525-690 VAC																		
D1/D3																		
PCA3	176F8692	Spare, power card, pdelc-xxxP45K177xxxxUxC	Power card, conformal coated, does not include scaling card					102										
PCA3	176F8693	Spare, power card, pdelc-xxxP55K177xxxxUxC	Power card, conformal coated, does not include scaling card						102									
PCA3	176F8694	Spare, power card, pdelc-xxxP75K177xxxxUxC	Power card, conformal coated, does not include scaling card							102								
PCA3	176F8695	Spare, power card, pdelc-xxxP90K177xxxxUxC	Power card, conformal coated, does not include scaling card															
PCA3	176F8696	Spare, power card, pdelc-xxxP110T77xxxxUxC	Power card, conformal coated, does not include scaling card															102
PCA3	176F8692	Spare, power card, pdelc-xxxP45K177xxxxUxC	Power card, conformal coated, does not include scaling card					202										
PCA3	176F8693	Spare, power card, pdelc-xxxP55K177xxxxUxC	Power card, conformal coated, does not include scaling card						202									
PCA3	176F8694	Spare, power card, pdelc-xxxP75K177xxxxUxC	Power card, conformal coated, does not include scaling card							202								
PCA3	176F8695	Spare, power card, pdelc-xxxP90K177xxxxUxC	Power card, conformal coated, does not include scaling card															
PCA3	176F8696	Spare, power card, pdelc-xxxP110T77xxxxUxC	Power card, conformal coated, does not include scaling card															202
PCA3	176F8692	Spare, power card, pdelc-xxxP45K177xxxxUxC	Power card, conformal coated, does not include scaling card					302										
PCA3	176F8693	Spare, power card, pdelc-xxxP55K177xxxxUxC	Power card, conformal coated, does not include scaling card						302									
PCA3	176F8694	Spare, power card, pdelc-xxxP75K177xxxxUxC	Power card, conformal coated, does not include scaling card							302								
PCA3	176F8695	Spare, power card, pdelc-xxxP90K177xxxxUxC	Power card, conformal coated, does not include scaling card															
PCA3	176F8696	Spare, power card, pdelc-xxxP110T77xxxxUxC	Power card, conformal coated, does not include scaling card															302
PCA4	176F8525	Spare, Current Scaling PCA, 5.85 Ohm	Installs on the Power Card															
PCA5	176F8626	Spare, FC Gate Drive PCA, CC, D&E Frame	Gate Drive Board					1	1	1	1	1	1	1	1	1	1	1
PCA8	176F8523	Spare, HF PCA, T7, D&E Frame	High Frequency Board					1	1	1	1	1	1	1	1	1	1	1
PCA11	176F8522	Spare, Soft charge PCA, CC, T7, D Frame	Soft charge Board, Includes mounting bracket					1	1	1	1	1	1	1	1	1	1	1
PCA9	176F8526	Spare, Balance, PCA, T7, D&E Frame	Capacitor Bank Balance Card, included with spare Cap Bank					1	1	1	1	1	1	1	1	1	1	1
Semiconductors																		
IGBT1,2	176F8632	Spare, FC IGBT kit, 300A, T7, D Frame	1 IGBT per kit					1	1	1	1	1	1	1	1	1	1	1
IGBT4,5	176F8316	Spare, Brake IGBT kit, D&E Frame	1 IGBT per kit					1	1	1	1	1	1	1	1	1	1	1
SCR1,2,3	176F8529	Spare, SCR/diode kit, 160A, T7, D Frame	1 SCR and diode per kit					3	3	3	3	3	3	3	3	3	3	3
Resistors																		
R1	176F8531	Spare, Soft charge Resistor, 68 Ohm, 110W	Soft charge resistor assembly					1	1	1	1	1	1	1	1	1	1	1

