Service Manual

TR200 New D-Frame, 110-400 kW

SAFETY WARNING

Only qualified personnel should install and service the equipment. The installation, starting up, and servicing of heating, ventilating, and air-conditioning equipment can be hazardous and requires specific knowledge and training. Improperly installed, adjusted or altered equipment by an unqualified person could result in death or serious injury. When working on the equipment, ovserve all precautions in the literature and on the tags, stickers, and labels that are attached to the equipment.

March 2014 **BAS-SVM01A-EN**

Contents

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 D-frame frequency converters

It provides the reader with a general view of the main assemblies and a description of the internal processing. This manual gives technicians the information needed for troubleshooting and repair.

This manual provides instructions for the frequency converter models and voltage ranges described in *chapter 1.5 Frame Size Definitions*.

Use this manual with the operating instructions that accompanied the frequency converter.

1.2 Product Overview

TR200 series frequency converters are designed for the HVAC markets. They operate in variable torque mode or constant torque down to 15 Hz and include special features and options designed for fan and pump applications.

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

series frequency converters are fully programmable for either constant torque or variable torque industrial applications. They operate a variety of applications and incorporate a wide range of control and communication options. These models are available in IP20 (chassis), IP21 (NEMA 1), and IP54 (NEMA 12) enclosures.

1.3 For Your Safety

1.3.1 Warnings

⚠WARNING

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

⚠WARNING

For dynamic test procedures, mains 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.

⚠WARNING

In frequency converters equipped with the optional contactor or anti-condensation heater, there may still be power inside the enclosure after the main power to the unit has been turned off.

1. DO NOT touch electrical parts of the frequency converter when connected to mains. After disconnecting from mains, wait 20 minutes before touching any components.
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, it is possible for the motor to start without warning. Press [Stop] when changing data.

1.4 Electrostatic Discharge (ESD)

⚠WARNING

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

⚠WARNING

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

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

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1.5 Frame Size Definitions

Model			
	kW @400 V AC	HP @460 V AC	Frame Size
N110	110	150	D1h/D3h/D5h/D6h
N132	132	200	D1h/D3hD5h/D6h
N160	160	250	D1h/D3hD5h/D6h
N200	200	300	D2h/D4h/D7h/D8h
N250	250	350	D2h/D4h/D7h/D8h
N315	315	450	D2h/D4h/D7h/D8h

Table 1.1 380-480 V AC

Model TR200	High/Normal Overload			
	kW @400 V AC	HP @460 V AC	kW @500 V AC	Frame Size
N90K	90/110	125/150	110/132	D1h/D3h/D5h/D6h
N110	110/132	150/200	132/160	D1h/D3h/D5h/D6h
N132	132/160	200/250	160/200	D1h/D3h/D5h/D6h
N160	160/200	250/300	200/250	D2h/D4h/D7h/D8h
N200	200/250	300/350	250/315	D2h/D4h/D7h/D8h
N250	250/315	350/450	315/355	D2h/D4h/D7h/D8h

Table 1.2 TR200 380-500 V AC

Model				
	kW @550 V AC	HP @575 V AC	kW @690 V AC	Frame Size
N75K	55	75	75	D1h/D3h/D5h/D6h
N90K	75	100	90	D1h/D3h/D5h/D6h
N110	90	125	110	D1h/D3h/D5h/D6h
N132	110	150	132	D1h/D3h/D5h/D6h
N160	132	200	160	D1h/D3h/D5h/D6h
N200	160	250	200	D2h/D4h/D7h/D8h
N250	200	300	250	D2h/D4h/D7h/D8h
N315	250	350	315	D2h/D4h/D7h/D8h
N400	315	400	400	D2h/D4h/D7h/D8h

Table 1.3 525-690 V AC

Model TR200	High/Normal Overload			
	kW @550 V AC	HP @575 V AC	kW @690 V AC	Frame Size
N55k	45/55	60/75	55/75	D1h/D3h/D5h/D6h
N75k	55/75	75/100	75/90	D1h/D3h/D5h/D6h
N90k	75/90	100/125	90/110	D1h/D3h/D5h/D6h
N110	90/110	125/150	110/132	D1h/D3h/D5h/D6h
N132	110/132	150/200	132/160	D1h/D3h/D5h/D6h
N160	132/160	200/250	160/200	D2h/D4h/D7h/D8h
N200	160/200	250/300	200/250	D2h/D4h/D7h/D8h
N250	200/250	300/350	250/315	D2h/D4h/D7h/D8h
N315	250/315	350/400	315/400	D2h/D4h/D7h/D8h

Table 1.4 TR200 525-690 V AC

1.6 Tools Required

Additional Tools Recommended for Testing

- Digital volt/ohmmeter (PWM compatible)
- Analog voltmeter
- Oscilloscope
- Clamp-on style ammeter
- Split bus power supply p/n 130B3146
- Signal test board p/n 176F8437
- Signal test board extension p/n 130B3147
- Metric socket set (7–19 mm)
- Socket extentions (100 mm–150 mm)
- Torx driver set (T10–T50)
- Torque wrench (0.5–19 Nm)
- Needle nose pliers
- Magnetic sockets
- Ratchet
- Screwdrivers
- ESD protective mat and wrist strap

1.7 General Torque Tightening Values

For fastening hardware described in this manual, the torque values in the tables 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	Drives Size Torx/Hex	Class A Nm [in.-lbs.]	Class Bin Nm [in.-lbs.]
M4	T20/7 mm	1.2 (10)	0.8 (7)
M5	T25/8 mm	2.3 (20)	1.2 (10)
M6	T30/10 mm	3.9 (35)	2.3 (20)
M8	T40/13 mm	9.6 (85)	3.9 (35)
M10	T50/17 mm	19 (169)	9.6 (85)
M12	18mm/19mm	19 (169)	

Table 1.5 Torque Values Standard Thread

Shaft Size	Drives Size Torx/Hex	Class A Nm [in.-lbs.]	Class B Nm [in.-lbs.]
M4.8	T25	5.7 (50)	3.1 (27)
M5	T25	1.7 (15)	

Table 1.6 Torque Values for Thread Cutting into Metal

Shaft Size	Drives Size Torx/Hex	Class A Nm [in.-lbs.]	Class Bin Nm [in.-lbs.]
M4	T20	2.8 (24)	2.8 (24)
M5	T25	5.1 (45)	4.0 (35)

Table 1.7 Torque Values for Thread Forming into Plastic

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

Optional Equipment	Location	
	Main Enclosure	Option Cabinet
RFI filter	X	
Mains fuses only	X	
Contactor*		X
Disconnect*		X
Circuit breaker*		X
Contactor + disconnect*		X

Table 1.8 Options Locations

**Contactor, disconnect, or circuit breaker options always include fuses. When these options are selected, the mains fuses are in the options cabinet.*

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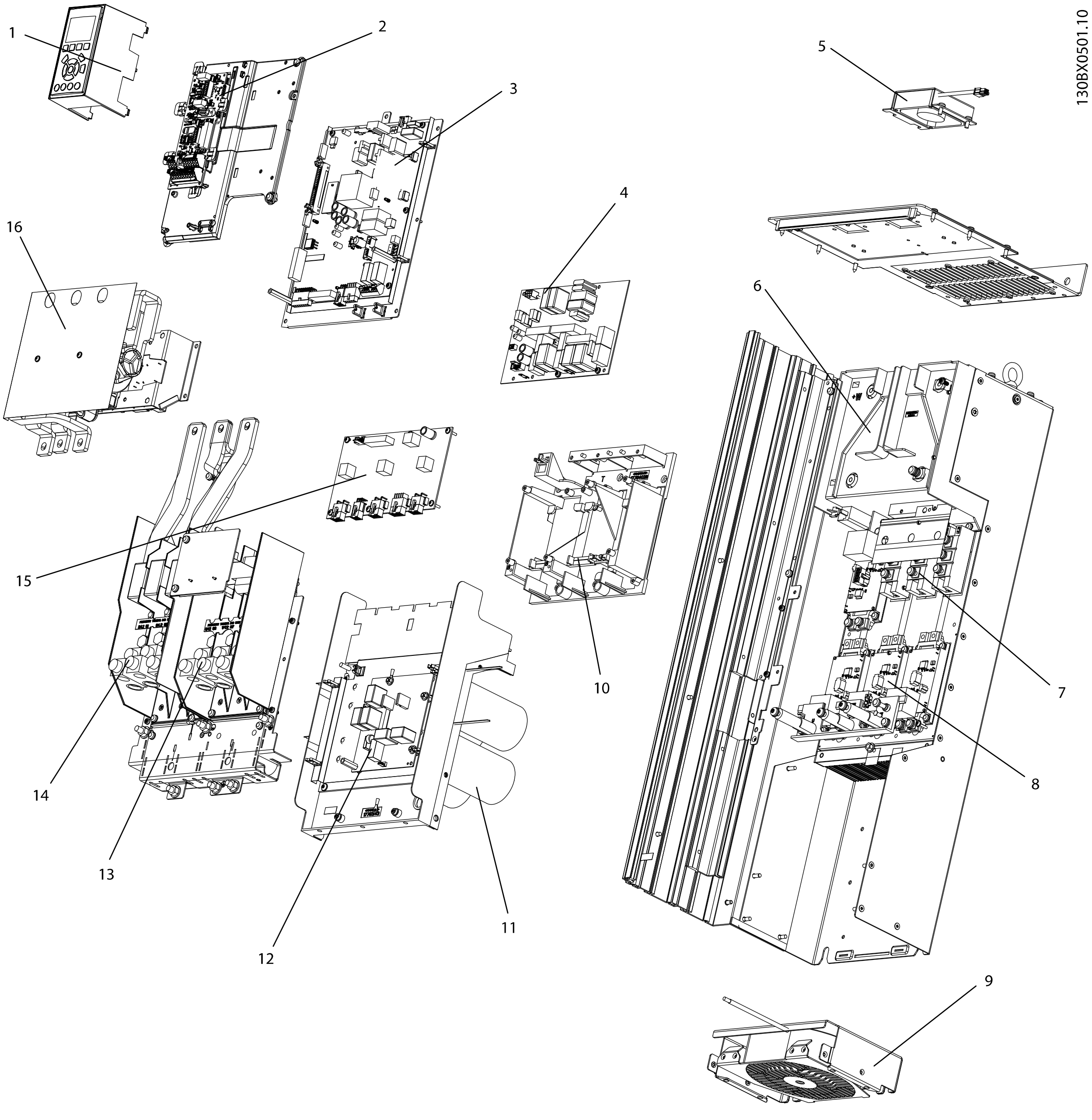
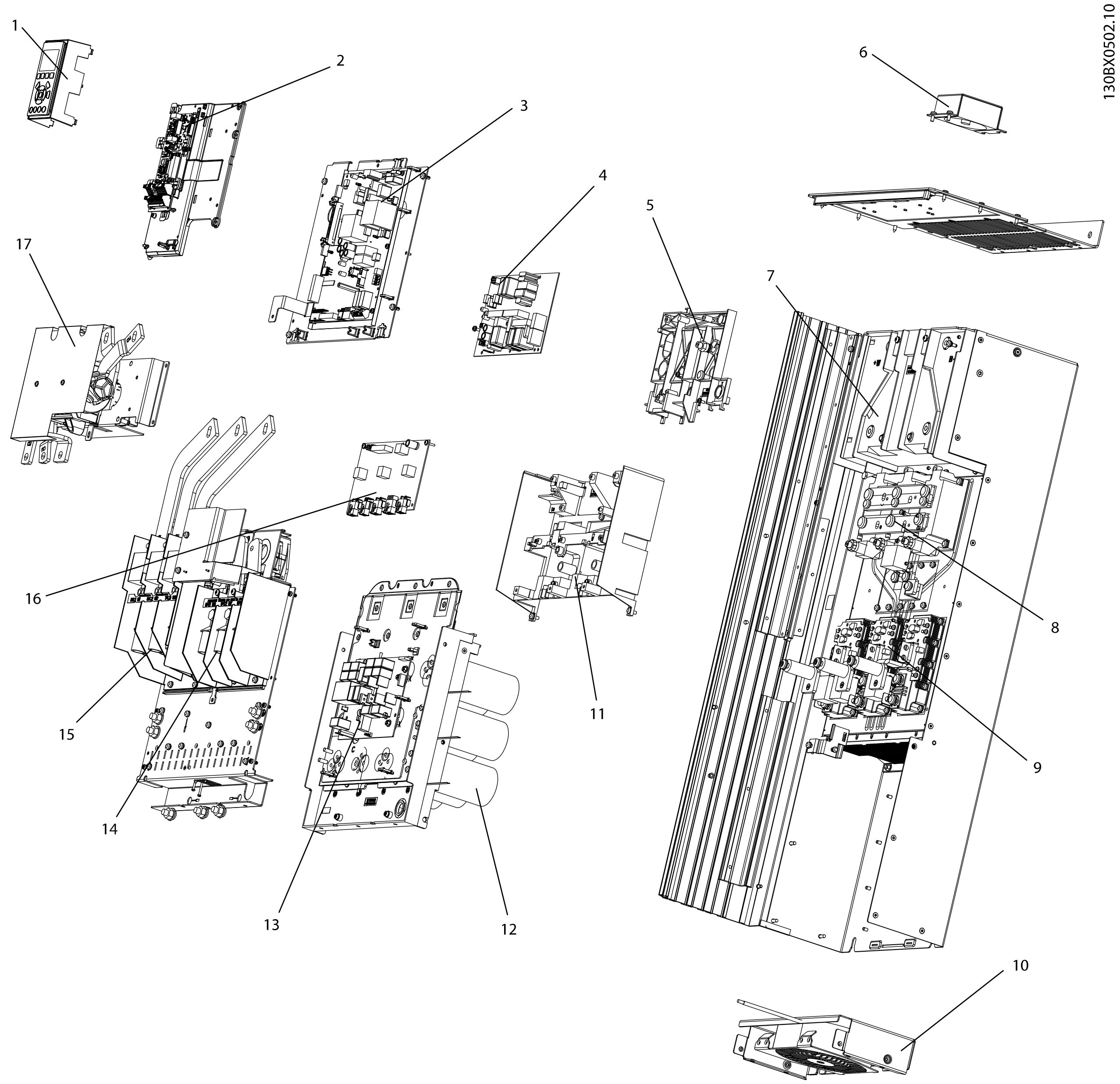
1.8 Exploded Views



1	Local control panel mounting bracket	9	Heatsink fan
2	Control card and mounting plate	10	Gate drive support bracket
3	Power card and mounting plate	11	Capacitor bank
4	Inrush card	12	Balance/High frequency card
5	Top fan (IP20 only)	13	Motor output terminals
6	DC inductor	14	Mains input terminals
7	SCR/Diode modules	15	Gate drive card
8	IGBT modules	16	(optional) RFI filter

Illustration 1.1 Exploded View D3h Frame Size (D1h Frame is Similar)



1	Local control panel mounting bracket	10	Heatsink fan
2	Control card and mounting plate	11	Gate drive support bracket
3	Power card and mounting plate	12	Capacitor bank
4	Inrush card	13	Balance/High frequency card
5	Inrush card mounting bracket	14	Motor output terminals
6	Top fan (IP20 only)	15	Mains input terminals
7	DC inductor	16	Gate drive card
8	SCR/Diode modules	17	(optional) RFI filter
9	IGBT modules		

Illustration 1.2 Exploded View D4h Frame Size (D2h Frame is Similar)

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1.9 Power-dependent Specifications

TR200 Model	N90K		N110		N132		N160		N200		N250	
High/Normal Load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical Shaft output at 400 V [kW]	90	110	110	132	132	160	160	200	200	250	250	315
Typical Shaft output at 460 V [hp]	125	150	150	200	200	250	250	300	300	350	350	450
Typical Shaft ouptut at 500 V [kW]	110	132	132	160	160	200	200	250	250	315	315	355
Enclosure IP21	D1h		D1h		D1h		D2h		D2h		D2h	
Enclosure IP54	D1h		D1h		D1h		D2h		D2h		D2h	
Enclosure IP20	D3h		D3h		D3h		D4h		D4h		D4h	
Output current												
Continuous (at 400 V) [A]	177	212	212	260	260	315	315	395	395	480	480	588
Intermittent (60 s overload) (at 400 V)[A]	266	233	318	286	390	347	473	435	593	528	720	647
Continuous (at 460/500 V) [A]	160	190	190	240	240	302	302	361	361	443	443	535
Intermittent (60 s overload) (at 460/500 V) [kVA]	240	209	285	264	360	332	453	397	542	487	665	588
Continuous kVA (at 400 V) [kVA]	123	147	147	180	180	218	218	274	274	333	333	407
Continuous kVA (at 460 V) [kVA]	127	151	151	191	191	241	241	288	288	353	353	426
Continuous kVA (at 500 V) [kVA]	139	165	165	208	208	262	262	313	313	384	384	463
Max. Input current												
Continuous (at 400 V) [A]	171	204	204	251	251	304	304	381	381	463	463	567
Continuous (at 460/500 V) [A]	154	183	183	231	231	291	291	348	348	427	427	516
Max. cable size: mains, motor, brake and load share [mm^2 (AWG[2]))][5)]	2x95 (2x3/0)						2x185 (2x350 mcm)					
Max. external mains fuses [A][1]	315		350		400		550		630		800	
Estimated power loss at 400 V [W] [4]	2031	2559	2289	2954	2923	3770	3093	4116	4039	5137	5005	6674
Estimated power loss at 460 V [W]	1828	2261	2051	2724	2089	3628	2872	3569	3575	4566	4458	5714
Weight, enclosure IP21, IP54 kg (lbs.)	62 (135)						125 (275)					
Weight, enclosure IP20 kg (lbs.)	62 (135)						125 (275)					
Efficiency[4)]	0.98											
Output frequency	0-800 Hz										0-600 Hz	
*High overload = 150% current for 60 s, Normal overload = 110% current for 60 s												

Table 1.9 Mains Supply 3x380-500 V AC

TR200 Model	N110	N132	N160	N200	N250	N315
High/Normal Load*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Typical Shaft output at 400 V [kW]	110	132	160	200	250	315
Typical Shaft output at 460 V [hp]	150	200	250	300	350	450
Typical Shaft ouptut at 480 V [kW]	132	160	200	250	315	355
Enclosure IP21	D1h	D1h	D1h	D2h	D2h	D2h
Enclosure IP54	D1h	D1h	D1h	D2h	D2h	D2h
	D3h	D3h	D3h	D3h	D4h	D4h
Output current						
Continuous (at 400 V) [A]	212	260	315	395	480	588
Intermittent (60 s overload) (at 400 V) [A]	233	286	347	435	528	647
Continuous (at 460/500 V) [A]	190	240	302	361	443	535
Intermittent (60 s overload) (at 460/500 V) [kVA]	209	264	332	397	487	588
Continuous kVA (at 400 V) [kVA]	147	180	218	274	333	407
Continuous kVA (at 460 V) [kVA]	151	191	241	288	353	426
Max. Input current						
Continuous (at 400 V) [A]	204	251	304	381	381 463	463 567
Continuous (at 460/500 V) [A]	183	231	291	348	348 427	427 516
Max. cable size: mains, motor, brake and load share [mm²] (AWG[2])[5]	2x95 (2x3/0)			2x185 (2x350)		
Max. external mains fuses [A][1]	315	350	400	550	630	800
Estimated power loss at 400 V [W] [4]	2555	2949	3764	4109	5129	6663
Estimated power loss at 460 V [W]	2257	2719	3622	3561	4558	5703
Weight, enclosure IP21, IP54 kg (lbs.)	62 (135)			125 (275)		
Weight, enclosure IP20 kg (lbs.)	62 (135)			125 (275)		
Efficiency[4]	0.98					
Output frequency	0–800 Hz					0–600 Hz
*Normal overload = 110% current for 60 s						

Table 1.10 Mains Supply 3x380-480 V AC

1) For type of fuse see Operating Instructions.

2) American Wire Gauge

3) Measured using 5 m screened motor cables at rated load and rated frequency.

4) The typical power loss is at nominal load conditions and within ±15% (depending on various voltage and cable conditions).

5) Field wiring terminals on TR200 N132, N160, and N315 models are not intended to receive conductors one size larger.

Values are based on a typical motor efficiency (eff2/eff3 border line). Motors with lower efficiency add to the power loss in the frequency converter and those with higher efficiency decrease it.

The losses are based on the default switching frequency. The losses increase significantly at higher switching frequencies. LCP and typical control card power consumptions are included. Further options and customer load may add up to 30 W to the losses. (Though typically, only 4 W extra for a fully loaded control card, or options for slot A or slot B, each).

TR200Model	N55K		N75K		N90K		N110		N132		N160	
High/Normal Load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical Shaft output at 550 V [kW]	45	55	55	75	75	90	90	110	110	132	132	160
Typical Shaft output at 575 V [hp]	60	75	75	100	100	125	125	150	150	200	200	250
Typical Shaft output at 690 V [kW]	55	75	75	90	90	110	110	132	132	160	160	200
Enclosure IP21	D1h		D1h		D1h		D1h		D1h		D2h	
Enclosure IP54	D1h		D1h		D1h		D1h		D1h		D2h	
Enclosure IP20	D3h		D3h		D3h		D3h		D3h		D4h	
Output current												
Continuous (at 550 V) [A]	76	90	90	113	113	137	137	162	162	201	201	253
Intermittent (60 s overload) (at 550 V) [A]	122	99	135	124	170	151	206	178	243	221	302	278
Continuous (at 575/690 V) [A]	73	86	86	108	108	131	131	155	155	192	192	242
Intermittent (60 s overload) (at 575/690 V) [kVA]	117	95	129	119	162	144	197	171	233	211	288	266
Continuous kVA (at 550 V) [kVA]	72	86	86	108	108	131	131	154	154	191	191	241
Continuous kVA (at 575 V) [kVA]	73	86	86	108	108	130	130	154	154	191	191	241
Continuous kVA (at 690 V) [kVA]	87	103	103	129	129	157	157	185	185	229	229	289
Max. Input current												
Continuous (at 550 V) [A]	77	89	89	110	110	130	130	158	158	198	198	245
Continuous (at 575 V) [A]	74	85	85	106	106	124	124	151	151	189	189	234
Continuous (at 690 V)	77	87	87	109	109	128	128	155	155	197	197	240
Max. cable size: mains, motor, brake and load share [mm^2] (AWG)	2x95 (2x3/0)										2x185 (2x350)	
Max. external mains fuses [A]	160		315		315		315		315		550	
Estimated power loss at 575 V [W]	1098	1162	1162	1428	1430	1740	1742	2101	2080	2649	2361	3074
Estimated power loss at 690 V [W]	1057	1204	1205	1477	1480	1798	1800	2167	2159	2740	2446	3175
Weight, enclosure IP21, IP54 kg (lbs.)	62 (135)										125 (275)	
Weight, enclosure IP20 kg (lbs.)	125 (275)											
Efficiency	0.98											
Output frequency	0–590 Hz											
Heatsink overtemperature trip	110 °C											
Control card ambient trip	75 °C											
*High overload=150% current for 60 s, Normal overload=110% current for 60 s.												

Table 1.11 Mains Supply 3x525-690 V AC

TR200 Model	N200		N250		N315	
High/Normal Load*	**HO**	**NO**	**HO**	**NO**	**HO**	**NO**
Typical Shaft output at 550 V [kW]	160	200	200	250	250	315
Typical Shaft output at 575 V [hp]	250	300	300	350	350	400
Typical Shaft output at 690 V [kW]	200	250	250	315	315	400
Enclosure IP21	D2h		D2h		D2h	
Enclosure IP54	D2h		D2h		D2h	
Enclosure IP20	D4h		D4h		D4h	
Output current						
Continuous (at 550 V) [A]	253	303	303	360	360	418
Intermittent (60 s overload) (at 550 V)[A]	380	333	455	396	540	460
Continuous (at 575/690 V) [A]	242	290	290	344	344	400
Intermittent (60 s overload) (at 575/690 V) [kVA]	363	319	435	378	516	440
Continuous kVA (at 550 V) [kVA]	241	289	289	343	343	398
Continuous kVA (at 575 V) [kVA]	241	289	289	343	343	398
Continuous kVA (at 690 V) [kVA]	289	347	347	411	411	478
Max. Input current						
Continuous (at 550 V) [A]	245	299	299	355	355	408
Continuous (at 575 V) [A]	234	286	286	339	339	390
Continuous (at 690 V)	240	296	296	352	352	400
Max. cable size: mains, motor, brake and load share [mm^2] (AWG)	2x185 (2x350)					
Max. external mains fuses [A]	550					
Estimated power loss at 575 V [W]	3012	3723	3642	4465	4146	5028
Estimated power loss at 690 V [W]	3123	3851	3771	4614	4258	5155
Weight, enclosure IP21, IP54 kg (lbs.)	125 (275)					
Weight, enclosure IP20 kg (lbs.)	125 (275)					
Efficiency	0.98					
Output frequency	0–590 Hz					
Heatsink overtemperature trip	110 °C					
Control card ambient trip	75 °C					
*High overload=150% current for 60 s, Normal overload=110% current for 60 s.						