Table 10.17: Spare Parts List PCA, Semiconductors and Resistors

Block Diagram		Spare Part		Spare Part Name		Comments	525-690 VAC					
Des-ignator	Spare Part Number	Number	Number				FC 102	P45K	P55K	P75K	P90K	P110
C2, 3, 4, 5, 6, 7, 8, 9, 10	176F8534			Spare, CAP, IGBT Snubber, 1250V, 1uF			3	3	3	3	3	3
CBANK1,2	176F8532			Spare, CAP Bank, D Frame, 4cap, T7			1	1	1	1	1	1
Capacitors												
F1+C1	176F8329			Spare, Heatsink Fan Assy, D Frame			1	1	1	1	1	1
F2,3	176F8330			Spare, Door Fan Kit, D&E Frame	Heatsink Fan. Includes fan, fan box, capacitor, gasket, cables		21/54	21/54	21/54	21/54	21/54	21/54
	176F8331			Spare, Door Vent Kit, D%E Frame	Door Fan Kit. Includes fan, grills, support, fasteners (1 fan per kit)		21/54	21/54	21/54	21/54	21/54	21/54
	176F8332			Spare, Door Fan Filter, PKG10, D&E Frame	Door Vent Kit. Includes grill, support, fasteners (1 vent per kit)		IP54	IP54	IP54	IP54	IP54	IP54
F4	176F8639			Spare, FC DC Top Fan, IP00 D Frame	Door Filters, Package of 10		IP00	IP00	IP00	IP00	IP00	IP00
F2,3	176F8333			Spare, Door/Top AC Fan, D&E Frame	IP00 Top Fan, Fan Only (1 fan per kit)		21/54	21/54	21/54	21/54	21/54	21/54
Fans												
FU1,2,3	176F8334			Spare, Fuse, Main, 350A	Mains Fuse. 1 fuse per kit		---	---	---	---	---	3
	176F8539			Spare, Fuse, Main, 200A	Mains Fuse. 1 fuse per kit		3	3	3	3	3	---
FU5	176F8336			Spare, Fuse, Soft charge, 20A, PKG3, D&E Frame	Soft charge fuse. Package of 3		1	1	1	1	1	1
	176F8440			Spare, Fuse, 4A, PKG3, Power PCA, Fan	Power Card Fuse, 4 amp. Package of 3		1	1	1	1	1	1
FU4	176F8440			Spare, Fuse, 4A, PKG3, Power PCA, Fan	Fan Transformer Fuse, 4 amp. Package of 3		1	1	1	1	1	1
Inductors and Current Sensors												
L1	176F8536			Spare, Bus Inductor, 350uH	DC Link Coil, Small D Frame		1	1	1	1	1	1
L2,3,4	176F8342			Spare, Current Sensor, 300A	Motor Current Sensor, 1 sensor per kit		3	3	3	3	3	3
TRI	176F8535			Spare, Fan Transformer Assy, 690V, 400VA	Fan Transformer. Includes cables and plug		1	1	1	1	1	1

Table 10.18: Spare Parts List Capacitors, Fans, Fuses and Inductors & Current Sensors

Block Diagram		Spare Part Name		525-690 VAC										
Des-ignator	Spare Part Number	Spare Part Name	Comments	FC 102	P45K	P55K	D1/D3	P75K	P90K	P110	P110	P90K	P75K	P90K
SW1	176F8345	Spare, Disconnect SW,200A, D Frame	Disconnect Switch		1	1		1	1	1				
	176F8346	Spare, Disconnect Handle, Rod, D Frame	Disconnect Handle		1	1		1	1	1				
Disconnects														
Cables														
CBL1	176F8640	Spare, Cable, FC LCP, D Frame, IP54	ribbon cable from LCP to control card, IP 54 enclosure	IP54	IP54	IP54		IP54	IP54	IP54				
CBL2	176F8641	Spare, Cable, Control PCA, 44pin, D&E Frame	ribbon cable from control card to power card	1	1	1		1	1	1				
CBL5	176F8541	Spare, Cable, FC Current Sensor, D Frame	wire harness from power card to current sensors	1	1	1		1	1	1				
CBL8	176F8542	Spare, Cable, HS Fan, D1 Frame	wire harness from the power card to the fan transformer	1	1	1		1	1	1				
CBL9	176F8354	Spare, Cable, Softchg RST prime, D Frame	wire harness from soft charge to power card	1	1	1		1	1	1				
CBL12	176F8358	Spare, Cable, Door Fan, D Frame	wire harness for AC door fans	21/54	21/54	21/54		21/54	21/54	21/54				
CBL13	176F8544	Spare, Cable, FC SCR, D1 Frame	wire harness from power card to SCR	1	1	1		1	1	1				
CBL14	176F8356	Spare, Cable, DC to Power PCA, D Frame	voltage from DC bus to power card	1	1	1		1	1	1				
CBL16	176F8363	Spare, Cable, FC Gate Drive, 16pin, D1 Frame	ribbon cable from power card to gate drive card	1	1	1		1	1	1				
CBL17,18,19	176F8364	Spare, Cable, IGBT Gate, D1 Frame	wire harness from gate drive card to IGBT module (1 per kit)	3	3	3		3	3	3				
CBL20	176F8352	Spare, Cable, IGBT Temperature	temperature connection from IGBT module to gate drive card	1	1	1		1	1	1				
CBL21	176F8365	Spare, Cable, Brake IGBT, D1 Frame	wire harness from gate drive card to brake IGBT module	1	1	1		1	1	1				
CBL22	176F8366	Spare, Cable, Brake Power Plus, D1 Frame	cable from brake IGBT to brake plus terminal	1	1	1		1	1	1				
CBL23	176F8367	Spare, Cable, Brake Power Minus, D1 Frame	cable from brake IGBT to brake minus terminal	1	1	1		1	1	1				
CBL24	176F8543	Spare, Cable, Softchg RST, D1 Frame	wire harness from input power to soft charge board	1	1	1		1	1	1				
CBL25	176F8355	Spare, Cable, Softchg to DC bus, D Frame	wire harness from soft charge to DC bus	1	1	1		1	1	1				