Table 1.12 Mains Supply 3x525-690 V AC

The typical power loss is at nominal load conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions).
The losses are based on the default switching frequency. The losses increase significantly at higher switching frequencies.
The options cabinet adds weight to the frequency converter. The maximum weights of the D5h–D8h frames is shown in Table D5h–D8h Weights in the operating instructions.

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TR200 Model	N75K	N90K	N110	N132	N160	N200
Normal Load*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Typical Shaft output at 550 V [kW]	55	75	90	110	132	160
Typical Shaft output at 575 V [hp]	75	100	125	150	200	250
Typical Shaft ouptut at 690 V [kW]	75	90	110	132	160	200
Enclosure IP21	D1h	D1h	D1h	D1h	D1h	D2h
Enclosure IP54	D1h	D1h	D1h	D1h	D1h	D2h
Enclosure IP20	D3h	D3h	D3h	D3h	D3h	D4h
Output current						
Continuous (at 550 V) [A]	90	113	137	162	201	253
Intermittent (60 s overload) (at 550 V)[A]	99	124	151	178	221	278
Continuous (at 575/690 V) [A]	86	108	131	155	192	242
Intermittent (60 s overload) (at 575/690 V) [kVA]	95	119	144	171	211	266
Continuous kVA (at 550 V) [kVA]	86	108	131	154	191	241
Continuous kVA (at 575 V) [kVA]	86	108	130	154	191	241
Continuous kVA (at 690 V) [kVA]	103	129	157	185	229	289
Max. Input current						
Continuous (at 550 V) [A]	89	110	130	158	198	245
Continuous (at 575 V) [A]	85	106	124	151	189	234
Continuous (at 690 V) [A]	87	109	128	155	197	240
Max. cable size: mains, motor, brake and load share [mm^2] (AWG)	2x95 (2x3/0)					2x185 (2x350 mcm)
Max. external mains fuses [A]	160	315	315	315	350	350
Estimated power loss at 575 V [W]	1161	1426	1739	2099	2646	3071
Estimated power loss at 690 V [W]	1203	1476	1796	2165	2738	3172
Weight, enclosure IP21, IP54 kg (lbs.)	62 (135)					125 (275)
Weight, enclosure IP20 kg (lbs.)	62 (135)					125 (275)
Efficiency	0.98					
Output frequency	0–590 Hz					
Heatsink overtemp. trip	110 °C					
Power card ambient trip	75 °C					
*Normal overload=110% current for 60 s						

Table 1.13 Mains Supply 3x525-690 V AC

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TR200 Model	N250	N315	N400
Normal Load*	**NO**	**NO**	**NO**
Typical Shaft output at 550 V [kW]	200	250	315
Typical Shaft output at 575 V [hp]	300	350	400
Typical Shaft ouTput at 690 V [kW]	250	315	400
Enclosure IP21	D2h	D2h	D2h
Enclosure IP54	D2h	D2h	D2h
Enclosure IP20	D4h	D4h	D4h
Output current			
Continuous (at 550 V) [A]	303	360	418
Intermittent (60 s overload) (at 550 V)[A]	333	396	460
Continuous (at 575/690 V) [A]	290	344	400
Intermittent (60 s overload) (at 575/690 V) [kVA]	319	378	440
Continuous kVA (at 550 V) [kVA]	289	343	398
Continuous kVA (at 575 V) [kVA]	289	343	398
Continuous kVA (at 690 V) [kVA]	347	411	478
Max. Input current			
Continuous (at 550 V) [A]	299	355	408
Continuous (at 575 V) [A]	286	339	390
Continuous (at 690 V) [A]	296	352	400
Max. cable size: mains, motor, brake, and load share, [mm^2] (AWG)	2x185 (2x350 mcm)		
Max. external mains fuses [A]	400	500	550
Estimated power loss at 575 V [W]	3719	4460	5023
Estimated power loss at 690 V [W]	3848	4610	5150
Weight, enclosure IP21, IP54 kg (lbs.)	125 (275)		
Weight, enclosure IP20 kg (lbs.)	125 (275)		
Efficiency	0.98		
Output frequency	0–590 Hz		
Heatsink overtemp. trip	110 °C		
Power card ambient trip	75 °C		
*Normal overload=110% current for 60 s			

Table 1.14 Mains Supply 3x525-690 V AC

The typical power loss is at nominal load conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions).
The losses are based on the default switching frequency. The losses increase significantly at higher switching frequencies.
The options cabinet adds weight to the frequency converter. The maximum weights of the D5h–D8h frames is shown in Table D5h–D8h Weights in the operating instructions.

380-480 V AC	Model	N110	N132	N160	N200	N250	N315
380-500 V AC	FC 302	N90k	N110	N132	N160	N200	N250
Overcurrent Warning	[A_{rms}]	327	392	481	583	731	888
Overcurrent Alarm[1] (1.5 s delay)	[A_{rms}]	330	395	483	585	734	893
Earth (Ground) Fault Alarm	[A_{rms}]	27	32	39	47	59	72
Short Circuit Alarm	[Apk]	593	711	868	1051	1318	1595
Heatsink Overtemperature	[°C]	110	110	110	110	110	110
Heatsink Undertemperature Warning	[°C]	0	0	0	0	0	0
Control Card Overtemperature	[°C]	75	75	75	80	80	80
Mains Phase Warning (30 s delay)	DC Bus Ripple Vpkpk	80	80	80	80	80	80
Mains Phase Alarm (60 s delay)	DC Bus Ripple Vpkpk	80	80	80	80	80	80
1) Based on crest factor of 1.414							

Table 1.15 Warning and Alarm Trip Points

525-690 V AC	Model	N75	N90	N110	N132	N160	N200	N250	N315	N400
Overcurrent Warning	[A_{rms}]	141	167	209	253	300	372	468	561	666
Overcurrent Alarm[1] (1.5 s delay)	[A_{rms}]	255	255	255	255	330	483	483	585	734
Earth (Ground) Fault Alarm	[A_{rms}]	11	14	17	21	24	30	38	45	54
Short Circuit Alarm	[Apk]	459	459	459	459	593	870	869	1050	1319
Heatsink Overtemperature	[°C]	110	110	110	110	110	110	110	110	110
Heatsink Undertem-perature Warning	[°C]	0	0	0	0	0	0	0	0	0
Control Card Overtem-perature	[°C]	75	75	75	75	75	75	80	80	80
Mains Phase Warning (30 s delay)	DC Bus Ripple Vpkpk	80	80	80	80	80	80	80	80	80
Mains Phase Alarm (60 s delay)	DC Bus Ripple Vpkpk	80	80	80	80	80	80	80	80	80
1) Based on crest factor of 1.414										

Table 1.16 Warning and Alarm Trip Points

	380-480 V/380-500 V units		**525-690 V units**
Inrush Circuit Enabled [V DC]	370		550
Inrush Circuit Disabled [V DC]	395		570
Inverter Under Voltage Disable [V DC]	373		553
Under Voltage Warning [V DC]	410		585
Inverter Under Voltage Re-enable (warning reset) [V DC]	413		602
	380-480 V units	**380-500 V units**	
Over Voltage Warning (without brake) [V DC]	778	817	1084
Dynamic Brake Turn On [V DC]	778	810	1099
Inverter Over Voltage Re-Enable (warning reset) [V DC]	786	821	1099
Over Voltage Warning (with brake) [V DC]	810	828	1109
Over Voltage Trip [V DC]	820	855	1130

Table 1.17 DC Voltage Levels

2 Operator Interface and Frequency Converter Control

2.1 Introduction

Frequency converters are designed with self-diagnostic circuitry to isolate fault conditions and activate display messages that 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 (keypad) display. Fault logs are maintained within the frequency converter for fault history.

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

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

2.2 User Interface

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

The keypad 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 keypad which can show up to five operating variables while 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 [Status], up to one extra line can be added.

c. **Status line:** Status messages displaying text.

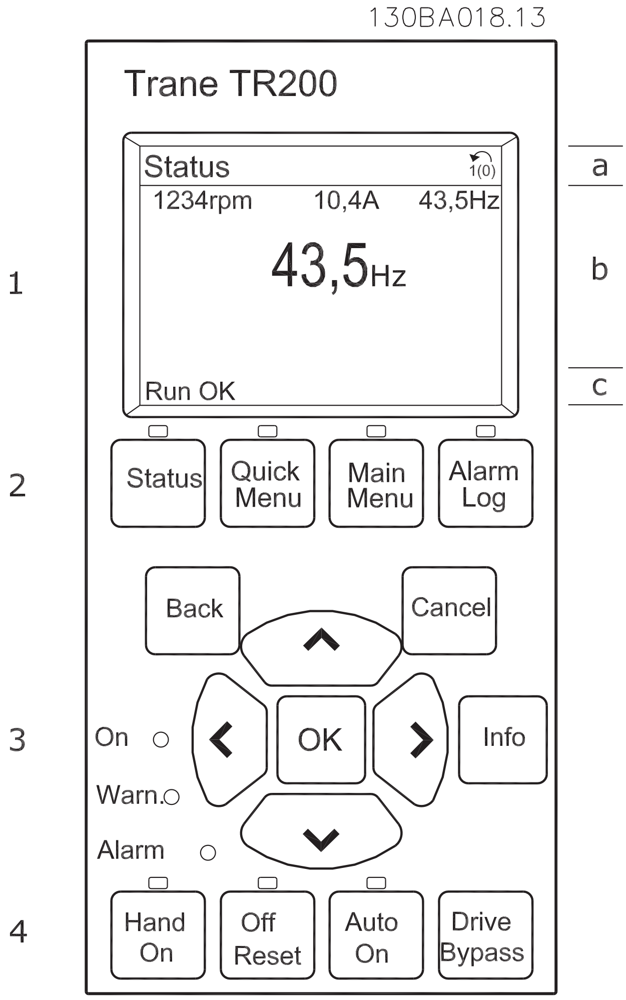


Illustration 2.1 LCP keypad

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 *0-10 Active Set-up*) 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.

Middle section
(b) shows up to 5 variables with related unit, regardless of status. When there is an alarm/warning, the warning is shown instead of the variables.

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

Several values or measurements can be linked to each of the displayed operating variables. The values/ measurements displayed can be defined via *0-20 Display Line 1.1 Small*, *0-21 Display Line 1.2 Small*, *0-22 Display Line 1.3 Small*, *0-23 Display Line 2 Large* and *0-24 Display Line 3 Large*, which can be accessed via [QUICK MENU] *Q3 Function Set-ups, Q3-1 General Settings, Q3-13 Display Settings*.

Each value/measurement readout parameter selected in *0-20 Display Line 1.1 Small* to *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.
Press [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.

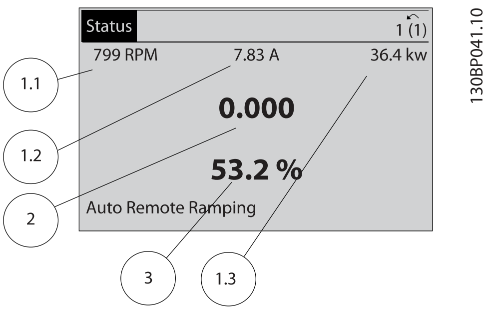


Illustration 2.2 Status Display I

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.

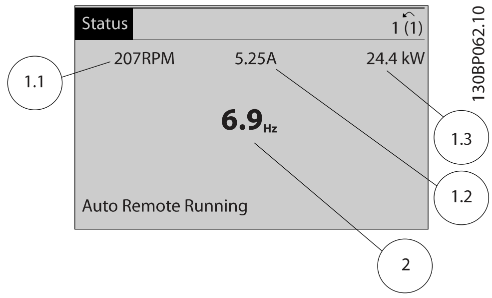


Illustration 2.3 Status Display II

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

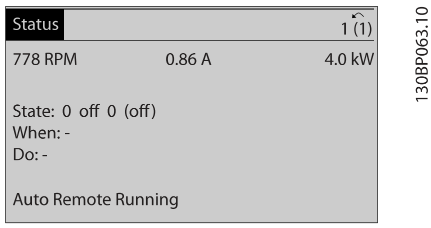


Illustration 2.4 Status Display III

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

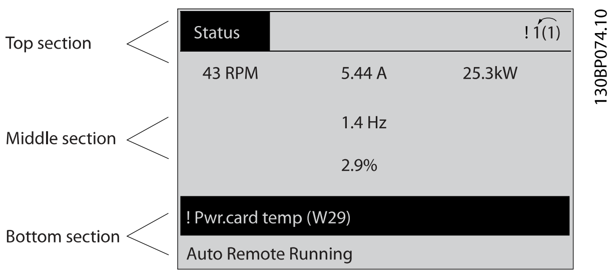


Illustration 2.5

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.

Illustration 2.6 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.

Illustration 2.7 Menu Keys

[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]** to select the mode of display or chang back to Display mode from Quick Menu mode, Main Menu mode, or Alarm mode. Press [Status] to toggle between the three readouts.

[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 most applications. Among other features, it also includes parameters for selecting which variables to display on the keypad.

[Main Menu]
Is used for programming all parameters. The Main Menu parameters can be accessed immediately unless a password has been created via *0-60 Main Menu Password*, *0-61 Access to Main Menu w/o Password*, *0-65 Personal Menu Password*, or *0-66 Access to Personal Menu w/o Password*.

[Alarm Log]
Displays an Alarm list of the five latest alarms (numbered A1-A5). To obtain more details about an alarm, press the navigation 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] key on the keypad allows access to both the Alarm log and Maintenance log.

[Back]
Reverts to the previous step or layer in the navigation structure.

Illustration 2.8 Back Icon

[Cancel]
Last change or command is cancelled as long as the display has not been changed.

Illustration 2.9 Cancel Icon

[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].

Illustration 2.10 Info Icon

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

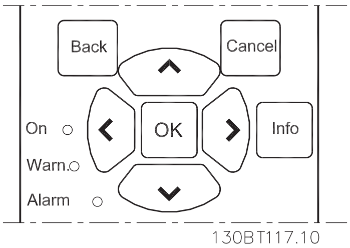


Illustration 2.11 Navigation Keys

Operation keys
For local control are placed at the bottom of the control panel.

Illustration 2.12 Operation Keys

[Hand On]
Enables control of the frequency converter via the keypad. [Hand On] also starts the motor, and it is now possible to enter the motor speed data with the navigation keys. The key can be selected as *[1] Enable* or *[0] Disable* via *0-40 [Hand on] Key on LCP*.
The following control signals are still 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

NOTICE

External stop signals activated with control signals or a serial bus overrides a *start* command via the keypad.

[Off]
Stops the connected motor. The key can be selected as *[1] Enable* or *[0] Disable* via *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 starts. The key can be selected as *[1] Enable* or *[0] Disable* via *0-42 [Auto on] Key on LCP*.

NOTICE

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 *[1] Enable* or *[0] Disable* via *0-43 [Reset] Key on LCP*.

2.2.2 Numeric Local Control Panel (NLCP)

See the Design Guide for instructions for using the numeric keypad.

2.2.3 Changing Settings with the LCP

- For most applications, the Quick Menu, Quick Set-up, and Function Set-up provide the simplest and quickest access to all the typical parameters required.
- Whenever possible, performing an AMA ensures 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.
- To access any parameter, press and hold the [Main Menu] key for 3 seconds.
- For service purposes, copy all of the parameters to the keypad, see *0-50 LCP Copy* for further information.

NOTICE

Exchanging or adding a control card, power card, or option card - or updating the software - requires a manual reinitialisation of the frequency converter for proper operation.

To reinitialise the frequency converter

1. Disconnect from mains and wait until the display turns off.
2. Press [Status] - [Main Menu] - [OK] at the same time during power up.
3. Release the keys after 5 s.
4. The frequency converter is now programmed according to default settings.

For more information about initialisation, consult the operating instructions.

Initialise the frequency converter to default settings in 2 ways.

Recommended initialisation (via *14-22 Operation Mode*)

1. Select *14-22 Operation Mode*
2. Press [OK]
3. Select *[2] Initialisation*
4. Press [OK]
5. Disconnect the mains supply and wait until the display turns off.
6. Reconnect the mains supply - the frequency converter is now reset.

14-22 Operation Mode initialises all except:

- 14-50 RFI Filter
- 8-30 Protocol
- 8-31 Address
- 8-32 Baud Rate
- 8-35 Minimum Response Delay
- 8-36 Maximum Response Delay
- 8-37 Maximum Inter-Char Delay
- 15-00 Operating hours to 15-05 Over Volt's
- 15-20 Historic Log: Event to 15-22 Historic Log: Time
- 15-30 Alarm Log: Error Code to 15-32 Alarm Log: Time

Manual initialisation

1. Disconnect from mains and wait until the display turns off.
2. 2a Press [Status] - [Main Menu] - [OK] at the same time while power up for LCP 102, Graphical Display

   2b Press [Menu] - [OK] while power up for LCP 101, Numerical Display
3. Release the keys after 5 s.
4. The frequency converter is now programmed according to default settings.

This procedure initialises all except:

15-00 Operating hours

15-03 Power Up's

15-04 Over Temp's

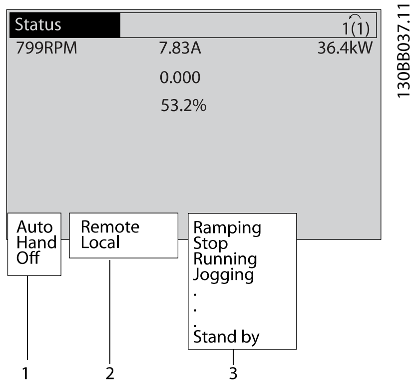
15-05 Over Volt's

NOTICE

A manual initialisation also resets serial communication, RFI filter settings (*14-50 RFI Filter*) and fault log settings.

2.3 Status Messages

When the frequency converter is in status mode, status messages are generated automatically and appear in the bottom line of the display (see *Illustration 2.13*).



1	Operation mode (see *Table 2.1*)
2	Reference site (see *Table 2.2*)
3	Operation status (see *Table 2.3*)

Illustration 2.13 Status Display

2.4 Status Message Definitions

Table 2.1 to *Table 2.3* describe the displayed status messages.

Off	The frequency converter does not react to any control signal until [Auto On] or [Hand On] is pressed.
Auto On	The frequency converter is controlled from the control terminals and/or the serial communication.
Hand On	Control the unit via the navigation keys on the LCP. Stop commands, reset, reversing, DC brake, and other signals applied to the control terminals can override local control.

Table 2.1 Operation Mode

Remote	The speed reference is given from external signals, serial communication, or internal preset references.
Local	The frequency converter uses [Hand On] control or reference values from the LCP.

Table 2.2 Reference Site

AC Brake	AC Brake was selected in *2-10 Brake Function*. The AC brake over-magnetises the motor to achieve a controlled slow down.
AMA finish OK	Automatic motor adaptation (AMA) was carried out successfully.
AMA ready	AMA is ready to start. Press [Hand On] to start.
AMA running	AMA process is in progress.
Braking	The brake chopper is in operation. The brake resistor absorbs generative energy.
Braking max.	The brake chopper is in operation. The power limit for the brake resistor has been reached.
Coast	• Coast inverse was selected as a function for a digital input (parameter group *5–1* Digital Inputs*). The corresponding terminal is not connected. • Coast activated by serial communication
Ctrl. Ramp-down	Control Ramp-down was selected in *14-10 Mains Failure*. • The mains voltage is below the value set in *14-11 Mains Voltage at Mains Fault* at mains fault • The frequency converter ramps down the motor using a controlled ramp down
Current High	The frequency converter output current is above the limit set in *4-51 Warning Current High*.
Current Low	The frequency converter output current is below the limit set in *4-52 Warning Speed Low*
DC Hold	DC hold is selected in *1-80 Function at Stop* and a stop command is active. The motor is held by a DC current set in *2-00 DC Hold/ Preheat Current*.
DC Stop	The motor is held with a DC current (*2-01 DC Brake Current*) for a specified time (*2-02 DC Braking Time*). • DC brake is activated in *2-03 DC Brake Cut In Speed [RPM]* and a stop command is active. • DC brake (inverse) is selected as a function for a digital input (parameter group *5–1* Digital Inputs*). The corresponding terminal is not active. • The DC brake is activated via serial communication.
Feedback high	The sum of all active feedbacks is above the feedback limit set in *4-57 Warning Feedback High*.
Feedback low	The sum of all active feedbacks is below the feedback limit set in *4-56 Warning Feedback Low*.
Freeze output	The remote reference is active, which holds the present speed. • Freeze output was selected as a function for a digital input (parameter group *5–1* Digital Inputs*). The corresponding terminal is active. Speed control is only possible via the terminal functions Speed Up and Speed Down. • Hold ramp is activated via serial communication.
Freeze output request	A freeze output command has been given, but the motor remains stopped until a run permissive signal is received.
Freeze ref.	*Freeze Reference* was selected as a function for a digital input (parameter group *5-1* Digital Inputs*). The corresponding terminal is active. The frequency converter saves the actual reference. Changing the reference is now only possible via terminal functions speed up and speed down.
Jog request	A jog command has been given, but the motor remains stopped until a run permissive signal is received via a digital input.
Jogging	The motor is running as programmed in *3-19 Jog Speed [RPM]*. • *Jog* was selected as function for a digital input (parameter group *5-1* Digital Inputs*). The corresponding terminal is active. • The jog function is activated via the serial communication. • The jog function was selected as a reaction for a monitoring function. The monitoring function is active.
Motor check	In *1-80 Function at Stop*, *Motor Check* was selected. A stop command is active. To ensure that a motor is connected to the frequency converter, a permanent test current is applied to the motor.
OVC control	*Overvoltage* control was activated in *2-17 Overvoltage Control*, *[2] Enabled*. The connected motor supplies the frequency converter with generative energy. The overvoltage control adjusts the V/Hz ratio to run the motor in controlled mode and to prevent the frequency converter from tripping.
PowerUnit Off	(Only frequency converters with an external 24 V power supply installed). Mains supply to the frequency converter is removed, but the control card is supplied by the external 24 V.

Protection md	Protection mode is active. The unit has detected a critical status (an overcurrent or overvoltage). • To avoid tripping, the switching frequency is reduced to 4 kHz. • If possible, protection mode ends after approximately 10 s. • Protection mode can be restricted in *14-26 Trip Delay at Inverter Fault*.
QStop	The motor is decelerating using *3-81 Quick Stop Ramp Time*. • *Quick stop inverse* was selected as a function for a digital input (parameter group *5–1* Digital Inputs*). The corresponding terminal is not active. • The quick stop function was activated via serial communication.
Ramping	The motor is accelerating/decelerating using the active ramp up/down. The reference, a limit value, or a standstill is not yet reached.
Ref. high	The sum of all active references is above the reference limit set in *4-55 Warning Reference High*.
Ref. low	The sum of all active references is below the reference limit set in *4-54 Warning Reference Low*.
Run on ref.	The frequency converter is running in the reference range. The feedback value matches the setpoint value.
Run request	A start command has been given, but the motor is stopped until a run permissive signal is received via digital input.
Running	The frequency converter drives the motor.
Sleep Mode	The energy saving function is enabled. The motor has stopped, but restarts automatically when required.
Speed high	Motor speed is above the value set in *4-53 Warning Speed High*.
Speed low	Motor speed is below the value set in *4-52 Warning Speed Low*.
Standby	In Auto On mode, the frequency converter starts the motor with a start signal from a digital input or serial communication.
Start delay	In *1-71 Start Delay*, a delay starting time was set. A start command is activated and the motor starts after the start delay time expires.
Start fwd/rev	Start forward and start reverse were selected as functions for 2 different digital inputs (parameter group *5–1* Digital Inputs*). The motor starts in forward or reverse depending on which corresponding terminal is activated.
Stop	The frequency converter has received a stop command from the LCP, digital input, or serial communication.
Trip	An alarm occurred and the motor is stopped. Once the cause of the alarm is cleared, the frequency converter can be reset manually by pressing [Reset] or remotely by control terminals or serial communication.
Trip lock	An alarm occurred and the motor is stopped. Once the cause of the alarm is cleared, power must be cycled to the frequency converter. The frequency converter can then be reset manually by pressing [Reset] or remotely by control terminals or serial communication.