Table 10.19: Spare Parts List Disconnects and Cables

Block Diagram		525-690 VAC												
Des-ignator	Spare Part Number	Spare Part Name	Comments										D1/D3	
			FC 102	P45K	P55K	P75K	P90K	P110	FC 202	P45K	P55K	P75K	P90K	P110
			FC 302	P37K	P45K	P55K	P75K	P90K						
Terminals, Labels, Insulators														
TB1	176F8374	Spare, BB, Terminals, Mains, Motor, D Frame		3	3	3	3	3						
TB2	176F8374	Spare, BB, Terminals, Mains, Motor, D Frame		3	3	3	3	3						
TB3	176F8395	Spare, BB, Terminal, LS, BK, D Frame		2	2	2	2	2						
TB4	176F8395	Spare, BB, Terminal, LS, BK, D Frame		2	2	2	2	2						
TB1	176F8371	Spare, Terminal Insul, mains, motor, D Frame		1	1	1	1	1						
TB2	176F8371	Spare, Terminal Insul, mains, motor, D Frame		1	1	1	1	1						
TB3	176F8372	Spare, Terminal Insul, Brk, LD Shr, D Frame		1	1	1	1	1						
TB4	176F8372	Spare, Terminal Insul, Brk, LD Shr, D Frame		1	1	1	1	1						
	176F8373	Spare, Label Set, Terminal Blk, D Frame		1	1	1	1	1						
	176F8545	Spare, Insul, Mylar, IGBT, Bus, D1 Frame		1	1	1	1	1						
	176F8547	Spare, Insul, IGBT snubber cap support		1	1	1	1	1						
	176F8410	Spare, BB Stand Off, PKG10		12	12	12	12	12						

Table 10.20: Spare Parts List Terminals, Labels & Insulators

		525-690 VAC									
Block Designator	Diagram	Spare Part Number	Spare Part Name	Comments	FC 102	P45K P37K	P55K P45K	P75K P55K	P90K P75K	P110 P90K	
Bus Bars											
		176F8380	Spare, BB, SCR, R\ST, D Frame	connects input plate bus bar to SCR input (1 per kit)		3	3	3	3	3	
		176F8548	Spare, Brkt, SCR BB Support, D Frame	SCR input bus bar support		1	1	1	1	1	
		176F8379	Spare, BB Assy, SCR, D Frame	connects to SCR outputs, sandwich assembly		1	1	1	1	1	
		176F8381	Spare, BB, SCR, Minus, D Frame	connects DC coil inputs to SCR output bus bar assembly (1 per kit)		2	2	2	2	2	
		176F8549	Spare, BB, DC Link, Plus, D Frame	connects DC Plus coil output to IGBT input bus bar assembly		1	1	1	1	1	
		176F8391	Spare, BB, DC Link, Plus, D Frame	connects DC Minus coil output to IGBT input bus bar assembly		1	1	1	1	1	
		176F8376	Spare, BB Assy, IGBT, D Frame	connects capacitor bank and IGBT inputs, sandwich assembly		1	1	1	1	1	
		176F8390	Spare, BB, IGBT, U\W, D Frame	connects IGBT output to long bus bar over the fan (1 per kit)		3	3	3	3	3	
		176F8392	Spare, BB, Motor, 2, D Frame	long output bus bar over the fan (1 per kit)		3	3	3	3	3	
		176F8397	Spare, BB, Brake, Plus, D Frame	connects DC Plus to brake IGBT		1	1	1	1	1	
		176F8398	Spare, BB, Brake, Minus, D Frame	connects DC Minus to brake IGBT		1	1	1	1	1	
		176F8401	Spare, BB, LS, Plus, D Frame	connects plus load share terminal to SCR output bus bar assembly		1	1	1	1	1	
		176F8400	Spare, BB, LS, Minus, D Frame	connects minus load share terminal to SCR output bus bar assembly		1	1	1	1	1	
		176F8405	Spare, BB, SCR, Input 2, D Frame	located on input plate (1 per kit)		3	3	3	3	3	
		176F8407	Spare, BB, Disc, D Frame	located on input plate (1 per kit)		3	3	3	3	3	
Enclosure											
		176F8430	Spare, Cable Clamp, 60 mm	60 mm power cable clamp		---	---	---	---	---	
		176F8490	Spare, Brkt, HF: board, gnd, D Frame	mounting bracket for high frequency board		1	1	1	1	1	

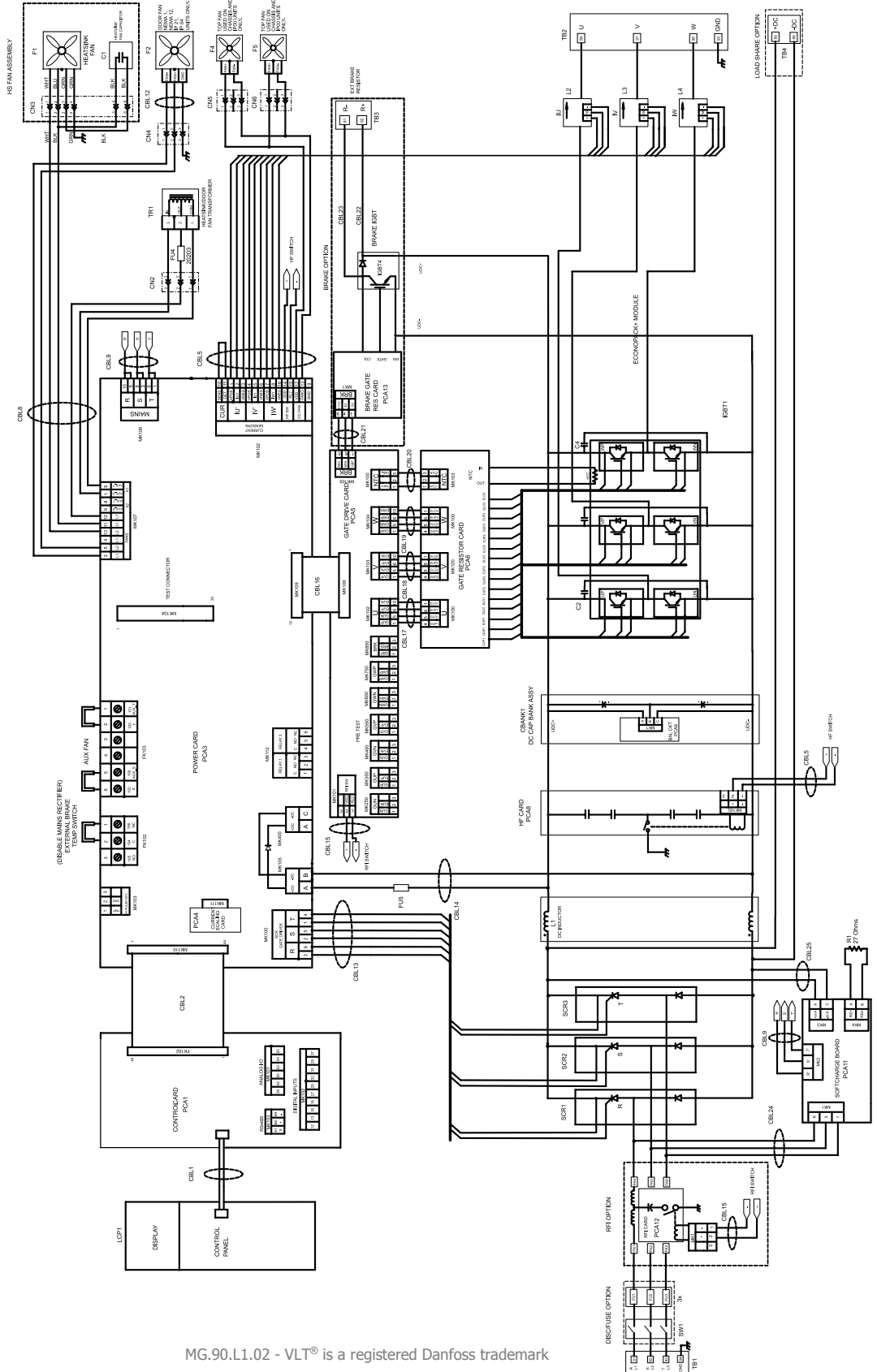
Table 10.21: Spare Parts List Bus Bars and Enclosure