Table 2.3 Operation Status

NOTICE

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

2.5 Service Functions

Service information for the frequency converter is on display lines 3 and 4. Included in the data are counters that tabulate operating hours, power ups, and trips; fault logs of status values during the 20 most recent events that stopped the frequency converter; and frequency converter nameplate data. The service information is accessed by displaying items in parameter group *15-** Drive Information*

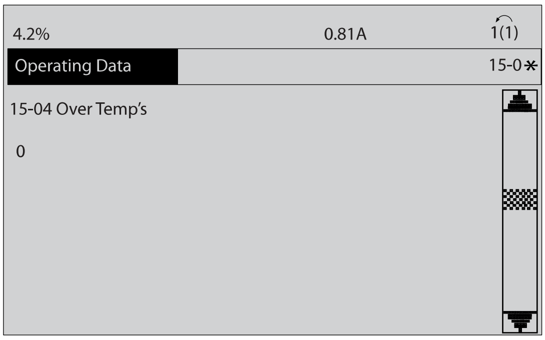


Illustration 2.14 Parameter Group 15 Menu

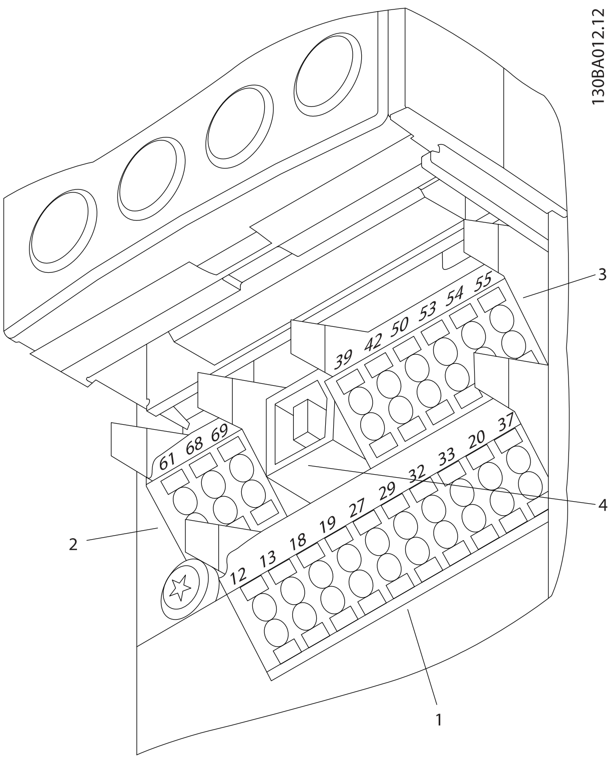
See the Programming Guide for detailed information on accessing and displaying parameters and for descriptions and procedures for service information available in parameter group *15-** Drive Information*

2.6 Frequency Converter Inputs and Outputs

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

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

The third way is through signal wiring connected to the frequency converter control terminals. See *Illustration 2.15*. The frequency converter control terminals are located below the frequency converter keypad. Improperly connected control wiring can be the cause of a motor not operating or the frequency converter not responding to a remote input.



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

Illustration 2.15 Control Terminals

2.6.1 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 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 include additional terminals for input signals.

Analog signals can be either voltage (0–10 V DC) or current (0–20 mA or 4–20 mA). Analog signals can be varied like dialing a rheostat up and down. The frequency converter can be programmed to increase or decrease output in relation to the amount of current or voltage. For example, a sensor or external controller 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 act as a switch. A 0–24 V DC signal controls the digital signals. A voltage signal lower than 5 V DC is a logic 0. A voltage higher than 10 V DC is a logic 1. 0 is open, 1 is closed. 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 is sometimes used for terminating screens when the control cable is run between multiple frequency converters, not other devices. See *chapter 2.9 Grounding Screened Cables* for correct methods for terminating a screened control cable.

2.6.2 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 V DC. In addition, a pulse reference can be provided on terminals 27 and 29. Output analog signals generally indicate the frequency converter frequency, current, torque, and so on, to an external controller or system. Digital outputs can be control signals used to open or close a damper, for example, or 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.

2.6.3 Control Power Supply

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

2.7 Control Terminals

Control terminals must be programmed. Each terminal has specific functions it performs and a numbered parameter associated with it. See *Table 2.4*. 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.

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. To select digital input for display, press the [status] key as discussed previously, or use a voltmeter to check for voltage at the control terminal. See *chapter 6.4.14 Input Terminal Signal Tests*

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

- wired properly
- powered
- programmed correctly for the intended function
- receiving a signal

2

2.8 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 more terminals.

Terminal No.	Function
01, 02, 03 and 04, 05, 06	Two Form C output relays. Maximum 240 V AC, 2 A. minimum 24 V DC, 10 mA, or 24 V AC, 100 mA. Can be used for indicating status and warnings. Physically located on the power card.
12, 13	24 V DC 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 V DC 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 V DC at a minimum of 500 Ω.
50	10 V DC, 15 mA maximum analog supply voltage for potentiometer or thermistor.
53, 54	Selectable for 0–10 V DC voltage input, R = 10 kΩ, or analog signals 0/4 to 20 mA at a maximum of 200 Ω. Used for reference or feedback signals. A thermistor can be connected here.
55	Common for terminals 53 and 54.
61	RS-485 common.
68, 69	RS-485 interface and serial communication.

Table 2.4 Control Terminals and Functions

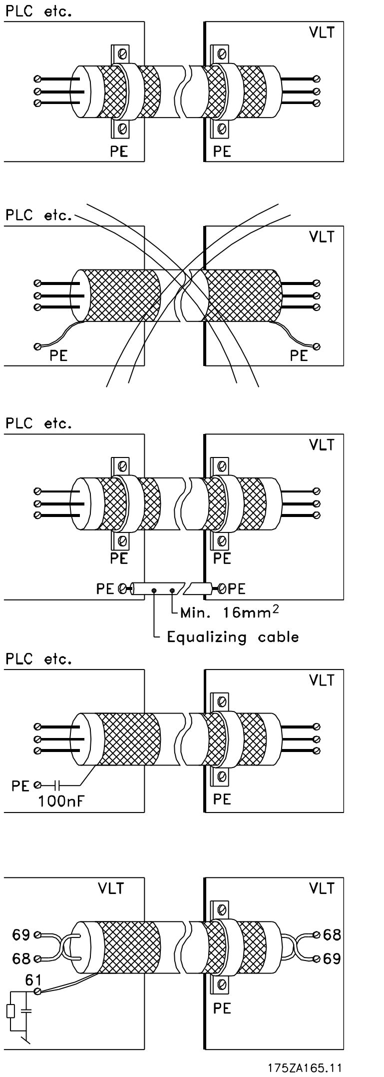
Terminal	18	19	27	29	32	33	37	53	54	42	1–3	4–6
Parameter	5–10	5–11	5–12	5–13	5–14	5–15	5–19	6–1*	6–2*	6–5*	5–4*	5–4*

Table 2.5 Control Terminals and Associated Parameter

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

2.9 Grounding Screened Cables

Connect the screened control cables with cable clamps at both ends to the metal cabinet of the frequency converter. *Table 2.6* shows ground cabling for optimal results.



Correct grounding Control cables and cables for serial communication must be fitted with cable clamps at both ends to ensure the best possible electrical connection.
Incorrect grounding Do not use twisted cable ends (pigtails) since these increase screen impedance at high frequencies.
Ground potential protection When the ground potential between the frequency converter and the PLC or other interface device is different, electrical noise occurs that can disturb the entire system. Fitting an equalizing cable next to the control cable will resolve this. Minimum cable cross section is 8 AWG.
50/60Hz ground loops When using long control cables, 50/60 Hz ground loops may occur that can disturb the entire system. Resolve this by connecting one end of the screen with a 100 nF capacitor and keeping the lead short.
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 ground through an internal RC link. Use twisted-pair cables to reduce the differential mode interference between conductors.

Table 2.6 Grounding Screened Cables

3 Internal Frequency Converter Operation

3.1 General

This section is intended to provide an operational overview of the main assemblies and circuitry. This information gives the repair technician a better understanding of the frequency converter and aid in the troubleshooting process.

3.2 Description of Operation

A frequency converter is an electronic controller that supplies a regulated amount of AC power to a three-phase induction motor 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 (DC bus), inverter, and control (see *Illustration 3.1*).

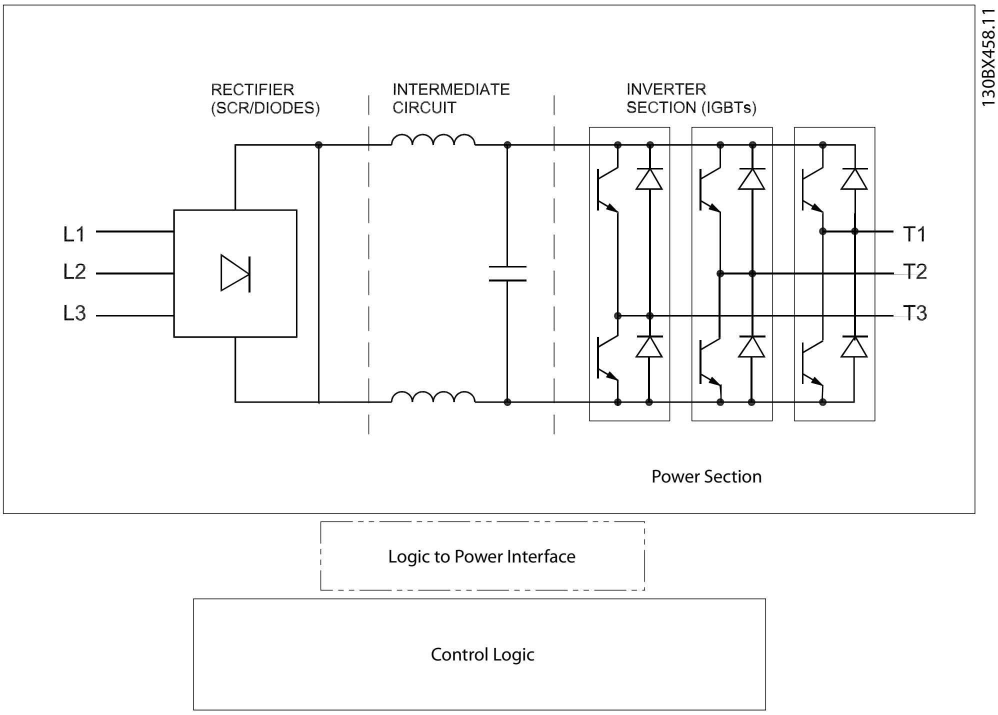


Illustration 3.1 Basic Block Diagram

To provide an overview, the main frequency converter components are grouped into three categories: The control logic section, logic to power interface, and power section. The sequence of operation description describes these sections in greater detail while explaining 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 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 allows for changing 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 on the power card.

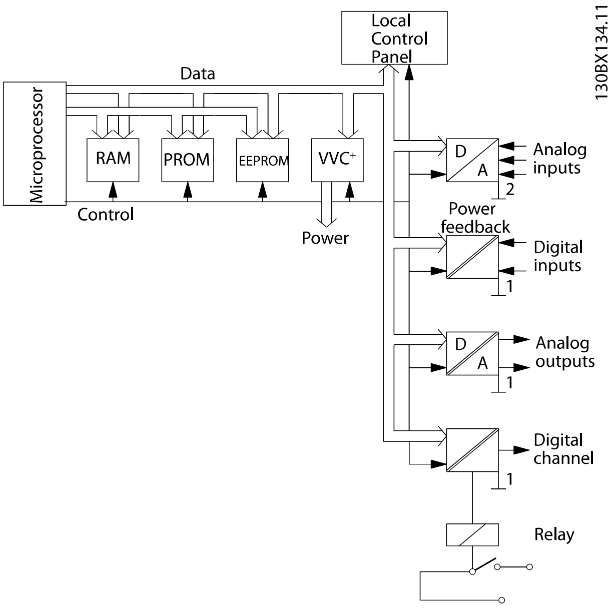


Illustration 3.2 Logic Section

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

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

All the programmable parameter settings can be uploaded into the EEPROM of the keypad. This function is useful for maintaining a backup frequency converter profile and parameter set. It can also be used, through its download function, in programming other frequency converters or to restore a program to a repaired unit. The keypad is removable during operation to prevent undesired program changes. With the addition of a remote mounting kit, the keypad can be mounted in a remote location of up to 3 m (10 ft.) 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 can communicate 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 V DC is used for switching functions such as start, stop, and forward/ reverse. The 24 V DC supply can supply 200 mA of power, part of which may be used to power external encoders or other devices. A 10 V DC supply on terminal 50 is rated at 17 mA is also available for use with speed reference circuitry.

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

Two relays for monitoring the status of the frequency converter are on the power card. These are programmable through parameter group *5–4* Relays*. The relays have different ratings. See the corresponding Operating Instructions or Design Guide for more information on ratings.

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

- Control
- Serial communications
- Additional relays
- Cascade pump controller
- custom operating

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.

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

The power card contains a switch mode power supply (SMPS), which provides the unit with 24 V DC, (+) 18 V DC, (–) 18 V DC and 5 V DC operating voltage. The SMPS powers the logic and interface circuitry. The SMPS is supplied by the DC bus voltage. The frequency converters can be purchased with an optional secondary SMPS, which is powered from a customer supplied 24 V DC source. This secondary SMPS provides power to the logic circuitry with 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 drive signals from the control card to the output transistors (IGBTs) are isolated and buffered on the gate drive card. In units that have the dynamic brake option, the driver circuits for the brake transistors are also on this card.

3.2.3 Power Section

The high-voltage power section consists of AC input and motor output terminals, fuses, wiring harness, AC and DC bus bars, and optional components. The power section (see *Illustration 3.3*) also contains circuitry for the 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.

The inrush circuit controls the firing of the SCRs in the rectifier. When power is applied, the SCRs limit the charging rate of the DC capacitors. Once the capacitors are charged, the inrush circuit sequences the firing of the SCRs to maintain the proper charge on the DC capacitors.
The DC bus circuitry regulates the pulsating DC voltage created by the input AC supply.

The DC coil is a single unit with 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.

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 three modules with two in each, one positive (+) and one negative (-) for each phase.

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

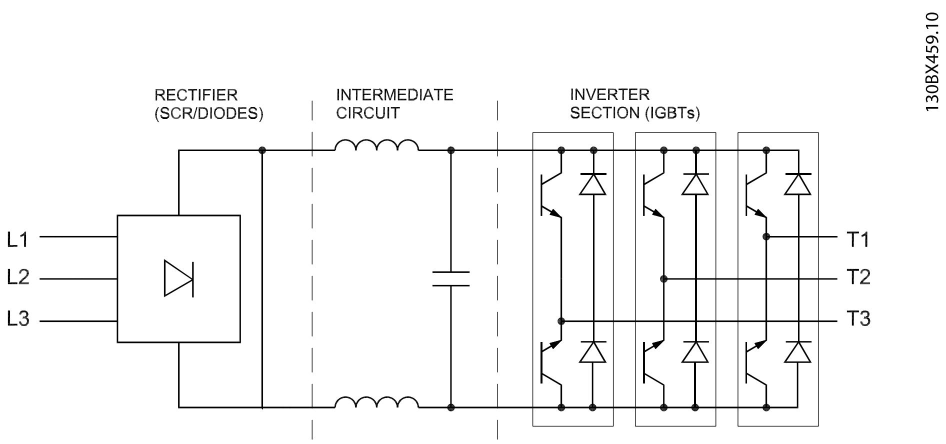


Illustration 3.3 Typical Power Section

3.3 Sequence of Operation

3.3.1 Rectifier section

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

The low voltage power supplies are activated when the DC bus reaches approximately 50 V DC less than the alarm voltage low for the DC bus. See *chapter 1.9 Power-dependent Specifications*. After a short delay, an inrush enable signal is sent from the control card to the inrush card SCR gating circuit. The SCRs are automatically gated when forward biased, acting similar to an uncontrolled rectifier as a result.

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

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

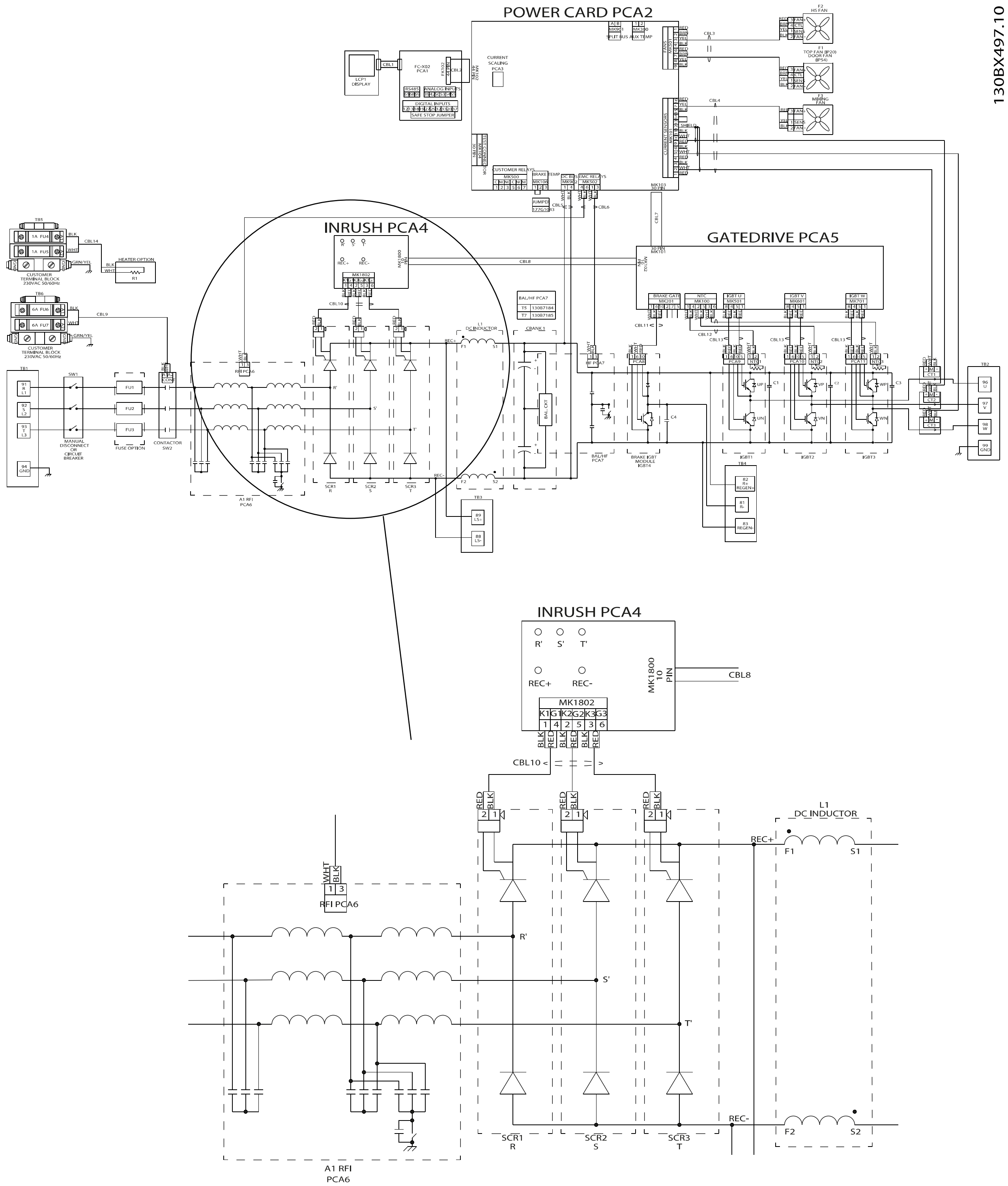


Illustration 3.4 Rectifier Circuit

3.3.2 Intermediate Section

Following the rectifier section, voltage passes to the intermediate section (see *Illustration 3.5*). An LC filter circuit consisting of the DC bus inductor and the DC bus capacitor bank smooths the rectified voltage.

The DC bus inductor provides series impedance to changing current. 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 12 capacitors arranged in series/parallel configuration. Also contained within the assembly is the bleeder/balance circuitry. This circuitry maintains equal voltage drops across each capacitor and provides a current path for discharging the capacitors once the frequency converter is powered down.

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-ground voltages in the three-phase AC input line. This can occasionally result in nuisance overvoltage alarms. For this reason, the high frequency filter card contains a set of relay contacts in the ground connection of the filter capacitors. The relay is tied into the RFI/HF switch, which can be switched on or off in *14-50 RFI Filter*. This disconnects the ground references to all filters in case unbalanced phase-to-ground voltages create nuisance overvoltage conditions.

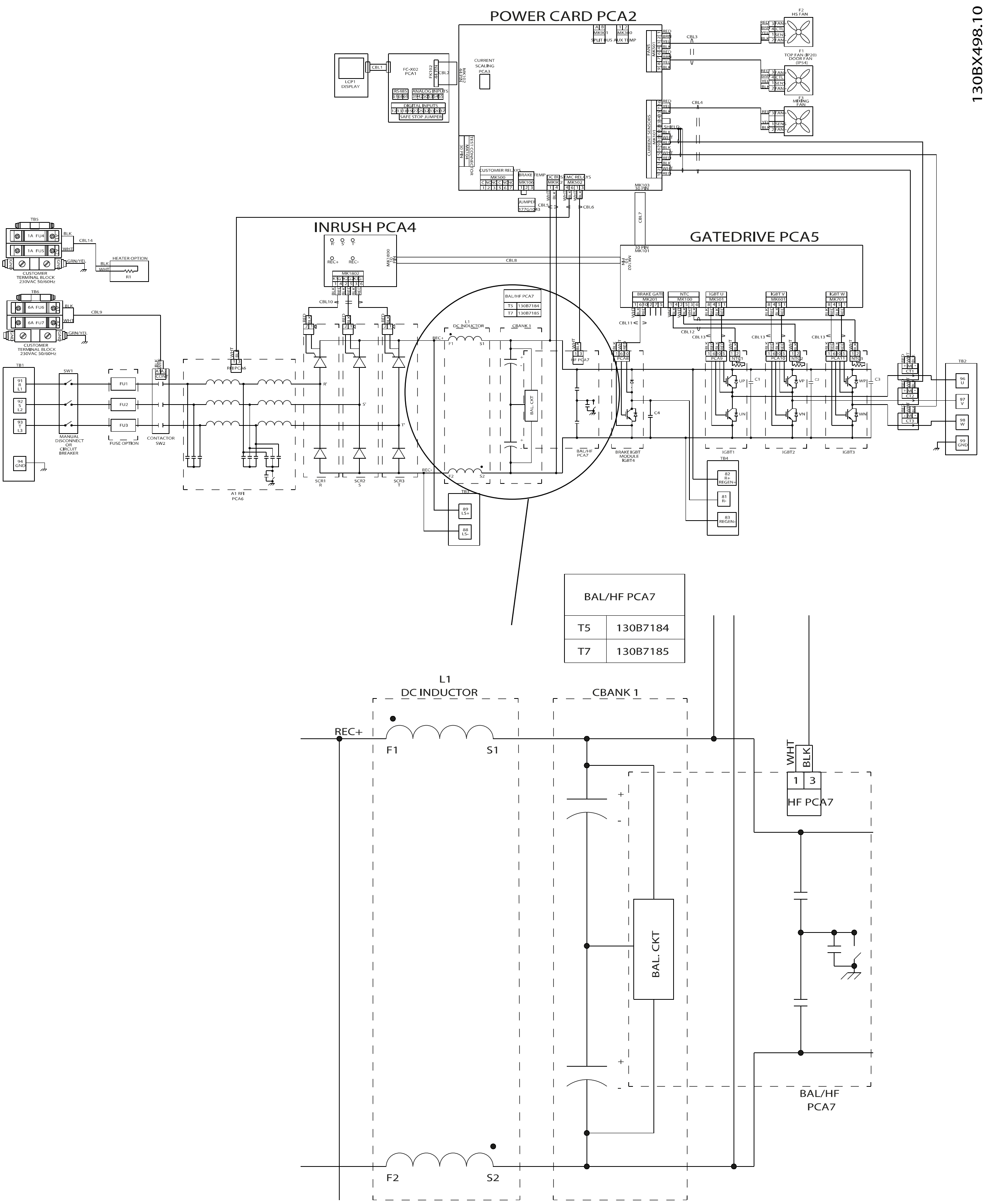


Illustration 3.5 Intermediate Section

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 drive 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, 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 pulse duration of applied DC voltage controls the width. Although the voltage waveform is a consistent amplitude, the inductance within the motor windings averages the voltage delivered so, as the pulse width of the waveform varies, the average voltage the motor detects also varies. The resultant current waveform takes on the sine wave shape common to an AC system. The rate at which the pulses occur determines the frequency of the waveform. By employing a sophisticated control scheme, the frequency converter delivers a current waveform that nearly replicates a true AC sine wave.