11 Block Diagrams

11.1 Block Diagrams for D-Frames

11.1.1 D1/D3 380–500 VAC

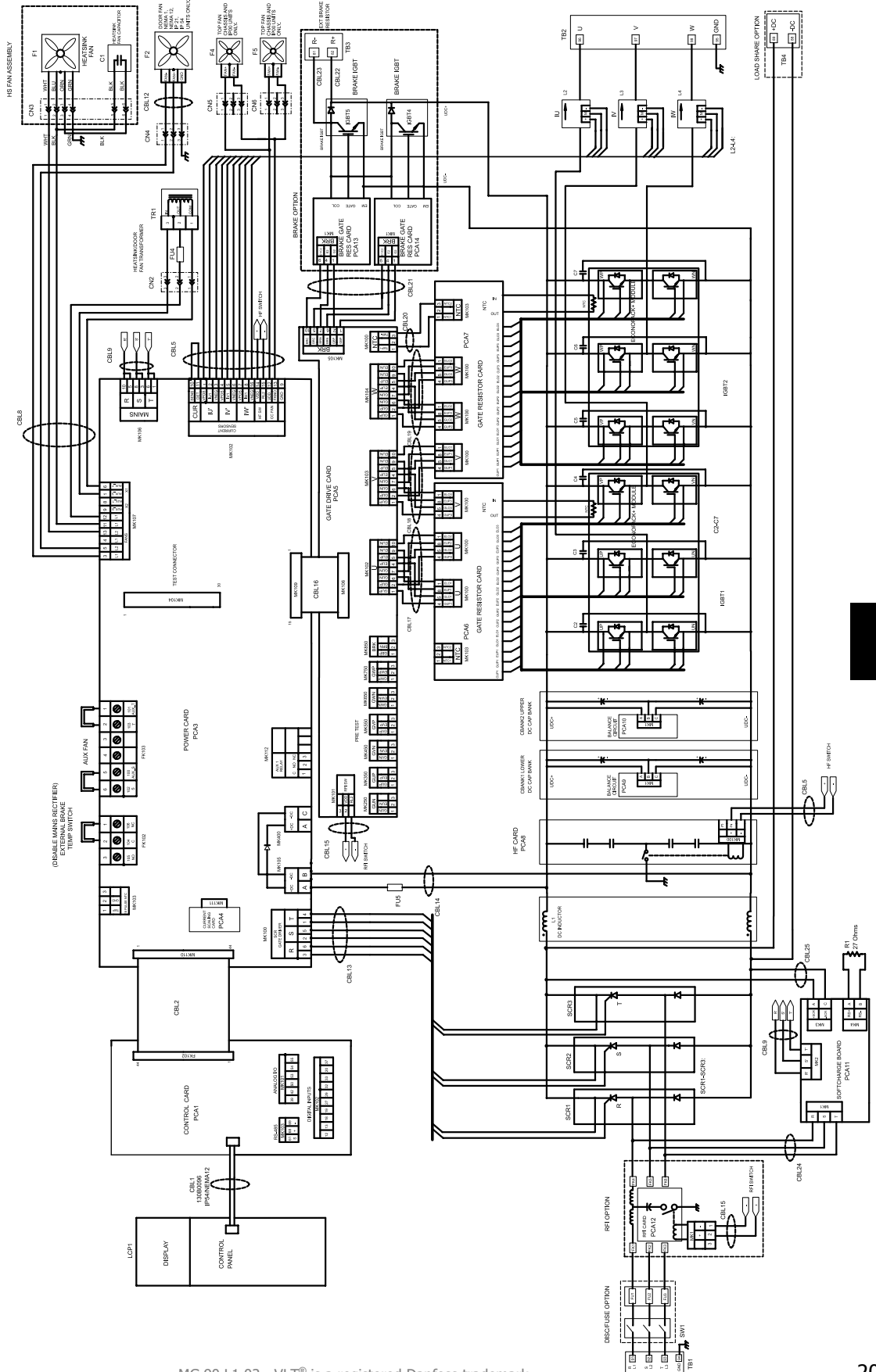