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

During normal 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 is monitored as well as the voltage delivered to the motor. A thermal sensor mounted inside each IGBT module provides heatsink temperature feedback.

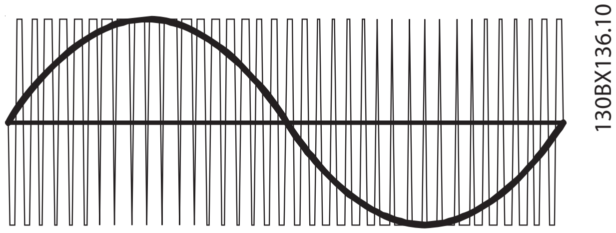


Illustration 3.6 Output Voltage and Current Waveforms

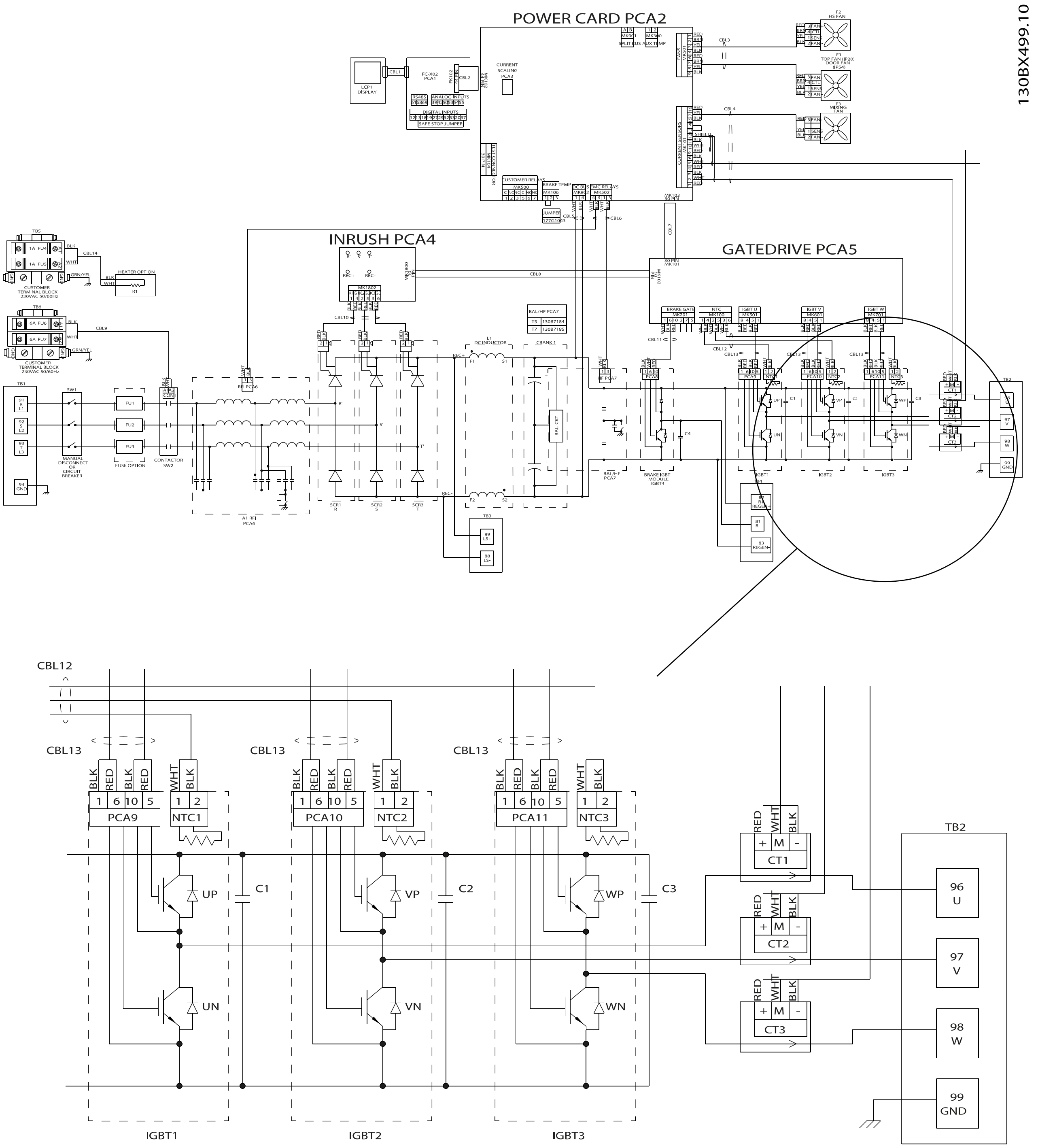


Illustration 3.7 Inverter Section

3.3.4 Brake Option

For frequency converters equipped with the dynamic brake option, a brake IGBT along with terminals 81(R-) and 82(R+) are 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 drives the motor causing the voltage to return to the DC bus circuit.

External placement of the brake resistor 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 when the brake resistor is overloaded.

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

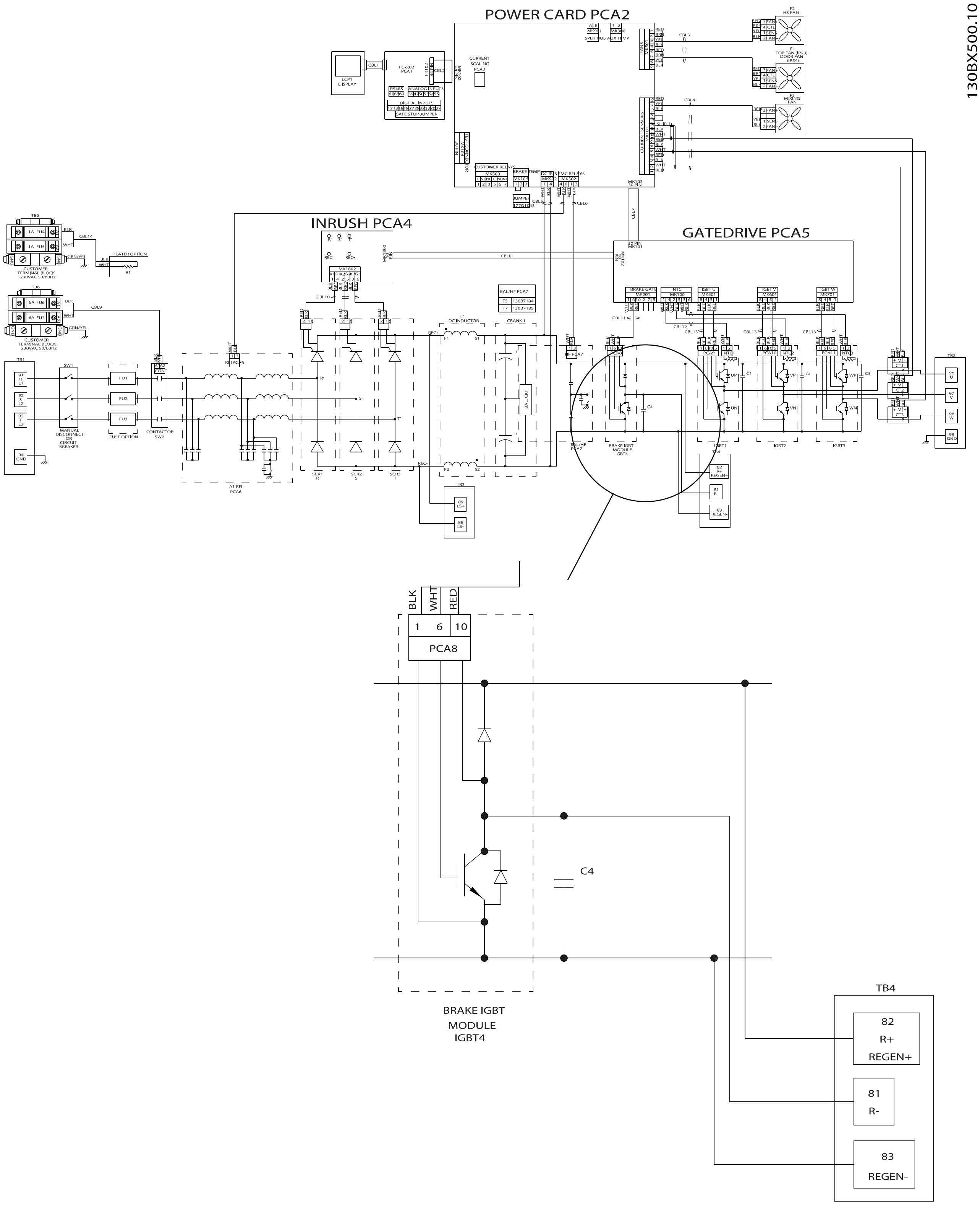


Illustration 3.8 Brake Option

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 IP21 (NEMA 1) and IP54 (NEMA 12) enclosures have a fan mounted in the enclosure door to provide more airflow to the unit. IP20 enclosures have a fan mounted to the top of the unit for more cooling. There is a small 24 V DC mixing fan mounted under the input plate. This fan operates anytime the frequency converter is powered on.

All fans run on DC voltage from the power card. The mixing fan is powered by 24 V DC from the main switch mode power supply. The heatsink fan and the door/top fan are powered by 48 V DC from a dedicated switch mode power supply on the power card. Each fan has tachometer feedback to the control card to confirm that the fan is operating correctly. On/off and speed control of the fans is provided to reduce overall acoustical noise and extend the life of the fans.

The following conditions activate the fans:

- Output current greater than 60% of nominal
- High IGBT temperature
- Low IGBT temperature
- High control card temperature
- DC hold active
- DC brake active
- Dynamic brake circuit active
- During pre-magnetization of the motor
- AMA in progress

In addition to these conditions, the fans are always started shortly after mains input power is applied to the frequency converter. Once fans are started, they run for a minimum of one minute.

3.3.6 Fan Speed Control

The following conditions cause the fans to run at full speed:

- Low IGBT temperature
- Active DC hold
- Active DC brake
- Active dynamic brake circuit
- Pre-magnetization of the motor
- AMA in progress

Mixing Fan
The mixing fan runs at full speed whenever the frequency converter has power.

Heatsink Fan
The IGBT temperature and the output current determine the speed of the heatsink fan. That fan runs at the higher of the two settings.

If the output is greater than 60% of the nominal current, the fan runs at 100% speed. If the output current is less than 60% of the nominal current, the fan turns off.

When the IGBT temperature reaches the fan turn on temperature, the fan starts and runs at its minimum speed. As the IGBT temperature increases, the fan speed increases. When the IGBT temperature reaches the fan maximum speed temperature, the fan is running at 100% speed. As the IGBT temperature decreases, the fan speed decreases. The fan stops running when the IGBT temperature falls below the fan turn off temperature.

- Fan turn on temperature = 40 °C
- Fan minimum speed temperature = 40 °C
- Fan maximum speed temperature = 80 °C
- Fan turn off temperature = 40 °C

Door/Top Fan
The control card temperature, the IGBT temperature, and the output current determine the speed of the door/top fan. The fan runs at the highest of the three settings.

If the output is greater than 60% of the nominal current, the fan runs at 100% speed. If the output current is less than 60% of the nominal current, the fan is turned off.

When the IGBT temperature reaches the fan turn on temperature, the fan starts and runs at its minimum speed. As the IGBT temperature increases, the fan speed increases. When the IGBT temperature reaches the fan maximum speed temperature, the fan is running at 100% speed. As the IGBT temperature decreases, the fan speed decreases. The fan stops running when the IGBT temperature falls below the fan turn off temperature.

- Fan turn on temperature = 40 °C
- Fan minimum speed temperature = 40 °C
- Fan maximum speed temperature = 80 °C
- Fan turn off temperature = 40 °C

When the control card temperature reaches the fan turn on temperature, the fan starts and runs at its minimum speed. As the control card temperature increases, the fan speed increases. When the control card temperature reaches the fan maximum speed temperature, the fan is running at 100% speed. As the control card temperature decreases, the fan speed decreases. The fan stops running when the control card temperature falls below the fan turn off temperature.

- Fan turn on temperature = 40 °C
- Fan minimum speed temperature = 40 °C
- Fan maximum speed temperature = 70 °C
- Fan turn off temperature = 35 °C

14-52 Fan Control commands the fans to run at a fixed speed. If the fans are commanded to run at 100% speed, which overrides any other speed command.

3.3.7 Load Sharing & Regeneration

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

The use of the load sharing terminals has two configurations.

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

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

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

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

3.3.8 Specific Power Card Connections

Connector MK106, terminals 104, 105 and 106 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 is connected between terminals 104 and 106 or a normally open switch between terminals 104 and 105. If the input change states, the frequency converter trips on an Alarm 27, Brake Chopper Fault. If no such input is used, or the normally open configuration is selected, a jumper must be installed between terminals 104 and 106.

MK500, terminals 1, 2, and 3, and 4, 5, and 6, provide access to two auxiliary relays. This is a form C set of contacts, meaning one normally open and one normally closed contact on a single throw. The contacts are rated for a maximum of 240 V AC, 2 A and a minimum of 24 V DC, 10 mA, or 24 V AC, 100 mA. The relays can be programmed via *5-40 Function Relay* to indicate frequency converter status.

4 Troubleshooting

4.1 Troubleshooting Tips

Before repairing a frequency converter, read and understand the following instructions.

1. Note all warnings concerning voltages present in the frequency converter. Always verify the presence of AC input voltage and DC link voltage before working on the unit. Some points in the frequency converter are referenced to the negative DC link. They are at DC link potential even though it sometimes appears on diagrams to be a neutral reference.

CAUTION

Voltage can be present for as long as 20 minutes on 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 damage other components when power is applied. Always perform the procedure for testing the unit after repair as described in *chapter 4.7 After Repair Tests*.
3. Never attempt to defeat any fault protection circuitry within the frequency converter, as this results in unnecessary component damage and can cause personal injury.
4. Always use factory approved replacement parts. The frequency converter is designed to operate within certain specifications. Incorrect parts can affect tolerances and result in further damage to the unit.
5. Read the instruction manual. A thorough understanding of the unit is the best approach. If ever in doubt, consult the factory or authorised repair centre for assistance.

4.2 Exterior Fault Troubleshooting

Servicing a frequency converter that has been operational for an extended period will be slightly different from a new installation. When using proper troubleshooting procedures on a long-term installation, do not assume that a motor is wired properly, possibly overlooking issues such as loose connections, improper programming, or added equipment. It is best to develop a detailed approach, beginning with a physical inspection of the system. See *Table 4.1* for items to examine.

4.3 Fault Symptom Troubleshooting

This troubleshooting section is organised based on the symptom being experienced. *Table 4.1*, provides a visual inspection checklist. Often, wrong installation or wiring of the frequency converter causes the problem. The checklist provides guidance through various items to inspect during any frequency converter service process.

The following symptoms can suggest problems to investigate further:

- An unrecognizable display on the LCP
- Problems with motor operation
- A warning or alarm displayed by the frequency converter

The frequency converter processor monitors inputs and outputs as well as internal frequency converter functions. Thus, an alarm or warning does not necessarily indicate a problem within the frequency converter itself.

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 more procedures. *chapter 4.3 Fault Symptom Trouble-shooting* presents detailed discussions on areas of frequency converter and system troubleshooting that an experienced repair technician must understand for effective analysis.

Finally, a list of tests, *chapter 4.7 After Repair Tests* is provided. Always perform these tests under the following conditions:

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

4

4.4 Visual Inspection

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

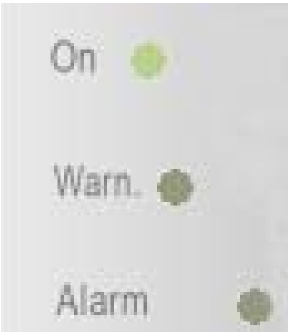
Inspect For	Description
Auxiliary equipment	Look for auxiliary equipment, switches, disconnects, or input fuses/circuit breakers that reside on either the input power side of frequency converter or the output side to the motor. Examine the operation and condition of these items for possible causes of operational faults. Check the function and installation of pressure sensors or encoders or other devises that provide feedback to the frequency converter.
Cable routing	Avoid routing motor wiring, mains wiring, and signal wiring in parallel. If parallel routing is unavoidable, try to maintain a separation of 150–200 mm (6–8 inches) between the cables or separate them with an grounded conductive partition. Avoid routing cables through free air.
Control wiring	Check for broken or damaged wires and connections. Check the voltage source of the signals. Though not always necessary depending on the installation conditions, the use of screened cable or a twisted pair is recommended. Ensure that the screen is terminated correctly. Refer to *chapter 2.9 Grounding Screened Cables*.
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 that 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 frequency converter.
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 regarding electromagnetic capability. Refer to the frequency converter operating instructions and *chapter 5 Frequency Converter and Motor Applications* for further details.
Environmental conditions	Under specific conditions, these units can be operated within a maximum ambient temperature of 50 °C (122 °F). Humidity levels must be less than 95% noncondensing. Check for harmful airborne contaminates such as sulphur-based compounds.
Grounding	The frequency converter requires a dedicated ground wire from its frame to the building ground. It is also suggested that the motor be grounded to the frequency converter frame as well. The use of a conduit or mounting the frequency converter onto a metal surface is not considered a suitable ground. Check for good ground connections that are tight and free of oxidation.
Input power wiring	Check for loose connections. 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 motor parameters (*1-20 Motor Power [kW]* through *1-25 Motor Nominal Speed*) are set according to the motor ratings.
Output to motor wiring	Check for loose connections. Check for switching components in the output circuit. Check for faulty contacts in the switch gear.
Programming	Make sure that the frequency converter parameter settings are correct according to motor, application, and I/O configuration.
Proper clearance	Frequency converters require adequate top and bottom clearance to ensure proper air flow for cooling in accordance with the frequency converter size. Frequency converters with exposed heatsinks out the back must be mounted on a flat solid surface.
Vibration	Look for any unusual amount of vibration around the frequency converter. The unit should be mounted solidly or the use of shock mounts employed.

Table 4.1 Visual Inspection

4.5 Fault Symptoms

4.5.1 No Display

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



130BP044.10

Illustration 4.1

If neither indication is available, then the source of the problem is elsewhere. Proceed to *chapter 6.4.1 No Display Test* 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. Improper control wiring, overload of the 24 V output, or a fault within the frequency converter itself could cause this overload.

The first step is to rule out a problem in the control wiring. Disconnect all control wiring from 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). Check all control wiring 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

When this symptom occurs, 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 is either incorrect control logic or an incorrectly programmed frequency converter. Such occurrences result in one or more of the following status messages being displayed.

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

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

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

Action: Ensure that a start command is present at terminal 18. Refer to *chapter 6.4.14 Input Terminal Signal Tests*.

Unit ready
Terminal 27 is low (no signal).

Action: Ensure that terminal 27 is logic “1”. Refer to *chapter 6.4.14 Input Terminal Signal Tests*.

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 for the proper reference signal at the frequency converter input terminals and to ensure that the unit is properly programmed to accept the signal provided. Refer to *chapter 6.4.14 Input Terminal Signal Tests*.

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

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

STOP
One of the digital input terminals 18, 19, 27, 29, 32, or 33 (parameter group *5–1* Digital Inputs*) is programmed for *[6] Stop Inverse* and the corresponding terminal is low (logic “0”).

Ensure that the parameters previously mentioned 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
If the unit is equipped with an external 24 V DC option, check that mains power is applied to the frequency converter.

NOTICE

Note: In this case, the keypad display shows *[8] DC under volt*

4.5.4 Incorrect Motor Operation

Occasionally, there is a fault where the motor continues to run, but not in the correct manner. There can be a number of different causes for this type of fault. The following is a list of possible problems and recommended procedures for determining their causes.

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

Ensure that the unit is programmed correctly according to the reference signal being used, and that all reference limits are set correctly as well. Perform *chapter 6.4.14 Input Terminal Signal Tests* 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, and so on). For closed loop operation, check PID settings. Perform the *chapter 6.4.14 Input Terminal Signal Tests* to check for faulty reference signals. Perform the *chapter 6.4.9 Output Imbalance of Motor Voltage and Current* to check for loss of motor phase.

Motor runs rough
Possible over-magnetization (incorrect motor settings), or an IGBT misfiring.

NOTICE

Other symptoms include motor stalling when loaded or the frequency converter tripping on Alarm 13.

Check setting of all motor parameters. Perform the *chapter 6.4.9 Output Imbalance of Motor Voltage and Current*
If output voltage is unbalanced, perform the *chapter 6.4.11 IGBT Gate Drive Signals Test*

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

Perform the *chapter 6.4.9 Output Imbalance of Motor Voltage and Current* to ensure that the frequency converter is providing correct output (See Motor runs rough).

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 is too short. Note: An alarm or warning message may occur.

Check all brake parameters and ramp down time (parameter group *2–0** and *3–4**).
Perform *chapter 6.3.4 Brake IGBT Test*

4.6 Warning/Alarm Messages

4.6.1 Warning/Alarm Code List

A code on the display or the LEDs on the front of the frequency converter signal a warning/alarm.

A **warning** indicates a condition that requires attention or a potentially alarming trend. 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. Reset it after the condition has been cleared by pressing [Reset] or through a digital input (parameter group 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.

There are three ways to reset:

1. Pressing [Reset].
2. A digital reset input.
3. Serial communication/optional fieldbus reset signal.

NOTICE

After a manual reset pressing [Reset], [Auto On] must be pressed to restart the motor.

A **trip lock** is an action when a potentially damaging alarm occurs. 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 *Table 4.2* means that action occurs. A warning precedes an alarm.

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock
1	10 volts low	X		
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		
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		

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock
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		
104	Mixing Fan Fault	X	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 4.2 Warning/Alarm Code List

(X) Programmable: dependent on parameter setting.

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

Warning	yellow
Alarm	flashing red
Trip locked	yellow and red

Table 4.3 LED Indication

⚠WARNING

Hazardous Service Procedures!
The maintenance and troubleshooting procedures recommended in this section of the manual could result in exposure to electrical, mechanical or other potential safety hazards. Always refer to the safety warnings provided throughout this manual concerning these procedures. Unless specified otherwise, disconnect all electrical power including remote disconnect and discharge all energy storing devices such as capacitors before servicing. Follow proper lockout/tagout procedures to ensure the power can not be inadvertently energized. When necessary to work with live electrical components, have a qualified licensed electrician or other individual who has been trained in handling live electrical components perform these tasks. Failure to follow all of the recommended safety warnings provided, could result in death or serious injury.

The warning/alarm information below defines each warning/alarm condition, provides the probable cause for the condition, and details a remedy or troubleshooting procedure.

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.

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

Troubleshooting

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

WARNING/ALARM 2, Live zero error
This warning or alarm only appears if programmed in *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. Broken wiring or faulty device sending the signal can cause this condition.

Troubleshooting

- Check 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).
- Check that the frequency converter programming and switch settings match the analog signal type.
- Perform input terminal signal test.