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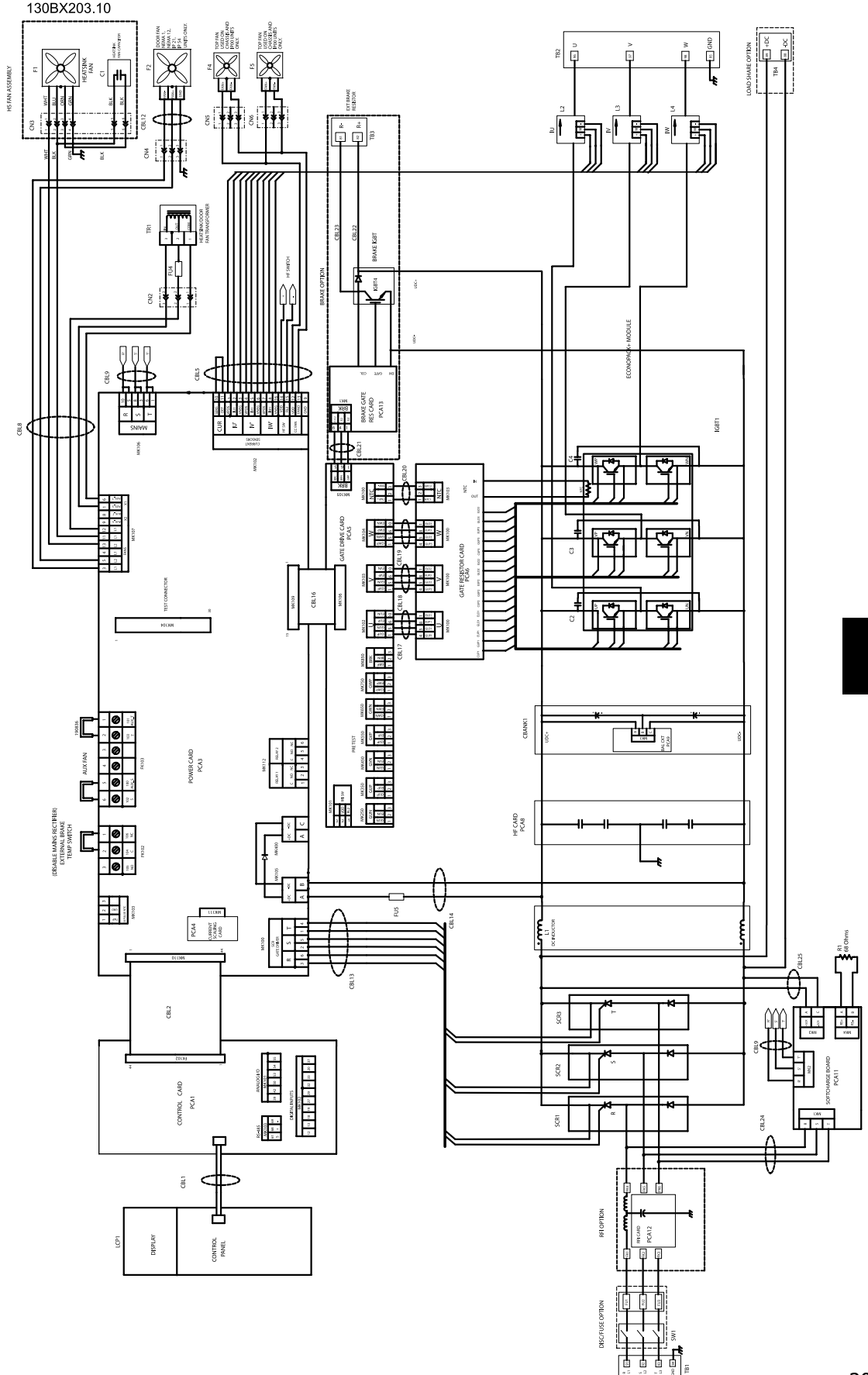
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11.1.2 D2/D4 380–500 VAC