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 *14-12 Function at Mains Imbalance*.

Troubleshooting

- Check the supply voltage and supply currents to the frequency converter.

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

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 unit is still active.

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 the functions in *2-10 Brake Function*
- Increase *14-26 Trip Delay at Inverter Fault*
- If the alarm/warning occurs during a power sag, use kinetic back-up (*14-10 Mains Failure*)

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

Troubleshooting

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

WARNING/ALARM 9, Inverter overload
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 issues 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 has run with more than 100% overload for too long.

Troubleshooting

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

WARNING/ALARM 10, Motor overload temperature
According to the electronic thermal protection (ETR), the motor is too hot. Select whether the frequency converter issues a warning or an alarm when the counter reaches 100% in *1-90 Motor Thermal Protection*. The fault occurs when the motor runs with more than 100% overload for too long.

Troubleshooting

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

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

⚠WARNING

Live Electrical Components!

Troubleshooting

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

⚠WARNING

Disconnect power before proceeding.

WARNING/ALARM 12, Torque limit
The torque has exceeded the value in *4-16 Torque Limit Motor Mode* or the value in *4-17 Torque Limit Generator Mode*. *14-25 Trip Delay at Torque Limit* can change this warning from a warning-only condition to a warning followed by an alarm.

Troubleshooting

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

WARNING/ALARM 13, Over current
The inverter peak current limit (approximately 200% of the rated current) is exceeded. The warning lasts about 1.5 s, then the frequency converter trips and issues an alarm. Shock loading or quick acceleration with high inertia loads can cause this fault. If the acceleration during ramp up is quick, the fault can also appear after kinetic back-up. If extended mechanical brake control is selected, trip can be reset externally.

Troubleshooting

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

ALARM 14, Earth (ground) fault
There is current from the output phases to ground, either in the cable between the frequency converter and the motor or in the motor itself.

Troubleshooting

- Remove power to the frequency converter and repair the ground fault.
- Check for ground faults in the motor by measuring the resistance to ground of the motor leads and the motor with a megohmmeter.

⚠WARNING

Disconnect power before proceeding.

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 Trane:

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

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

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

⚠WARNING

Disconnect power before proceeding.

WARNING/ALARM 17, Control word timeout
There is no communication to the frequency converter.
The warning is only active when *8-04 Control Timeout Function* is NOT set to *[0] Off*.
If *8-04 Control Timeout Function* is set to *[5] Stop and Trip*, a warning appears and the frequency converter ramps down until it stops then displays an alarm.

⚠WARNING

Live Electrical Components!

Troubleshooting

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

ALARM 18, Start failed
The speed has not been able to exceed *1-77 Compressor Start Max Speed [RPM]* during start within the allowed time. (set in *1-79 Compressor Start Max Time to Trip*). This may be caused by a blocked motor.

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

For the D, E, and F-frame filters, the regulated voltage to the fans is monitored.

Troubleshooting

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

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

Troubleshooting

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

WARNING/ALARM 28, Brake check failed
The brake resistor is not connected or not working.
Check *2-15 Brake Check*.

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

Troubleshooting
Check for the following conditions.

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

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

⚠WARNING

Disconnect power before proceeding.

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

4

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

⚠WARNING

Disconnect power before proceeding.

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

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

⚠WARNING

Disconnect power before proceeding.

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

ALARM 33, Inrush fault
Too many power-ups have occurred within a short time period. 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 36, Mains failure
This warning/alarm is only active if the supply voltage to the frequency converter is lost and *14-10 Mains Failure* is not set to *[0] No Function*. Check the fuses to the frequency converter and mains supply to the unit.

ALARM 38, Internal fault
When an internal fault occurs, a code number defined in *Table 4.4* is displayed.

Troubleshooting

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

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

No.	Text
0	Serial port cannot be initialised. Contact your Trane supplier or Trane Service Department.
256-258	Power EEPROM data is defective or too old. Replace power card.
512-519	Internal fault. Contact your Trane supplier or Trane Service Department.
783	Parameter value outside of min/max limits
1024-1284	Internal fault. Contact your Trane supplier or the Trane Service Department.
1299	Option SW in slot A is too old
1300	Option SW in slot B is too old
1315	Option SW in slot A is not supported (not allowed)
1316	Option SW in slot B is not supported (not allowed)
1379-2819	Internal fault. Contact your Trane supplier or Trane Service Department.
2561	Replace control card
2820	LCP stack overflow
2821	Serial port overflow
2822	USB port overflow
3072-5122	Parameter value is outside its limits
5123	Option in slot A: Hardware incompatible with control board hardware
5124	Option in slot B: Hardware incompatible with control board hardware
5376-6231	Internal fault. Contact your Trane supplier or Trane Service Department.

Table 4.4 Internal Fault Codes

ALARM 39, Heat Sink sensor
No feedback from the heat sink temperature sensor.

The signal from the IGBT thermal sensor is not available on the power card. The problem could be on the power card, on the gate drive card, or the ribbon cable between the power card and gate drive card.

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

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

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

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

ALARM 45, Earth fault 2
Ground fault.

Troubleshooting

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

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

There are 3 power supplies generated by the switch mode power supply (SMPS) on the power card: 24 V, 5 V, ±18 V. When powered with 24 V DC with the MCB 107 option, only the 24 V and 5 V supplies are monitored. When powered with 3-phase mains voltage, all 3 supplies are monitored.

Troubleshooting

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

WARNING 47, 24 V supply low
The 24 Vdc is measured on the control card. This alarm arises when the detected voltage of terminal 12 is lower than 18 V.

Troubleshooting

- Check for a defective control card.

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

WARNING 49, Speed limit
When the speed is not within the specified range in *4-11 Motor Speed Low Limit [RPM]* and *4-13 Motor Speed High Limit [RPM]*, the frequency converter shows a warning. When the speed is below the specified limit in *1-86 Trip Speed Low [RPM]* (except when starting or stopping), the frequency converter trips.

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

ALARM 51, AMA check U_{nom} and I_{nom}
The settings for motor voltage, motor current and motor power are wrong. Check the settings in parameters 1-20 to 1-25.

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

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

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

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

ALARM 56, AMA interrupted by user
The user has interrupted the AMA.

ALARM 57, AMA internal fault
Try to restart AMA again. Repeated restarts can over heat the motor.

ALARM 58, AMA Internal fault
Contact the Trane supplier.

WARNING 59, Current limit
The current is higher than the value in *4-18 Current Limit*. Ensure that motor data in parameters 1–20 to 1–25 are set correctly. Possibly increase the current limit. Be sure that the system can operate safely at a higher limit.

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

WARNING 62, Output frequency at maximum limit
The output frequency has reached the value set in *4-19 Max Output Frequency*. Check the application to determine the cause. Possibly increase the output frequency limit. Be sure the system can operate safely at a higher output frequency. The warning clears when the output drops below the maximum limit.

WARNING/ALARM 65, Control card over temperature
The cut-out temperature of the control card is 80 °C.

Troubleshooting

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

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

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

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

Troubleshooting

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

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

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

ALARM 92, No flow
A no-flow condition has been detected in the system. *22-23 No-Flow Function* is set for alarm. Troubleshoot the system and reset the frequency converter after the fault has been cleared.

ALARM 93, Dry pump
A no-flow condition in the system with the frequency converter operating at high speed may indicate a dry pump. *22-26 Dry Pump Function* is set for alarm. Troubleshoot the system and reset the frequency converter after the fault has been cleared.

ALARM 94, End of curve
Feedback is lower than the set point. This may indicate leakage in the system. *22-50 End of Curve Function* is set for alarm. Troubleshoot the system and reset the frequency converter after the fault has been cleared.

ALARM 95, Broken belt
Torque is below the torque level set for no load, indicating a broken belt. *22-60 Broken Belt Function* is set for alarm. Troubleshoot the system and reset the frequency converter after the fault has been cleared.

ALARM 96, Start delayed
Motor start has been delayed due to short-cycle protection. *22-76 Interval between Starts* is enabled. Troubleshoot the system and reset the frequency converter after the fault has been cleared.

WARNING 97, Stop delayed
Stopping the motor has been delayed due to short cycle protection. *22-76 Interval between Starts* is enabled. Troubleshoot the system and reset the frequency converter after the fault has been cleared.

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

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

WARNING 201, Fire mode was active
This indicates the frequency converter had entered fire mode. Cycle power to the unit to remove the warning. See the fire mode data in the alarm log.

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

WARNING 203, Missing motor
With a frequency converter operating multi-motors, an under-load condition was detected. This could indicate a missing motor. Inspect the system for proper operation.

WARNING 204, Locked rotor
With a frequency converter operating multi-motors, an overload condition was detected. This could indicate a locked rotor. Inspect the motor for proper operation.

WARNING 250, New spare part
A component in the frequency converter has been replaced. Reset the frequency converter for normal operation.

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

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. Following the procedure ensures that all circuitry in the frequency converter is functioning properly before putting the unit into operation.

1. Perform visual inspection procedures as described in *chapter 4.4 Visual Inspection*.
2. Perform static test procedures to ensure that frequency converter is safe to start.
3. Disconnect motor leads from output terminals (U, V, W) of the frequency converter.
4. Apply AC power to frequency converter.
5. Give the frequency converter a run command and slowly increase 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 V. If unbalanced voltage is measured, refer to *chapter 6.4.2 Input Voltage Test*.
7. Stop the frequency converter and remove input power. Allow 20 minutes for DC capacitors to discharge fully.
8. Reconnect motor cables to frequency converter output terminals (U, V, W).
9. Reapply power and restart frequency converter. Adjust motor speed to a nominal level.
10. Using a clamp-on style ammeter, measure output current on each output phase. All currents must be balanced.

5 Frequency Converter and Motor Applications

5.1 Torque Limit, Current Limit, and Unstable Motor Operation

Excessive loading of the frequency converter could result in warning or tripping on torque limit, overcurrent, or inverter time. Tripping 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 are sometimes 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.

1-03 Torque Characteristics sets the mode in which the frequency converter operates.

Parameters *1-20 Motor Power [kW]* to *1-29 Automatic Motor Adaptation (AMA)* match the frequency converter to the motor and adapt to the motor characteristics.

4-17 Torque Limit Generator Mode and *14-25 Trip Delay at Torque Limit* set the torque control features of the frequency converter for the application.

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.

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 the load type is constant torque and variable torque is selected, it may be very difficult or impossible for the frequency converter to start the load. Consult the factory if uncertain about the torque characteristics of an application.

Parameters *1-20 Motor Power [kW]* to *1-25 Motor Nominal Speed* configure the frequency converter for the connected motor. These parameters are motor power, voltage, frequency, current, and rated motor speed. Accurate setting of these parameters is crucial. 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.

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, *1-30 Stator Resistance (Rs)* and *1-35 Main Reactance (Xh)*. If the motor operation is unstable, perform AMA. 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.

1-30 Stator Resistance (Rs) and *1-35 Main Reactance (Xh)*, as stated, are 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 if it seems to improve operation. Such adjustments can result in unpredictable operation under changing conditions.

4-16 Torque Limit Motor Mode sets the limit for frequency converter torque. The factory setting is 160% for TR200 series and 110% for/seriesTR200 and vary with motor power setting. For example, a frequency converter programmed to operate a small motor yields a higher torque limit value than one programmed to operate a larger size motor. It is important that this value is not set too low for the requirements of the application. In some cases, it is desirable to have a torque limit set at a lesser value. This offers protection for the application in that the frequency converter limits the torque. A higher torque may be required at initial startup, which could cause nuisance tripping.

14-25 Trip Delay at Torque Limit works with torque limit. This parameter selects the length of time the frequency converter operates in torque limit before 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. When the load remains excessive long enough, the frequency converter trips on inverter time. Adjustments cannot be made to alter this circuit. Improper parameter settings affecting load current can result in premature trips of this type. The timer can be displayed.

5.1.1 Overvoltage Trips

This trip occurs when the DC bus voltage reaches its DC bus alarm voltage high. Before tripping, the frequency converter displays a high voltage warning. Most times, an over voltage condition is due to fast deceleration ramps regarding 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. 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. The diodes in the IGBT modules rectify this return voltage, which raises the DC bus. If the amount of returned voltage is too high, the frequency converter trips.

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. 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 a level that keeps the unit from tripping. Overvoltage control corrects minor, but not major discrepancies between ramp rates. For example, if a deceleration ramp of 100 seconds is required due to the inertia, and the ramp rate is set at 70 seconds, the overvoltage control corrects it. However, with the same inertia, if the ramp is set at a larger difference, such as 3 seconds, overvoltage control engages initially and then disengages, allowing the frequency converter to trip. This trip is done deliberately to avoid confusion about the operation of the frequency converter. A third method in controlling regenerated energy is with a dynamic brake. The frequency converter monitors the level of the DC bus. If the level becomes 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 increases deceleration rate.

Less often, the load causes an overvoltage condition while running at speed. When this condition occurs, the dynamic brake option or the overvoltage control circuit can be used. 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. If the load becomes regenerative while the frequency converter is running at a steady state speed, the overvoltage circuit increases the frequency to match the speed of the load. The same restriction on the amount of influence applies. The frequency converter adds about 10% to the base speed before a trip occurs. Otherwise, the speed could continue to rise to potentially unsafe levels.

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. If the ripple voltage on the DC bus is left unchecked, the lifetime of the capacitors and DC coil is drastically reduced.

When the input voltage becomes unbalanced or a phase disappears completely, the ripple voltage increases. This causes the frequency converter to trip and issue Alarm 4. A line disturbance or imbalance can also cause increased bus ripple. Loads affecting the form factor of the AC waveform, such as notching or defective transformers, cause line disturbances. Mains imbalances that 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. When a mains imbalance trip occurs, 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. Use an oscilloscope to view line disturbances. Conduct tests for input imbalance of supply voltage, input waveform, and output imbalance of supply voltage as described in *chapter 6.4.2 Input Voltage Test*, *chapter 6.4.6 Input Imbalance of Supply Voltage Test*, and *chapter 6.4.9 Output Imbalance of Motor Voltage and Current*.

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 various signals. 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). A correct reading indicates that the microprocessor detects the desired signal. See *chapter 2.6 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, line 2 or 3 of the display can be set to indicate the signals coming in. A correct reading indicates that the microprocessor detects the desired signal. This data is available in parameter group *16-6* Inputs & Outputs*.

If there is not a correct indication, the next step is to determine whether the signal is present at the input terminals. Perform this test with a voltmeter or oscilloscope in accordance with the *chapter 6.4.14 Input Terminal Signal Tests*.

If the signal is present at the terminal, the control card is defective and must be replaced. If the signal is not present, the problem is external to the frequency converter. 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. Programming errors affect frequency converter and motor operation in the areas of motor settings, references and limits, and I/O configuration.

The frequency converter must be set up correctly for the motor or motors connected to it. Parameters *1-20 Motor Power [kW]* to *1-25 Motor Nominal Speed* must have data from the motor nameplate entered into the frequency converter. This data enables the frequency converter processor to match the frequency converter to 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 usually solves the problem.

Any references or limits set incorrectly results in substandard performance. For instance, if maximum reference is set too low, the motor is unable to reach full speed. These parameters must be set according to the requirements of the particular installation. References are set in parameter group *3–0* Reference Limits*.

Incorrectly set I/O configuration usually results in the frequency converter not responding to the function as commanded. For every control terminal input or output, there are corresponding parameter settings. These settings determine how the frequency converter responds to an input signal or the type of signal present at that output. Utilising an I/O function is 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 parameter groups *5–0* Digital I/O Mode* and *6–0* Analog I/O Mode*.

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-ground 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. Measure with a clamp-on style ammeter to determine whether the current is balanced on the three output phases.

A torque limit alarm or warning usually indicates incorrect mechanical load. Disconnect the motor from the load, if possible, to determine whether 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 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 type of malfunction typically means that one or more output IGBTs are not switching on and off correctly. A defective IGBT or gate signal from the gate drive card can cause this. Perform the IGBT gate signal test.

5.2 Internal Frequency Converter Problems

Most 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. However, there are 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

When an overtemperature indication is displayed, determine whether this condition actually exists within the frequency converter or whether the thermal sensor is defective. This can easily be detected by touching the outside of the unit, if the overtemperature condition is still present. If not, check the temperature sensor with an ohmmeter.

5.2.2 Current Sensor Faults

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

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

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

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

To determine which current sensor is defective, measure the voltage offset at zero current for each current sensor. See *chapter 6.4.12 Current Sensors Test*.

5.2.3 EMI Signal and Power Wiring

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

5.2.4 Effects of EMI

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

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

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

Frequency converters 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 [dU/dt] is the primary source of the frequency converter generated EMI.

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

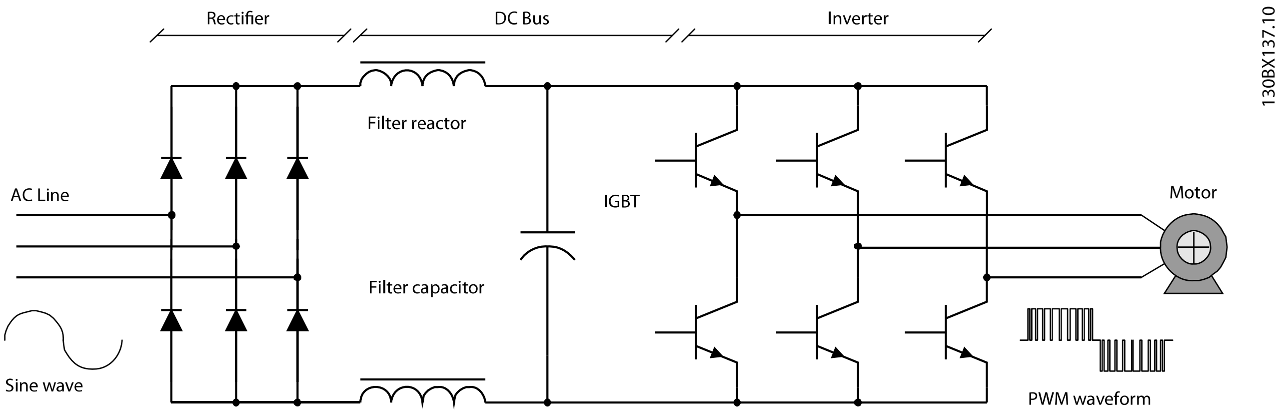


Illustration 5.1 Frequency Converter Functionality Diagram

5.2.6 EMI Propagation

Frequency converter generated EMI is both conducted to the mains and radiated to nearby conductors. See *Illustration 5.2*.

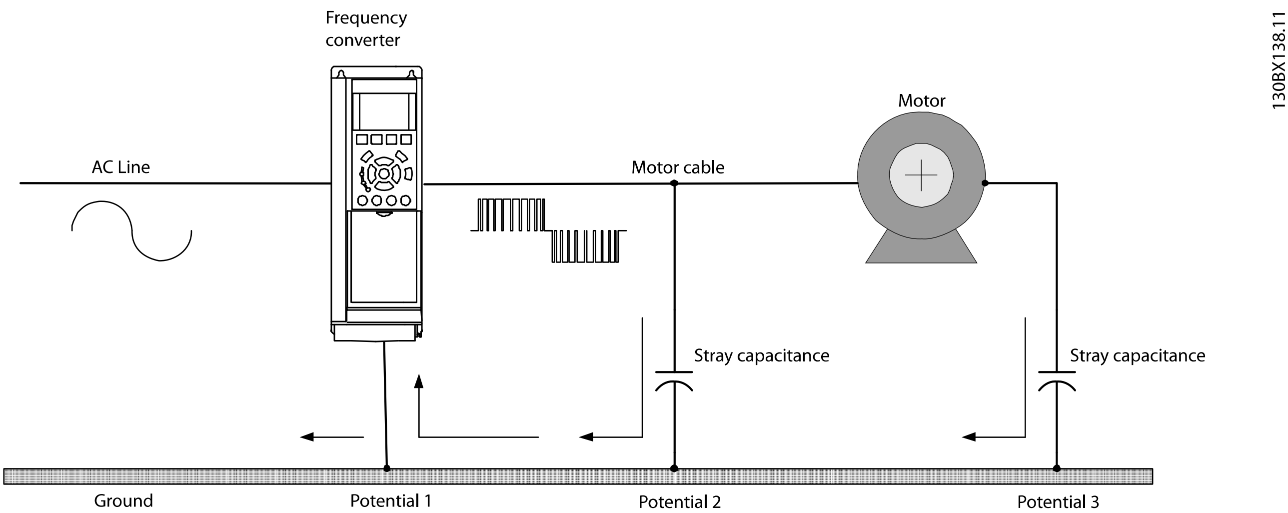


Illustration 5.2 Ground Currents

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

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

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

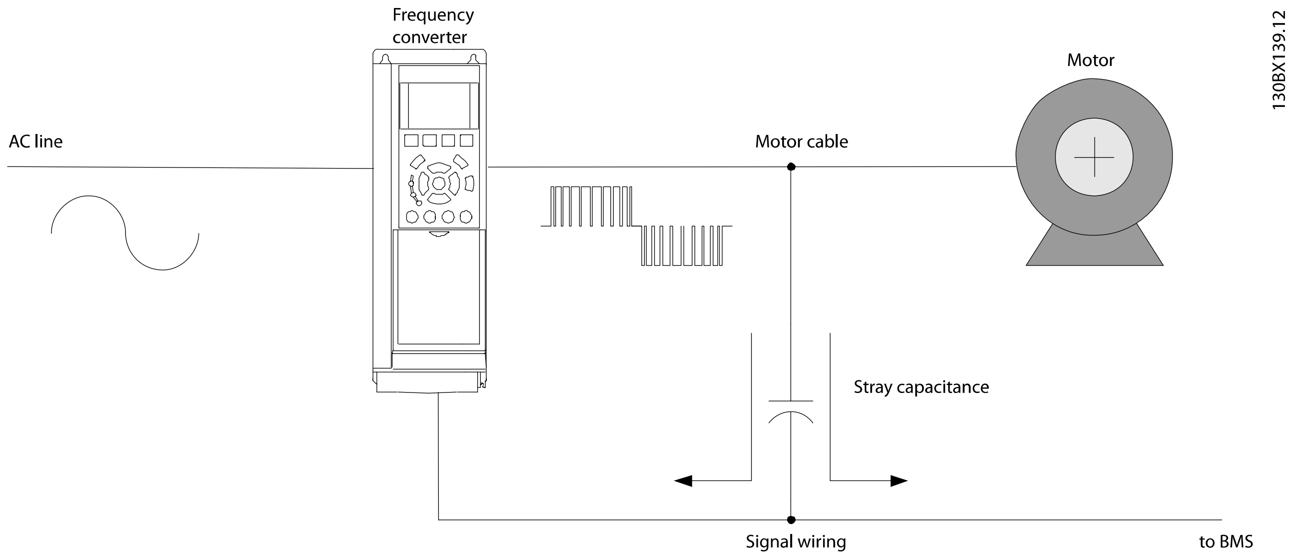


Illustration 5.3 Signal Conductor Currents

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

Signal conductors are especially vulnerable when they are run parallel to the power conductors for any distance. EMI coupled into these conductors can affect either the frequency converter or the interconnected control device. See *Illustration 5.4*.

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

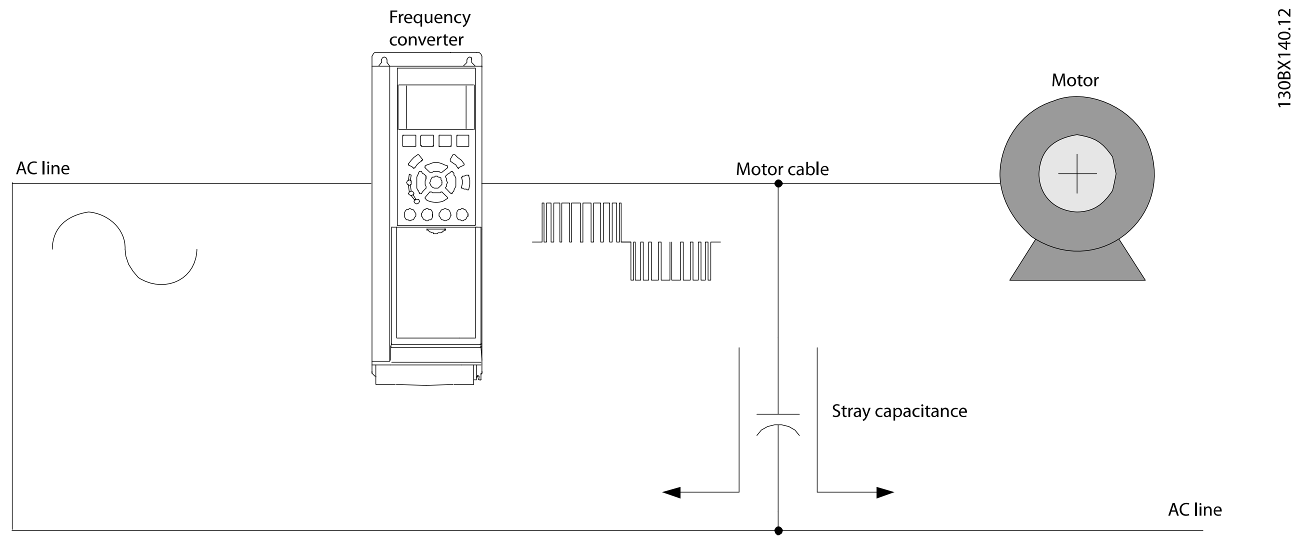


Illustration 5.4 Alternate Signal Conductor Currents

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.

Grounding
Ground the frequency converter and motor solidly to the equipment frame. A good high frequency connection allows the high frequency currents to return to the frequency converter rather than travel through the power network. The ground connection is ineffective if it has high impedance to high frequency currents. Make the connection as short and direct as is practical. Flat-braided cable has lower high-frequency impedance than round cable. Mounting the frequency converter or motor onto a painted surface does not create an effective ground connection. In addition, running a separate ground conductor directly between the frequency converter and the running motor is recommended.

Cable Routing
Avoid routing 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 an grounded conductive partition. Avoid routing cables through free air.

Signal Cable Selection
Single conductor 600 V rated wires provide the least protection from EMI. Twisted-pair and screened twisted-pair cables are available that are designed to minimise the effects of EMI. While unscreened twisted-pair cables are often adequate, screened twisted-pair cables provide another degree of protection. Terminate the screen on the signal cable in a manner that is appropriate for the connected equipment. Avoid terminating the screen through a pigtail connection, which increases the high frequency impedance and spoils the effectiveness of the screen. Refer to *chapter 2.9 Grounding Screened Cables*.

An alternative is to twist the existing single conductors to provide a balanced capacitive and inductive coupling, cancelling 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. Check these conductors first when EMI problems occur. Single conductor wires provide the least protection from EMI emissions. Often, if these conductors are routed separately from the signal and mains wiring, then no further consideration is needed. If the conductors are routed close to other susceptible conductors, or if the system is suspected to cause EMI problems, consider alternate motor wiring methods.

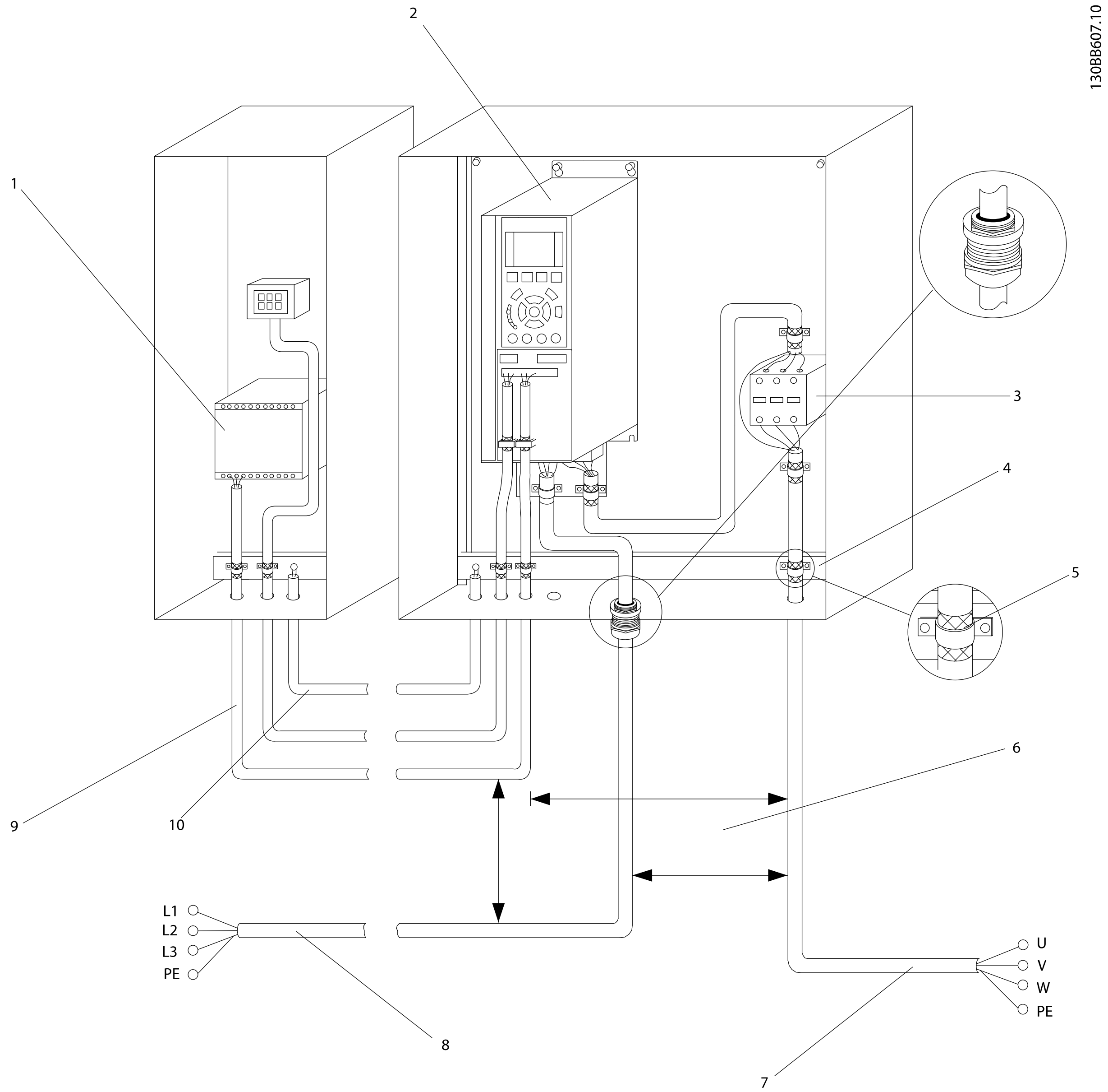
Installing screened power cable is the most effective means to alleviate EMI problems. The screen forces the noise current to flow directly back to the frequency converter before it gets back into the power network or takes other undesirable and unpredictable high frequency paths. Unlike most signal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

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

Serial Communications Cable Selection
There are various serial communication interfaces and protocols in the market. Each 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 more EMI protection, the screen capacitance could reduce the maximum allowable cable length at high data rates.

5.2.8 Proper EMC Installation

A correct installation with EMC considerations in mind appears in *Illustration 5.5*. Although most installations do 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 the example below. Attempt to replicate this installation recommendation as closely as possible to alleviate such problems.



1	PLC	6	Min. 200 mm (7.9 in) between control cables, motor and mains
2	Frequency converter	7	Motor, 3-phase and PE
3	Output contactor (generally not recommended)	8	Mains, 3-phase and reinforced PE
4	Earth (ground) rail (PE)	9	Control wiring
5	Cable insulation (stripped)	10	Equalizing min. 16 mm^2 (0.025 in)

Illustration 5.5 Proper EMC Installation

6 Test Procedures

6.1 Introduction

WARNING

Touching electrical parts of the frequency converter could be fatal even after equipment has been disconnected from AC power. Wait 20 minutes after power has been removed before touching any internal components to ensure that capacitors have fully discharged. See the label on the front of the frequency converter door for specific discharge time.

6

This section contains detailed procedures for testing frequency converters. Previous sections of this manual provide symptoms, alarms, and other conditions that require more test procedures to diagnose the frequency converter. The results of these tests indicate the appropriate repair actions. Because the frequency converter monitors I/O signals, motor conditions, AC and DC power and other functions, the source of fault conditions is not always internal to the frequency converter. Testing described in this chapter isolates many of these conditions as well.

Frequency converter testing is divided into

- Static tests
- Dynamic tests
- 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 with these tests. Static tests are performed with little or no disassembly. The purpose of static testing is to check for shorted power components. Perform these tests on any unit suspected of containing faulty power components before applying power.

WARNING

For dynamic test procedures, mains 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.

Replace any defective component and retest the frequency converter with the new component before applying power as described in *chapter 4.7 After Repair Tests*.

Additional Tools Recommended for Testing

- Digital volt/ohmmeter (PWM compatible)
- Analog voltmeter
- Oscilloscope
- Clamp-on style ammeter
- Split bus power supply p/n 130B3146
- Signal test board p/n 176F8437
- Signal test board extension p/n 130B3147
- Metric socket set (7–19 mm)
- Socket extentions (100 mm–150 mm)
- Torx driver set (T10–T50)
- Torque wrench (0.5–19 Nm)
- Needle nose pliers
- Magnetic sockets
- Ratchet
- Screwdrivers
- ESD protective mat and wrist strap

6.1.1 Signal Test Board

The signal test board is used to test circuitry within the frequency converter and provides easy access to test points. Its use is described in the procedures where called out. See *chapter 8.1 Test Equipment*, for detailed pin descriptions. Plug the signal test board into power card connector MK 104.

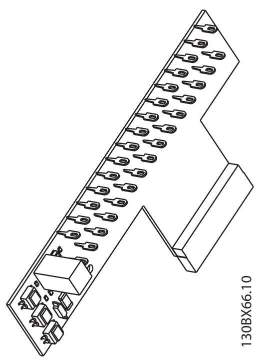
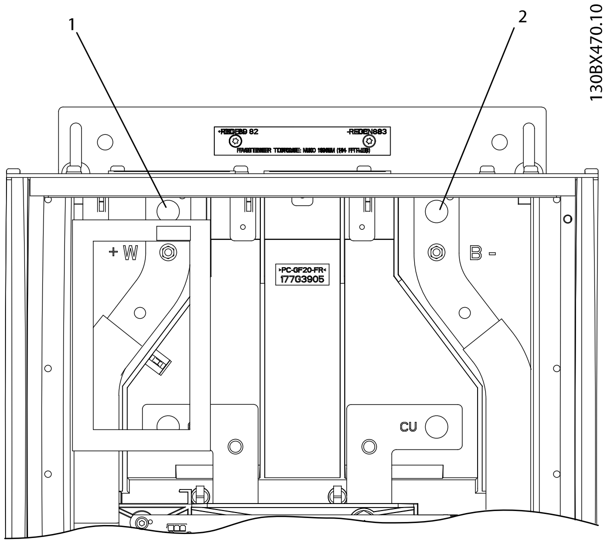


Illustration 6.1 Signal Test Board

6.2 Access to DC Bus

Many of the following test procedures require access to the DC bus.



1	(+) DC bus
2	(-) DC bus
Fasteners are M5 studs	

Illustration 6.2 Location of DC Bus Bars

Before performing any work:

- **Ensure that the mains power is disconnected.**
- **Ensure that the motor is disconnected.**
- **If there is a brake option, ensure that the brake is disconnected.**
- **If there is a load share/regeneration option, ensure that it is disconnected.**

⚠WARNING

Touching electrical parts of the frequency converter could be fatal even after the equipment has been disconnected from AC power. Wait 20 minutes after the power has been removed before touching any internal components to ensure that the capacitors have fully discharged. See the label on the front of the frequency converter door for exact discharge times.

Before doing any work, ensure the DC bus capacitors have discharged. Measure the DC bus using a voltage meter. See *Illustration 6.2*

6

6

6.3 Static Test Procedures

6.3.1 Pre-test Precautions

Consider the following safety precautions before performing static tests.

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

Perform all tests 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.

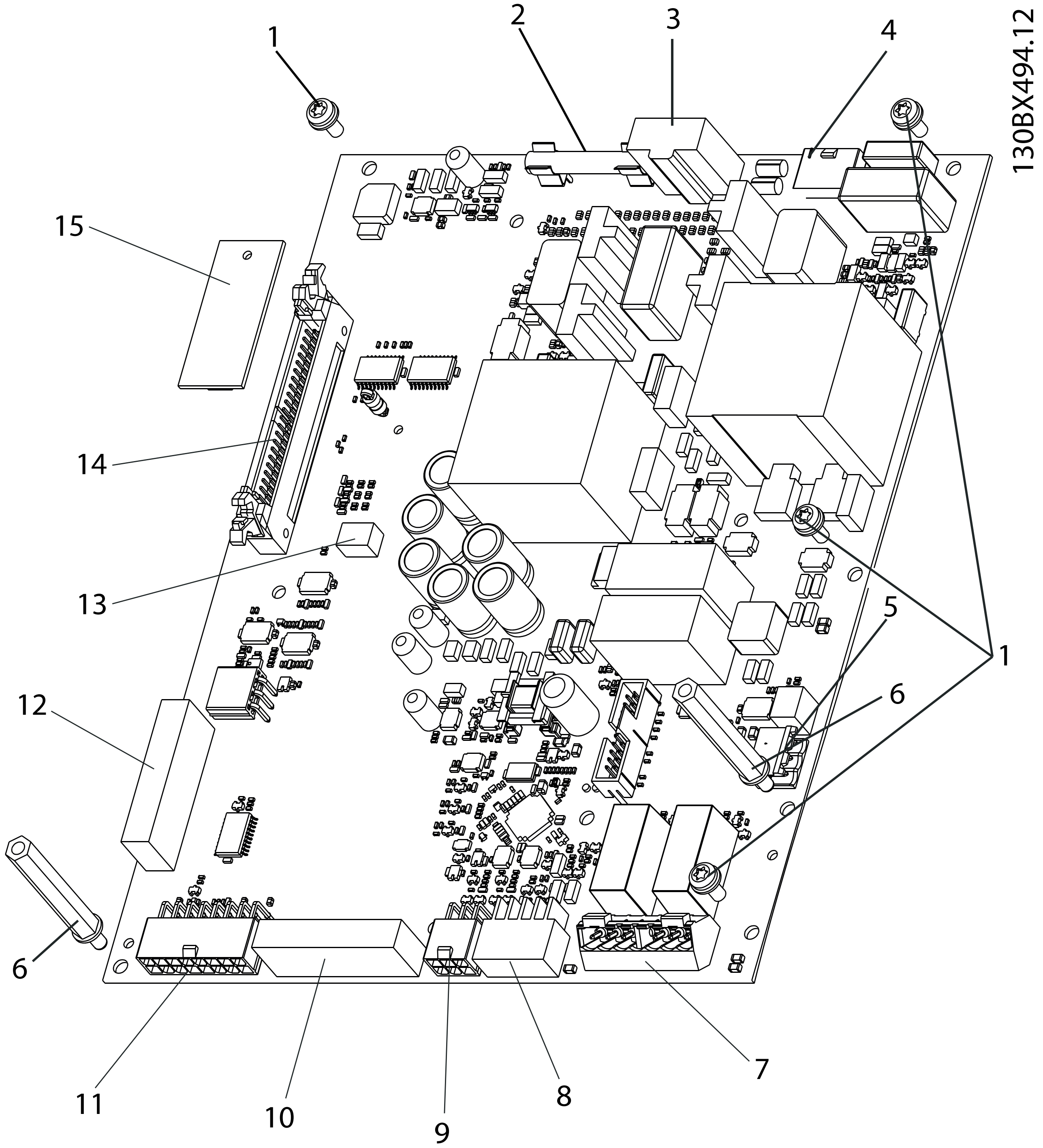
Illustration 6.3 is provided as a reference for finding the appropriate connectors described in the test procedures in this section. Some connectors are optional and not on all frequency converter configurations.

NOTICE

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

Diode Drop

A diode drop reading varies 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 is around 0.300 to 0.500. The opposite reading is referred to as infinity and most display the value OL for overload.



1	FK901: Switch mode power supply (SMPS) fuse	8	MK103: Gate drive and inrush control signals
2	MK901: DC input terminals for use with split bus power supply	9	MK101: Current sensor feedback
3	MK902: DC voltage from DC bus to power card SMPS	10	MK104: Signal test board connector
4	MK106: Brake temperature switch input	11	MK100: Current scaling board connector
5	MK500: Customer terminals for relays 1 and 2	12	MK102: Control card to power card connection
6	MK501: Heatsink and door/top fan control	13	Current scaling
7	MK502: RFI relay control		

Illustration 6.3 Power Card

6

6.3.2 Rectifier Circuits Test

Pay close attention to the polarity of the meter leads to identify a faulty component if an incorrect reading appears.

NOTICE

If the unit has a circuit breaker, contactor, disconnect or mains fuse option, make test connections L1, L2, and L3 to the output (drive) side of these devices.

Main rectifier circuit test part I

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

The correct reading is infinity. The meter starts at a low value and slowly climbs towards infinity due to the meter charging capacitance within the frequency converter.

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, the SCRs are shorted. Replace the shorted SCR/diode module.

Main rectifier circuit test part II

1. Reverse meter leads by connecting the negative (–) meter lead to the positive (+) DC bus.
2. Connect the positive (+) meter lead to L1, L2, and L3 in sequence.

The correct reading is infinity.

Incorrect reading
With the Part II test connection, even though the SCRs in the SCR/diode modules are forward biased by the meter, current does not flow through the SCRs without providing a signal to their gates.

A short circuit reading indicates either one or more of the SCRs are shorted in the SCR/diode module. Replace the shorted SCR/diode module.

Main rectifier circuit test part III

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

A diode drop indicates a correct reading.

Incorrect reading
With the Part III test connection, the diodes in the SCR/diode modules are forward biased. The meter reads the diode drops. If a short circuit exists, it would be possible that the SCR/diode modules are shorted. Replace the shorted SCR/diode module.

If an open reading occurs, replace the open SCR/diode module.

Main rectifier circuit test part IV

1. Reverse meter leads by connecting the negative (–) meter lead to the negative (-) DC bus.
2. Connect the positive (+) meter lead to L1, L2, and L3 in sequence.

Infinity is the correct reading. The meter starts at a low value and slowly climbs toward infinity due to the meter charging capacitance within the frequency converter.

Incorrect reading
With the Part IV test connection, the diodes in the SCR/diode modules are reverse biased. If a short circuit exists, the diodes in the SCR/diode modules are shorted. Replace the shorted SCR/diode module.

6.3.3 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. The IGBTs are grouped into module. One module is used for each output phase.

⚠CAUTION

Disconnect motor leads when testing the inverter section. With leads connected, a short circuit in one phase reads in all phases, making isolation difficult.

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

Inverter test part I

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

Infinity is the correct reading. The meter starts at a low value and slowly climbs toward infinity due to the meter charging capacitance within the frequency converter.

Inverter test part II

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

A diode drop indicates a correct reading.

Inverter test part III

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

A diode drop indicates a correct reading.

Inverter test part IV

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

Infinitiy is a correct reading. The meter starts at a low value and slowly climb toward infinity due to the meter charging capacitance within the frequency converter.

Incorrect reading
An incorrect reading in any inverter test indicates a failed IGBT module. Replace the IGBT module according to *chapter 7 Disassembly and Assembly Instructions*. Following an IGBT failure, it is important to verify that the gate drive signals are present and the wave form is correct. See *chapter 6.4.11 IGBT Gate Drive Signals Test*.

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

Infinity is a correct reading. 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 81 (R-).
2. Connect the negative (-) meter lead to the brake resistor terminal 82 (R+).

A diode drop indicates a correct reading.

Brake IGBT test part III

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

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

Brake IGBT test part IV

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

A diode drop indicates a correct reading.

Incorrect reading
An incorrect reading on any of these tests indicates that the brake IGBT is defective. Replace the brake IGBT module.

6.3.5 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. Connect the positive (+) meter lead to the (+) DC and the negative (-) meter lead to the negative (-) DC.
3. The meter starts out with low ohms and then move towards infinity as the meter charges the capacitors.
4. Reverse the meter leads such that the (-) meter lead is connected to the positive (+) DC and the positive (+) meter lead is connected to the negative (-) DC.
5. The meter pegs at zero while the meter discharges the capacitors. 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 that the capacitors are fully functional, it ensures that no short circuits exist in the intermediate circuit.

Incorrect reading
A short in the rectifier or inverter section could cause a short circuit. 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 for failure would be a defective capacitor.

There is not an effective test of the capacitor bank when it is fully assembled. It is unlikely that a physically damaged capacitor would indicate a failure within the capacitor bank. If a failure is suspected, all the capacitors must be replaced. Replace the capacitors in accordance with *chapter 7 Disassembly and Assembly Instructions*.

Further static tests could require some disassembly. See *chapter 7 Disassembly and Assembly Instructions*

6.3.6 IGBT Temperature Sensor Test

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

On the gate drive card, the resistance signal is converted to a frequency signal. The frequency signal is sent to the power card for processing. The temperature data is used to regulate fan speed and to monitor for over and under temperature conditions. There are 3 sensors, one in each IGBT module.

1. Use ohmmeter set to read ohms.
2. Unplug connector MK100 on the gate drive card (see *Illustration 6.9*) and measure the resistance across each black and white pair.

The relationship between temperature and resistance is nonlinear. At 25 °C, the resistance is approximately 5k Ohms. At 0 °C, the resistance is approximately 13.7 kΩ. At 60 °C, the resistance is approximately 1.5 kΩ. The higher the temperature, the lower the resistance.

6.3.7 Gate Resistor Test

Mounted to each IGBT module is an IGBT gate resistor board containing gate resistors for the IGBT transistors. In some cases, a defective IGBT can still produce good readings in the previous tests. In most cases, an IGBT failure results in the failure of the gate resistors, so the gate resistor test can identify an IGBT failure.

Remove the AC input bus bars or RFI filter (depending on options) if necessary to access the gate drive card. See *chapter 7 Disassembly and Assembly Instructions* for disassembly instructions.

A 3-pin test connector is on the gate drive card near each gate signal lead. These leads are labelled MK500, MK502, MK600, MK602, MK700, MK702, and, if the frequency converter is equipped with a brake option, MK200. See *Illustration 6.9*

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

With an ohmmeter, measure pins 1 and 2 of each test connector. The reading should be the same for each test connector.

Incorrect Reading
An incorrect reading indicates either that the gate signal wires are not connected from the gate drive card to the gate resistor board, or that the gate resistors are defective. Connect the gate signal wires if needed. If the resistors are defective, replace the entire IGBT module assembly. See *chapter 7 Disassembly and Assembly Instructions* for disassembly and assembly information.

6.3.8 Mains Fuse Test

Optional mains fuses can be located in one of two places. In most cases, they are in the main enclosure. When an optional contactor and disconnect are both present, the mains fuses are located in the options cabinet between these two components.
For the mains fuse test:

1. Use an ohmmeter set to measure the ohms.
2. Measure the resistance across each fuse. A short circuit indicates good continuity. An open circuit means that the fuse needs to be replaced.

Perform the additional static checks before replacing the fuse.

6.3.9 Disconnect Test

The mains disconnect switch is optional. If present, it is located in the options cabinet.
For the mains disconnect test:

1. Use an ohmmeter set to read ohms.
2. Open the disconnect switch.
3. Measure the resistance across each of the three phases.

An open circuit (infinite resistance) is a correct reading. A short circuit (0 Ω) indicates a problem with the switch.

1. Close the disconnect switch.
2. Measure the resistance across each of the three phases.

A short circuit (0 Ω) is a correct reading. An open circuit (infinite resistance) or high resistance reading indicates a problem with the switch. Replace the disconnect switch.

6.3.10 Circuit Breaker Test

The circuit breaker is optional. If present, it is located in the option cabinet.

1. Use an ohmmeter set to read Ohms.
2. Open the circuit breaker
3. Measure the resistance across each of three phases.

An open circuit (infinite resistance) is a correct reading. A short circuit (0 Ω) indicates a problem with the circuit breaker.