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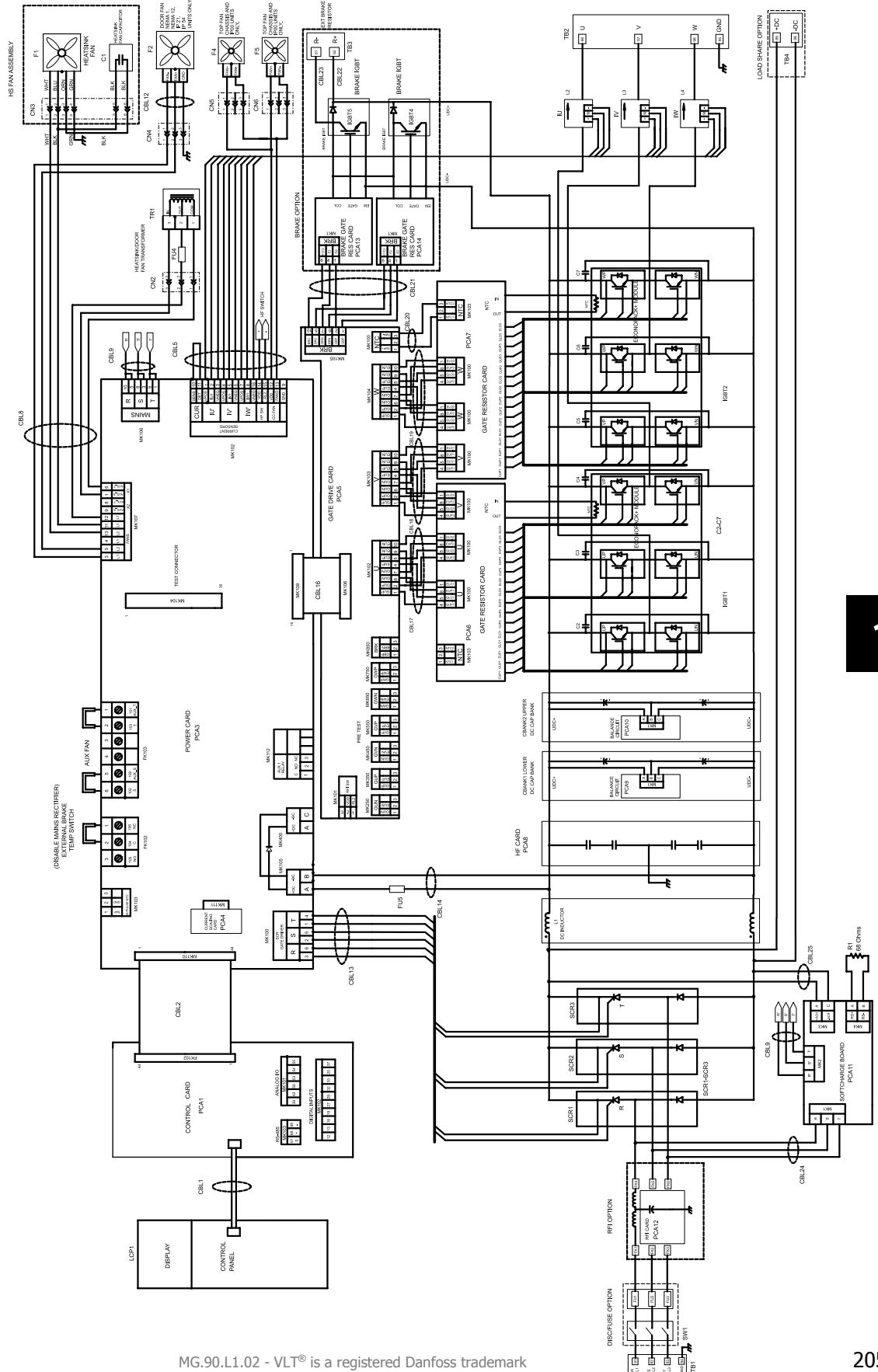