1. Close the circuit breaker
2. Measure the resistance across each of the three phases.

A short circuit (0 Ω) is a correct reading. An open circuit (infinite resistance), or high resistance reading indicates a problem with the circuit breaker.
If there is a problem with any of the phases, replace the circuit breaker.

6.3.11 Contactor Test

The contactor is optional. If present, it is located in the option cabinet. The contactor uses a customer-supplied 230 V AC control signal wired to the contactor coil. When power is applied to the contactor coil, the contactor is closed. When there is no power, the contact is open.

NOTICE

Complete testing of the contactor requires an external 230 V AC power supply.

Contactor Test part I

1. Remove power to the contactor coil.
2. Use an ohmmeter to measure across each of the three phases.

An open circuit (infinite resistance) is a correct reading. A short circuit (0 Ω) indicates a problem with the contactor.

Contactor Test part II

1. Manually engage the contactor
2. With the contactor engaged, measure the resistance across each of the three phases.

A short circuit (0 Ω) is the proper reading. An open circuit (infinite resistance) or high resistance reading indicates a problem with the contactor.

Contactor Coil Test

NOTICE

230 V AC power is required to test the contactor coil

1. Apply power to the coil to energise the contactor.
2. Use a voltmeter set to measure AC voltage between A1 and A2 on TB6.
3. Measure the resistance across each of the three phrases.

When power is applied, the contactor energises and is engaged. A short circuit (0 Ω) is a correct reading. An open circuit (infinite resistance) or high resistance reading indicates a problem with the contactor.

If there is a problem with any of the phases, replace the contactor.

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6

6.4 Dynamic Test Procedures

NOTICE

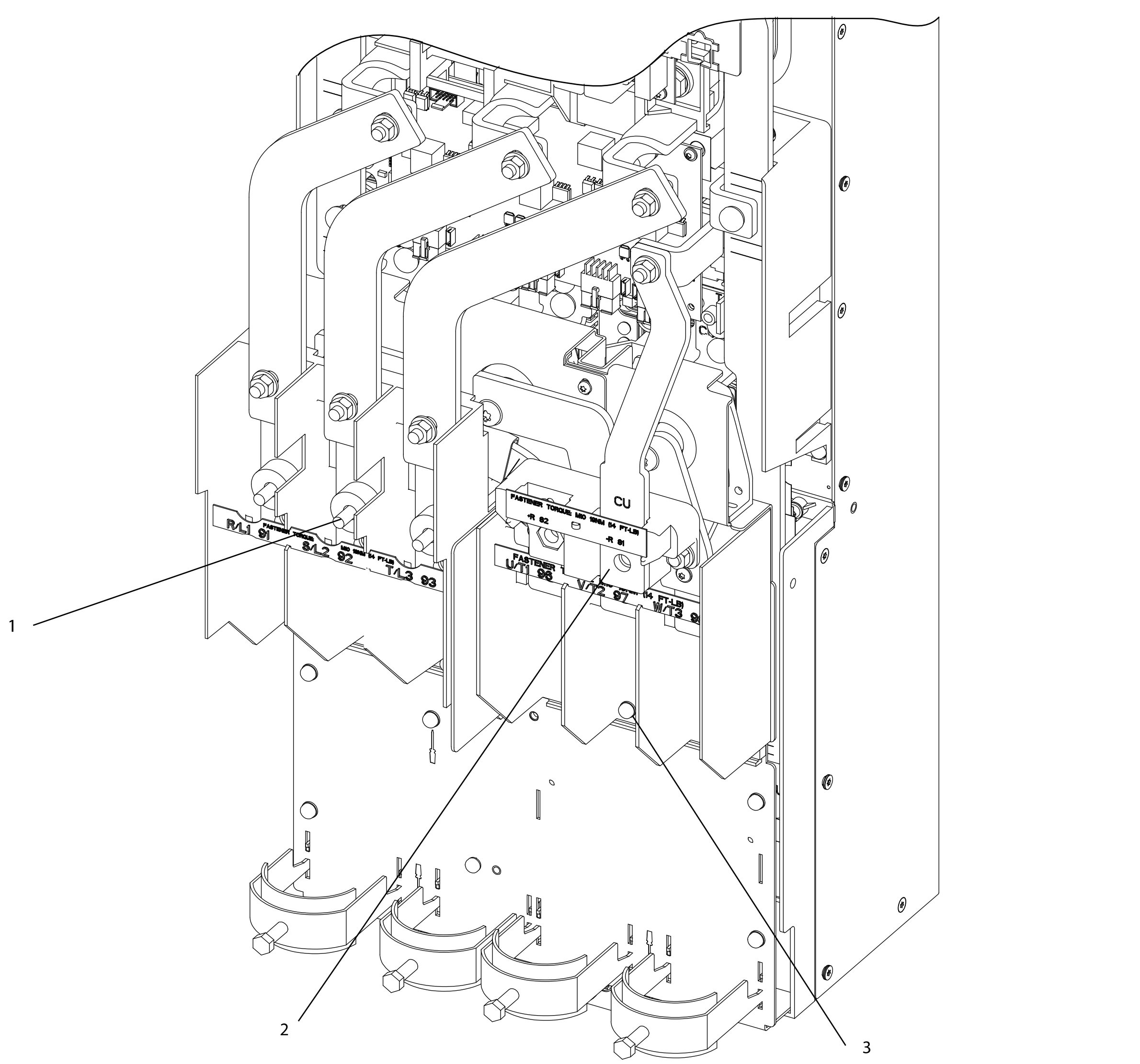
Test procedures in this section are numbered for reference only. Perform tests in any order and only as necessary.

⚠WARNING

Do not disconnect the input cabling to the frequency converter with power applied due to danger of severe injury or death.

⚠WARNING

Before starting the frequency converter, take all the necessary safety precautions for system start-up.



1	Main 3-phase AC power to frequency converter	3	3-phase output to motor
2	Brake Resistor Connection (optional)		

Illustration 6.4 Frequency Converter Power Terminals

Whenever possible, perform these procedures with a split bus power supply. For more information, see *chapter 8.1.1 Split Bus Power Supply*.

NOTICE

Always perform static tests (*chapter 6.3 Static Test Procedures*) before applying power to the unit.

6.4.1 No Display Test

A frequency converter with no display can be the result of several causes. Verify first that there is no display.

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

6.4.2 Input Voltage Test

If the frequency converter is equipped with optional equipment, ensure that it is functioning properly. See *chapter 6.3.9 Disconnect Test*, *chapter 6.3.8 Mains Fuse Test*, *chapter 6.3.11 Contactor Test*, and *chapter 6.3.10 Circuit Breaker Test* for more information.

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

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

Trane calculates mains imbalance per an IEC specification.

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

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

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

Incorrect reading

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

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

CAUTION

Open (blown) input fuses or tripped circuit breakers usually indicate a more serious problem. Before replacing fuses or resetting breakers, perform static tests described in *chapter 6.3 Static Test Procedures*.

If the input voltage test was successful, check for voltage to the control card.

6.4.3 Basic Control Card Voltage Test

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

An incorrect reading here could indicate that a fault in the customer connections is loading down the supply. Unplug the terminal strip and repeat the test. If this test is successful, continue. Remember to check the customer connections.

2. Measure the 10 V DC control voltage at terminal 50 regarding terminal 55. A correct reading is 10 V DC (9.2–11.2 V DC).

An incorrect reading here could indicate that a fault in the customer connections is loading down the supply. Unplug the terminal strip and repeat the test. If this test is successful, continue. Remember to check the customer connections.

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

6.4.4 DC Bus Voltage Test

DC bus voltage test part I

1. Using a voltmeter, read the DC bus voltage. See *chapter 6.2.1 Access to DC Bus* for DC bus location.

The measured voltage should be at least 1.35 x the AC input voltage.
An incorrect reading could indicate a problem in the inrush circuit, or with the rectifier. See *chapter 6.4.8 Input SCR Test*.

DC bus voltage test part II

1. Power down the frequency converter.
2. Wait for the DC bus to discharge.
3. Remove the control card mounting plate. See *chapter 7.3.2 Control Card and Control Card Mounting Plate* or *chapter 7.4.2 Control Card and Control Card Mounting Plate*.
4. Use an ohmmeter set to measure ohms.
5. Measure from (+) DC bus to power card MK902, pin 1.
6. Measure from (-) DC bus to power card MK902, pin 2.

A short circuit (0 ohms) is the correct reading.
An incorrect reading indicates a bad connection between the DC bus and the power card. Replace the wire harness.

DC bus voltage test part III

- Measure across fuse F901 on the top of the power card.

An open fuse indicates a failure of the power supplies on the power card. Replace the power card.

6.4.5 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 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. Install the signal test board (with extension).
2. Install the split bus power supply. Power the power card using split bus mode.
   chapter 8.1.1 Split Bus Power Supply.
3. Connect the negative (-) meter lead to terminal 4 (common) of the signal board. With a positive (+) meter lead, check the following terminals on the signal board.

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

Table 6.1 Measured Voltages at Select Terminals

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

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

The lack of any one of these power supplies indicates that the low voltage supplies on the power card are defective. Replace the power card in accordance with the disassembly procedures in *chapter 7 Disassembly and Assembly Instructions*.

6.4.6 Input Imbalance of Supply Voltage Test

All three phases should have an equal current draw. Some imbalance is possible, however, due to variations in the phase to phase input voltage.

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

1. Perform the input voltage test before checking the current, in accordance with *chapter 6.4.2 Input Voltage Test*. Voltage imbalances automatically result in a corresponding current imbalance.
2. Apply power to the frequency converter and place it in run mode.
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 does not vary from phase to phase by more than 5%.
   If a greater current variation exists, it indicates a possible problem with the mains supply 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. 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.

6. Reapply power to the frequency converter and place it in run.
7. Repeat the current measurements.

If the imbalance of supply current moves with swapping the leads, then the mains supply is suspect. Otherwise, there could be a problem with the gating of the SCR, perhaps due to a defective SCR/diode module. This result could also indicate a problem in the gate signals from the inrush card to the module, including the possibility of the wire harness from the inrush card to the SCR gates. Proceed to testing the input waveform and input SCR in accordance with *chapter 6.4.7 Input Waveform Test* and *chapter 6.4.8 Input SCR Test*.

6.4.7 Input Waveform Test

Testing the current waveform on the input of the frequency converter can help 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 SCR/diode modules control the rectifier section. If one of the SCR/diode modules becomes defective or the gate signal to the SCR is lost, the frequency converter responds the same as if one of the phases were lost.

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 6.5*.

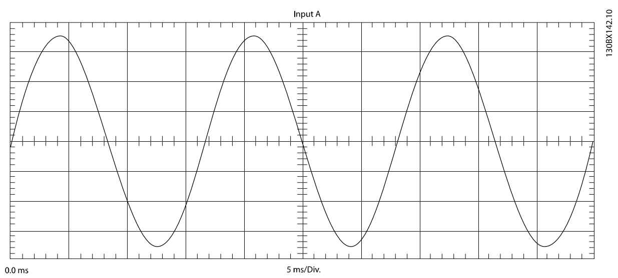


Illustration 6.5 Normal AC Input Voltage Waveform

The waveform shown in *Illustration 6.6* represents the input current waveform for the same phase as *Illustration 6.5* 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.

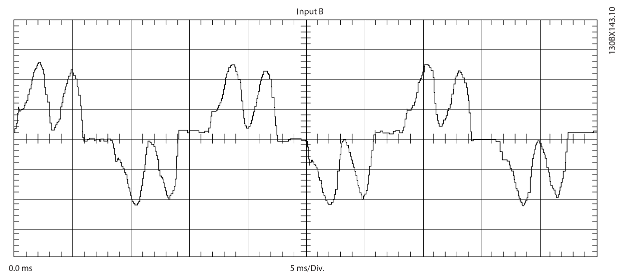


Illustration 6.6 AC Input Current Waveform with Diode Bridge

With a phase loss, the current waveform of the remaining phases would take on the appearance shown in *Illustration 6.7*.

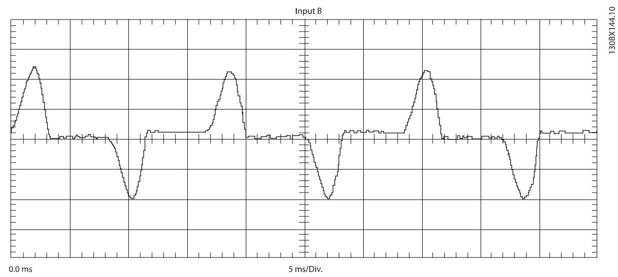


Illustration 6.7 Input Current Waveform with Phase Loss

Always verify the condition of the input voltage waveform before forming a conclusion. The current waveform follows the voltage waveform. If the voltage waveform is incorrect, 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, the input rectifier circuit in the frequency converter is suspect. Perform the rectifier circuit test and input SCR test.

6.4.8 Input SCR Test

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

SCR test part I

1. Remove the power card mounting plate.
2. Unplug the MK1802 connector from the inrush board.
3. The plug has three pairs of wires, one for each SCR module. Measure the resistance of each pair. Red is the SCR gate and black is the SCR cathode.

A proper reading is be 5–50 Ω. A significantly higher reading or an open circuit indicates a failed SCR or a faulty connection.

SCR test part II

1. Check the connections of the gate cables to the SCR/diode modules.
2. If the connections are good, replace the failed SCR/diode module.

If the SCR checks are successful and there is still no DC bus voltage, replace the inrush board.

6.4.9 Output Imbalance of Motor Voltage and Current

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

If the voltage is balanced but the current is not the motor could be 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 frequency converter being improperly connected.

NOTICE

Use a PWM-compatible digital or 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, disconnect the motor cables to isolate the problem further.

1. 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 40 Hz, which is normally the frequency limitation of such meters.

A balanced output current from phase to phase is correct. A variation of more than 2–3% is not correct. If the test is successful, the frequency converter is operating normally.

2. 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.

A variation of more than 8 V AC among the three readings is not correct. 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 50 Hz/60 Hz the voltage is approximately equal to the mains voltage applied. At 25 Hz/30 Hz, it is about half of that, and so on, for any other speed selected. The exact voltage reading is less important than balance between phases.

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

Since the current follows the voltage, it is necessary to differentiate between a load problem and a frequency converter problem. If a voltage imbalance in the output occurs with the motor disconnected, test the gate drive circuit for proper firing. Proceed to *chapter 6.4.10 IGBT Switching Test*.

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.

6.4.10 IGBT Switching Test

⚠CAUTION

Before proceeding, remove input AC voltage and wait 20 minutes for the DC bus capacitors to discharge fully.

Provide power using the split bus power supply to determine whether the IGBTs are switching correctly.

1. Connect the split bus power supply. See *chapter 8.1.1 Split Bus Power Supply*.
2. Switch on the 650 V DC and 24 V DC power supplies.
3. Apply a run command and speed command of approximately 40 Hz.
4. Measure the phase to phase output waveform on all three output phases of the frequency converter using an oscilloscope (preferred) or a voltmeter.

4a When measuring with an oscilloscope, the waveform appears the same as in normal operation, except that the amplitude is 24 V peak. *Illustration 6.8*

4b When measuring with a voltmeter set to read AC voltage, the meter reads approximately 17 V AC on all three phases. Differences in drive settings could cause a slight variation in this reading, but it is important that the readings are equal on all three phases.

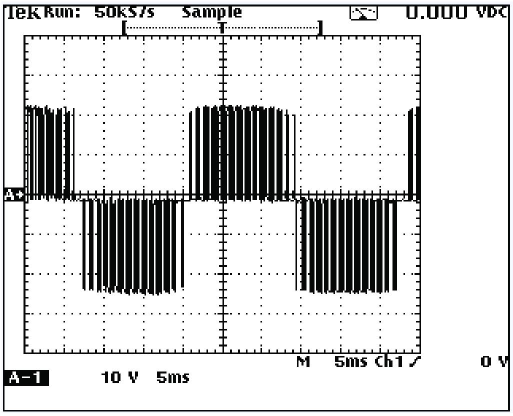


Illustration 6.8 Output Wave Form

An incorrect reading indicates either a defective IGBT or gate drive signal. Perform the gate drive signal test (see *chapter 6.4.11 IGBT Gate Drive Signals Test*) to determine if the gate drive signal is correct.

6.4.11 IGBT Gate Drive Signals Test

This procedure tests the gate drive signals at the output of the gate drive card just before they are delivered to the IGBTs.

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

WARNING

Disable the DC bus when performing this test with split bus power supply. Failure to do so could result in damage to the frequency converter if the probe is inadvertently connected to the wrong pins. Exercise caution when working close to high-voltage components.

Before beginning the tests, ensure that power is removed from the unit and that the DC Bus capacitors have been discharged.

Install the split bus power supply.

- Remove the AC bus bars or RFI filter (option).
- Connect the split bus power supply according to *chapter 8.1.1 Split Bus Power Supply*

A 3-pin test connector is on the gate drive card near each gate signal lead. These leads are labelled MK500, MK502, MK600, MK602, MK700, MK702, and, if the frequency converter is equipped with a brake option, MK200. See *Illustration 6.9*

Refer to the 3 pins as one, two, and three, reading bottom to top. Pins 1 and 2 of each connector are in parallel with the gate drive signal sent to the IGBTs. Pin 1 is the signal and pin 2 is common.

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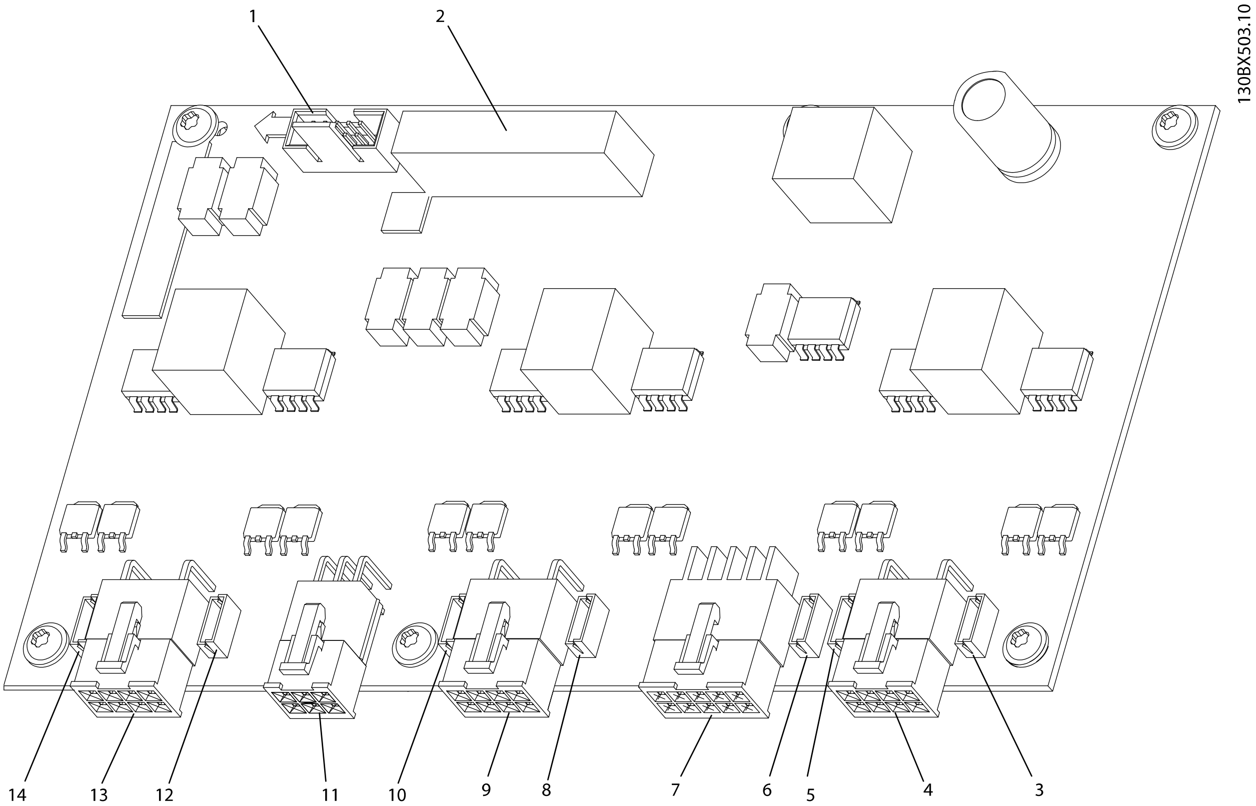
1. Turn on the split bus power supply (only 650 V).
2. In stop mode, measure pins 1 and 2 of each test connector. A correct reading reading is approximately -9 V DC, which indicates that all IGBTs have been turned off.
3. Apply the run command to the frequency converter and 30 Hz reference.
4. If using a voltmeter, measure pins 1 and 2 of each connector. Waveform to IGBTs is a square wave that goes positive to 14 V DC and negative to -9 V DC. Average voltage read by the voltmeter is 2.2 to 2.5 V DC.



1	MK102: Connection to inrush board	8	MK600: V phase upper IGBT test point
2	MK101: Gate drive and inrush control signals to the power card	9	MK601: V phase IGBT gate signal
3	MK700: W phase upper IGBT test point	10	MIK602: V phase lower IGBT test point
4	MK701: W phase IGBT signal	11	MK100: IGBT temperature feedback
5	MK702: W phase lower IGBT test point	12	MK500: U phase upper IGBT test point
6	MK200: Brake IGBT test point (optional)	13	MK501: U phase IGBT gate signal
7	MK201: Brake IGBT gate signal (optional)	14	MK502: U phase lower IGBT test point

Illustration 6.9 Gate Drive Card

When using an oscilloscope, the readings in *Illustration 6.10* are correct.

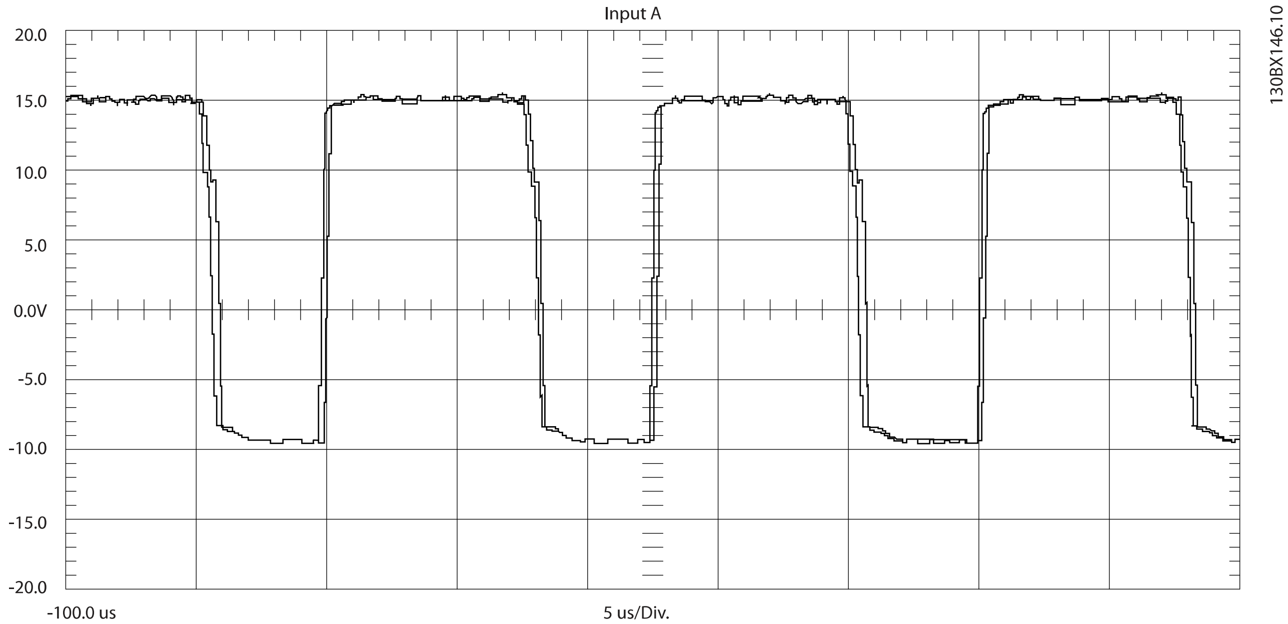


Illustration 6.10 Gate Signal Waveform from Gate Drive Card

IGBT Gate Signal measured on the Gate Drive Card: 5 V per division vertical scale, 50 ms per division time scale. Unit running at 30 Hz.