11.1.3 D1/D3 525–690 VAC



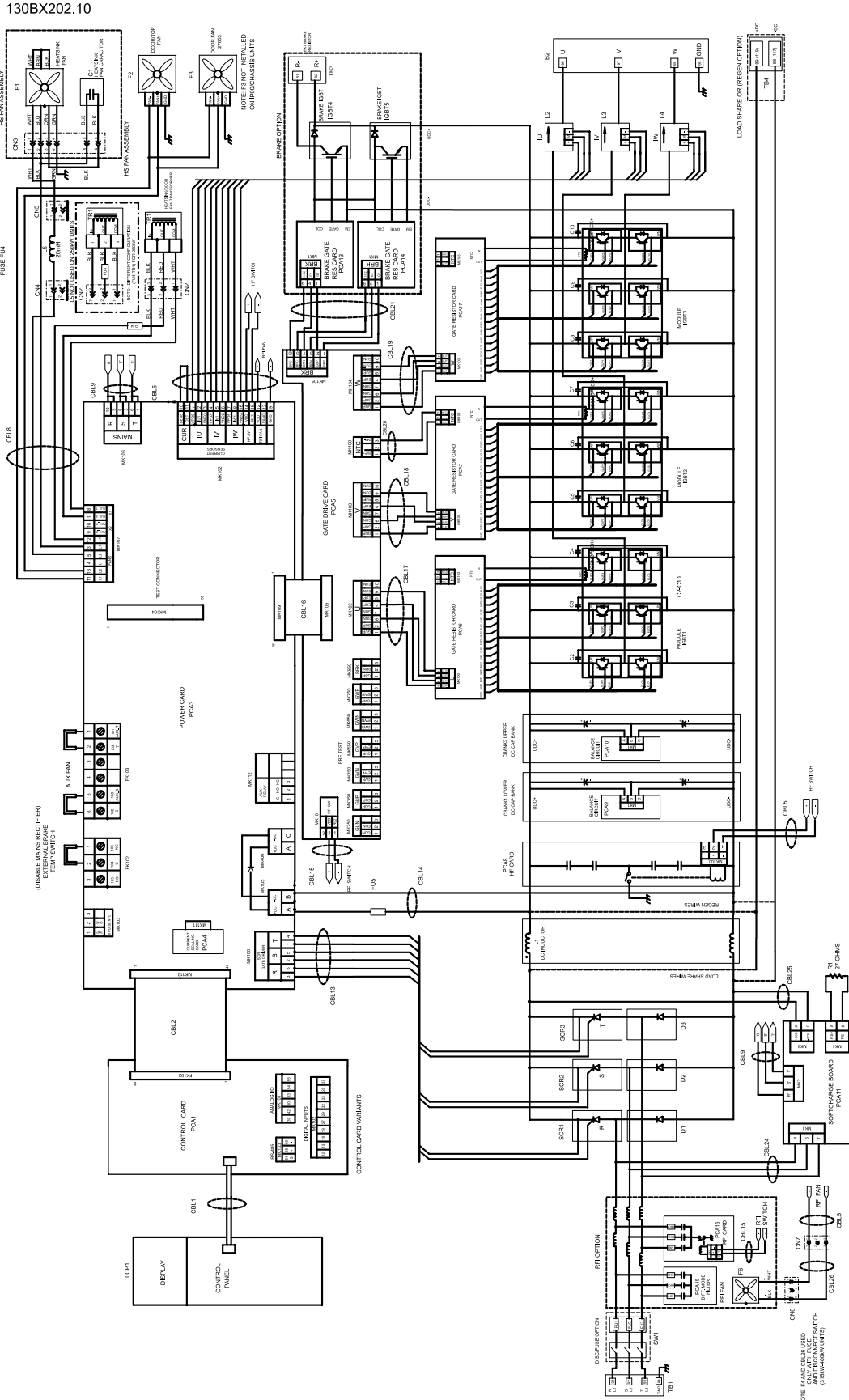
11.1.4 D2/D4 525–690 VAC

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11.2 Block Diagrams for E-Frames

11.2.1 E1/E2 380–500 VAC



11

11.2.2 E1/E2 525–690 VAC