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

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

The waveform in *Illustration 6.11*is the correct result.

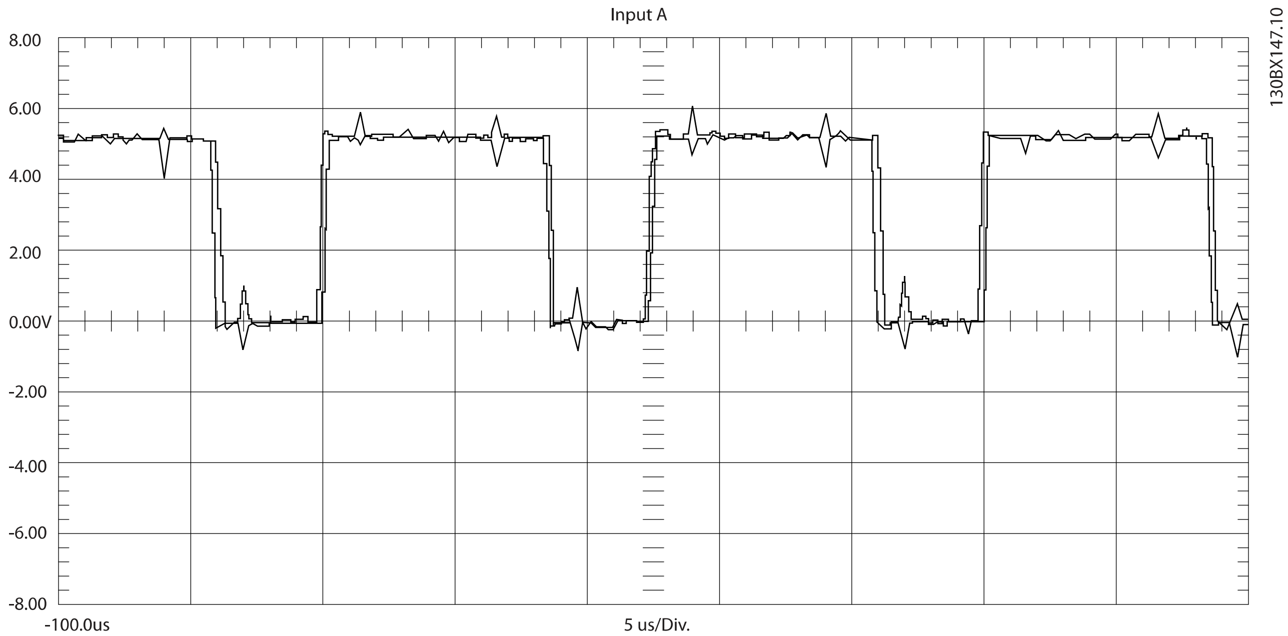


Illustration 6.11 Gate Signal Waveform from Signal Test Board

IGBT Gate Signal measured with the Signal Test Board: 2 V per division vertical scale, 50 ms per division time scale. Unit running at 30 Hertz.

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

An incorrect reading of a gate signal indicates that the control card is defective. Replace the control card.

If the signal is good on the signal test board but missing on the gate drive board, the failure could be the gate drive board, the power card, or the ribbon cable between them. Replace the gate drive board and repeat the test.

6.4.12 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 (ground) faults and overcurrent trips. In such instances, the fault only occurs at higher loads. If the incorrect current scaling card is installed, the current signals are not scaled properly. Incorrect scaling could cause erroneous overcurrent trips. If the current scaling card is not installed, the frequency converter trips.

There are two ways to determine the status of the sensors.

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

1. Apply power to the frequency converter.
2. Ensure that the following parameter setups are disabled:
   - 2a Motor check
   - 2b pre-magnetizing
   - 2c DC hold
   - 2d DC brake
   - 2e Any others that create a holding torque while at zero speed.

   If these parameters are not diable, the current displayed exceeds 1–2 A.
3. Run the frequency converter with a zero speed reference. Note the output current reading in the display. The correct reading on the display is approximately 1–2 A.

If the current is greater than 1–2 A and no current-producing parameters are active, disconnect the motor cables and repeat the test.

4. Remove power from the frequency converter.
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. A correct reading is less than 1 A.

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

To test current feedback with the signal test board.

8. Remove power to the frequency converter. Make sure the DC bus is fully discharged.
9. Install the signal test board into power card connector MK104.
10. Using an ohmmeter, measure the resistance between terminals 1 and 4, 2 and 4, and 3 and 4 of the signal test board. The correct resistance is an identical readings on all three terminals.
11. Reapply power to the frequency converter.
12. Using a voltmeter, 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.

The current sensor feedback signal in the circuit reads approximately 400 mV at a 100% frequency converter load. Any reading above 15 mV while the frequency converter is at zero speed negatively affects the way the frequency converter interprets the feedback signal.

Replace the corresponding current sensor if a reading of greater than 15 mV occurs. See the disassembly instructions in *chapter 7 Disassembly and Assembly Instructions*.

Table 6.2 and *Table 6.3* contain approximate resistance readings based on power and voltage rating and the current scaling card. When measuring with the signal test board, the reading could be higher due to meter lead resistance. A reading of no resistance indicates a missing scaling card.

Scaling Resistance Measured in Ω	TR200 Model	
4.6	N110T4	N90kT5
3.8	N132T4	N110T5
3.1	N160T4	N132T5
2.6	N200T4	N160T5
5.1	N250T4	N200T5
4.2	N315T4	N250T5
4.5	P110T4	P90kT5
3.8	P132T4	P110T5
3.1	P160T4	P132T5
2.6	P200T4	P160T5
5.1	P250T4	P200T5
4.2	P315T4	P250T5
2.6	P355T4	P315T5
2.6	P400T4	P355T5
2.3	P450T4	P400T5
4.2	P400T4	P450T5
4.2	P560T4	P500T5
2.6	P630T4	P560T5
2.3	P710T4	P630T5
4.2	P800T4	P710T5
2.6	P1M0T4	P800T5

Table 6.2 Scaling Resistance 380–500 V

Scaling Resistance Measured in Ω	TR200 Model	
5.9	N75kT7	N55kT7
5.9	N90kT7	N75kT7
5.9	N110T7	N90kT7
5.9	N132T7	N110T7
5.0	N160T7	N132T7
4.0	N200T7	N160T7
3.2	N250T7	N200T7
2.7	N315T7	N250T7
5.6	N400T7	N315T7
5.9	P45kT7	P37kT7
5.9	P55kT7	P45kT7
5.9	P75kT7	P55kT7
5.9	P90kT7	P75kT7
5.9	P110T7	P90kT7
5.9	P132T7	P110T7
4.5	P160T7	P132T7
3.1	P200T7	P160T7
3.1	P250T7	P200T7
2.6	P315T7	P250T7
5.1	P400T7	P315T7
4.5	P450T7	P355T7
4.5	P500T7	P400T7
3.8	P560T7	P500T7
2.6	P630T7	P560T7
4.5	P710T7	P630T7
3.8	P800T7	P710T7
2.6	P900T7	P800T7
4.5	P1M0T7	P900T7
3.8	P1M2T7	P1M0T7
2.6	P1M4T7	P1M2T7

Table 6.3 Scaling Resistance 525–690 V

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6.4.13 Fan Tests

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

Mixing Fan
The mixing fan should operate any time the frequency converter is powered up. If the frequency converter is powered and the mixing fan is not running, replace the mixing fan.

Heatsink and Door/Top Fans
14-52 Fan Control can be used to command the fans to run at 100% speed.

1. Use *14-52 Fan Control* to command the fans to run at 100% speed.
2. Confirm that the heatsink fan is running by checking for air flow through the back channel of the frequency converter.
3. Confirm that the door/top fan is running by checking for air flow around the fan.

The two fans ramp up at different rates, and may take several seconds, but both will run at 100% speed..

Incorrect Reading
If neither fan is running, the most likely cause is that the fan control circuit on the power card is faulty. Replace the power card.
If only one fan is running, the most likely cause is that the other fan is faulty. Replace the failed fan.

6.4.14 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. *16-60 Digital Input* through *16-64 Analog Input 54* display the status for the standard inputs. Some options add inputs to the frequency converter and there are more parameters to show the status of these inputs.

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

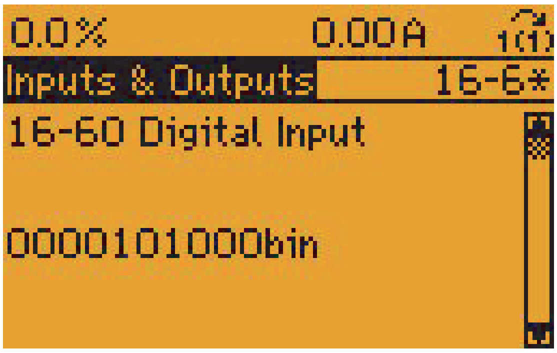

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Illustration 6.12 Digital Inputs Display

If the display does not show the desired signal, the problem could be the external control wiring to the frequency converter, incorrect programming of *5-00 Digital I/O Mode*, or a faulty control card.

Using *5-00 Digital I/O Mode*, the digital inputs can be programmed to either accept a sourcing output (PNP) or a sinking output (NPN). When programmed for PNP (factory default), the digital input turns on when 24 V DC is applied to the digital input terminal. When programmed for NPN, the digital input turns on when the terminal is connected to Signal Common (terminal 20).
The power for the digital inputs can either come from the (+) 24 V DC built into the frequency converter, or from an external power supply. If an external power supply is used, the common of the supply must be referenced to terminal 20.

Measure the DC voltage as follows:

1. Connect the (-) negative meter lead to terminal 20.
2. Connect the (+) positive meter lead to terminal 12 or 13.

A correct reading is 21–27 V DC. If the power supply voltage is not present, perform the basic control card voltage test.

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

Measure the DC voltage as follows:

1. Connect the (-) negative meter lead to terminal 20.
2. Connect the (+) positive meter lead to each digital input in sequence.

The correct display for each digital input where the voltage reading was greater than 10 V DC is 1. The correct display for each digital input where the voltage reading was less than 5 V DC is 0. If the display does not correspond with the measured inputs, the digital inputs on the control card have failed. Replace the control card.

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

Measure the DC voltage as follows:

1. Connect the (-) negative meter lead to terminal 20.
2. Connect the (+) positive meter lead to each digital input in sequence.

The correct display for each digital input where the voltage reading was less than 14 V DC is 1. The correct display for each digital input where the voltage reading was greater than 19 V DC is 0. If the display does not correspond with the measured inputs, the digital inputs on the control card have failed. Replace the control card.

Analog Inputs

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

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

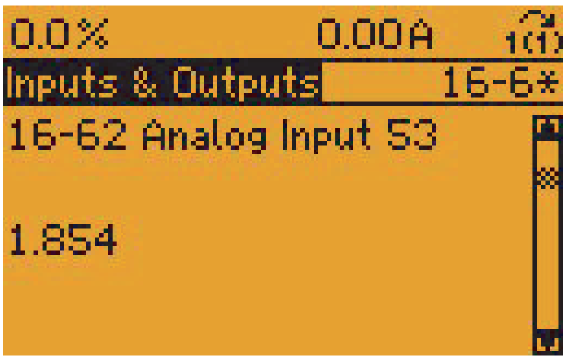

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Illustration 6.13 Analog Inputs Display

Problems in the external control wiring to the frequency converter, configuration of the switches, or a faulty control card cause an incorrect signal to display.

The power for the analog inputs can either come from the power supply built into the frequency converter, or from an external power supply. If an external power supply is used, the common of the supply must be referenced to terminal 55.

Verify the control voltage power supply

1. Connect the (-) negative meter lead to terminal 55
2. Connect the (+) positive meter lead to terminal 50.

The correct reading is 9.2–11.2 V DC. If the power supply voltage is not present, perform the basic control card voltage test.

Verify that the analog input is configured for the type of signal being sent to the frequency converter. *16-61 Terminal 53 Switch Setting* shows the configuration of terminal 53, and *16-63 Terminal 54 Switch Setting* shows the configuration of terminal 54. If the inputs are not configured correctly, power down the frequency converter and change switches S201 and S202.

6

Check the individual inputs if configured for voltage

Measure the DC voltage as follows:

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

For each analog input, the measured DC voltage should match the value shown in the display parameter. If the display does not correspond with the measured input and the switch is configured for voltage, the analog input on the control card has failed. Replace the control card.

Check the individual inputs if configured for current

Measure the DC voltage as follows:

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

When configured for current, the current flows through a 200 Ω resistor to create a voltage drop. A 4 mA current flow creates approximately a 0.8 V DC voltage reading. A 20 mA current flow creates approximately a 4.0 V DC voltage reading. The display shows the mA value. If the display does not correspond with the measured input, the analog input on the control card has failed. Replace the control card.

NOTICE

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

6.5 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. Following the procedure ensures that all circuitry in the frequency converter is functioning properly before putting the unit into operation.

1. Perform visual inspection procedures as described in *chapter 4.4 Visual Inspection*.
2. Perform static test procedures to ensure that frequency converter is safe to start.
3. Disconnect motor leads from output terminals (U, V, W) of the frequency converter.
4. Apply AC power to frequency converter.
5. Give the frequency converter a run command and slowly increase 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 V. If unbalanced voltage is measured, refer to *chapter 6.4.2 Input Voltage Test*.
7. Stop the frequency converter and remove input power. Allow 20 minutes for DC capacitors to discharge fully.
8. Reconnect motor cables to frequency converter output terminals (U, V, W).
9. Reapply power and restart frequency converter. Adjust motor speed to a nominal level.
10. Using a clamp-on style ammeter, measure output current on each output phase. All currents must be balanced.

7 Disassembly and Assembly Instructions

7.1 Introduction

WARNING

Frequency converters contain dangerous voltages when connected to mains voltage. Do not disassemble when power is applied. Disconnect power to the frequency converter, and wait for a minimum period of 20 minutes for the frequency converter capacitors to discharge fully. Competent technicians are the only persons qualified to perform these procedures.

NOTICE

Frame size is used throughout this manual where procedures or components differ between frequency converters based upon the unit's physical size. Refer to the tables in *chapter 1.5 Frame Size Definitions* to determine frame size definitions.

In this chapter, *chapter 7.3 D1h/D3h Disassembly and Assembly Instructions* describes the disassembly procedure for the D1h, D3h, D5h, and D6h frequency converter, and *chapter 7.4 D2h/D4h Disassembly and Assembly Instructions* describes the procedure for D2h, D4h, D7h, and D8h.

7.2 Electrostatic Discharge (ESD)

ELECTROSTATIC DISCHARGE (ESD)
Many electronic components within the frequency converter are sensitive to static electricity. Voltages so low that they are undetectable can reduce the life, affect performance, or completely destroy sensitive electronic components.

CAUTION

Use the correct ESD procedures to prevent damage to sensitive components when servicing the frequency converter.

7.3 D1h/D3h Disassembly and Assembly Instructions

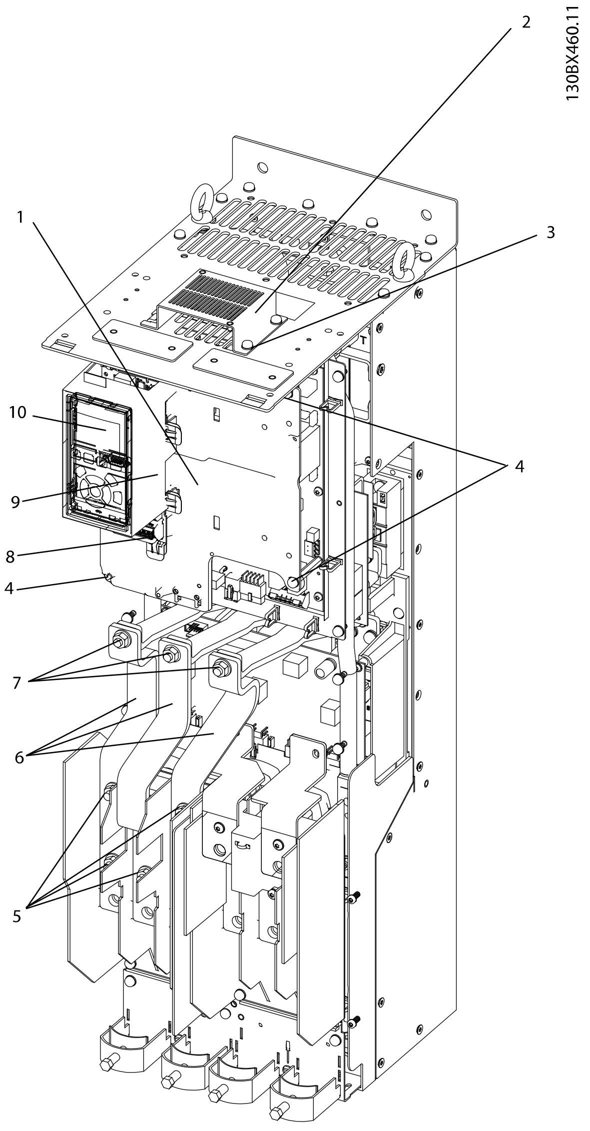
7.3.1 General Information

These disassembly instructions are based on IP21 (NEMA 1) IP54 (NEMA 12) enclosure. Some details vary for the IP20 version.

7.3.2 Control Card and Control Card Mounting Plate

1. Open the front panel door or remove the front cover, depending on the enclosure type.
2. Remove the LCP cradle and LCP ribbon cable. The LCP cradle can be removed by hand.
3. Remove any customer control wiring from the control card and option cards.
4. Remove the 4 screws (T20) from the corners of the control card mounting plate.
5. Unplug the ribbon cable connecting the control card and the power card.

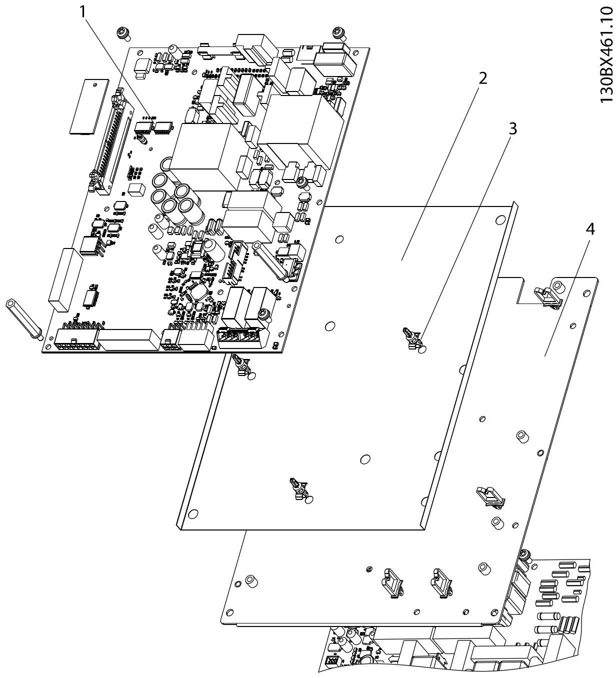
Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*. See *Illustration 7.1*.



1	Control card mounting plate	6	AC Input bus bars
2	Top fan (IP20)	7	Top bus bar mounting nuts (10 mm)
3	T25 Screw	8	Control terminals
4	Control card mounting plate screws (T20)	9	LCP cradle
5	Bottom bus bar mounting nuts (13 mm)	10	LCP

Illustration 7.1 Control Card and Mounting Plate

7.3.3 Power Card Mounting Plate



1	Power card PCA3	3	Plastic standoff
2	Insulator	4	Power card mounting plate

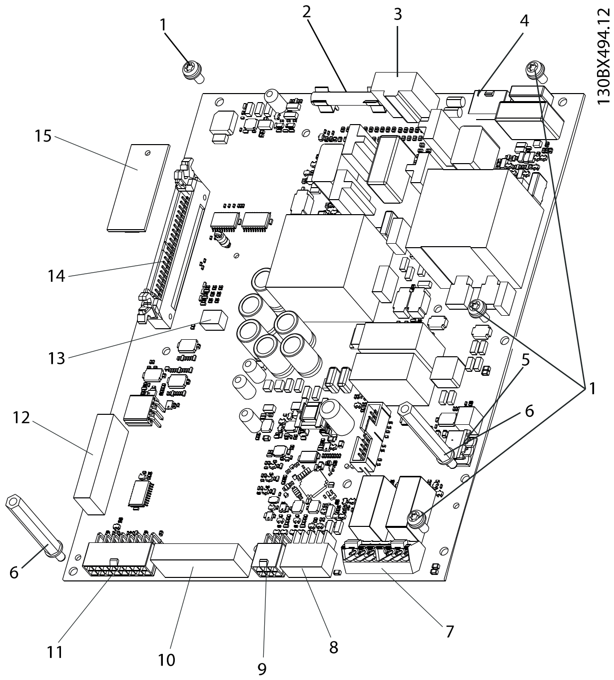
Illustration 7.2 Power Card and Mounting Plate

1. Remove the control card mounting plate in accordance with *chapter 7.3.2 Control Card and Control Card Mounting Plate*.
2. The power card mounting plate can be removed with the power card still mounted. Remove the power card in accordance with *chapter 7.3.4 Power Card*, if necessary.
3. To remove the power card mounting plate with the power card attached, unplug the connectors:
   - 3a MK101
   - 3b MK103
   - 3c MK501
   - 3d MK502
   - 3e MK902
   - 3f Any additional customer-supplied wiring at MK500 and MK 106
4. Remove the 4 screws (T20), one from each corner of the mounting plate.
5. Remove the 1 screw (T25) from the top centre of the mounting plate.

The IP20 enclosure has a different type and number of fasteners.

Reinstall in reverse order of this procedure and tighten hardware in accordance with *chapter 1.7 General Torque Tightening Values*. See *Illustration 7.2* and *Illustration 7.3*.

7.3.4 Power Card



1	Mounting screws (T20)	9	MK502
2	F901	10	MK103
3	MK901	11	MK101
4	MK902	12	MK104
5	MK106	13	MK100
6	Mounting standoffs (8 mm)	14	MK102
7	MK500	15	Current scaling card
8	MK501		

Illustration 7.3 Power Card

1. Remove the control card mounting plate in accordance with *chapter 7.3.2 Control Card and Control Card Mounting Plate*.
2. Unplug the power card connectors:
   - 2a MK101
   - 2b MK103
   - 2c MK501
   - 2d MK502
   - 2e MK902
   - 2f any additional customer-supplied wiring at MK500 and MK106
3. Remove the 5 power card mounting screws (T20).
4. Remove the 2 standoffs (8 mm).
5. Remove the power card from the 3 plastic standoffs.
6. Remove the current scaling card from the power card by pushing in the retaining clips on the standoffs. The scaling card controls signals operating specifically with this frequency converter and is not part of the replacement power card.

NOTICE

Keep this scaling card for future reinstallation of any replacement power card.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*. When installing the power card, ensure that the insulator sheet is installed behind the power card. See *Illustration 7.2*

7.3.5 AC Input Bus Bars

See *Illustration 7.1* for location of bus bars.

7.3.5.1 Mains Fuses Only

1. Remove mains fuses by removing 6 nuts (13 mm), one at each end of each fuse.
2. Remove 3 nuts (10 mm) at the top of of the bus bars. One per phase.
3. Remove the bus bars.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.5.2 RFI Only

1. Remove 3 nuts (10 mm) at the top of the RFI filter, one per bus phase.
2. Remove 6 nuts (13 mm) at the bottom of the RFI filter, two per phase.
3. Remove 4 mounting screws (T20 thread cutting) connecting the RFI filter to the side channels of the frequency converter.
4. Remove the RFI filter and unplug the RFI cable from MK100 on the printed circuit board assembly.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

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7.3.5.3 Fuses and RFI

1. Remove mains fuses by removing 6 nuts (13 mm), one at each end of each fuse.
2. Remove 3 nuts (10 mm) at the top of the RFI filter, one per phase.
3. Remove 4 mounting screws (T20 thread cutting) connecting the RFI filter to the side channels of the frequency converter.
4. Remove the RFI filter and unplug the RFI cable from MK100 on the printed circuit board assembly.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.5.4 No Options

1. Remove 3 nuts (10 mm) at the top of the bus bars, one per phase.
2. Remove 6 nuts (13 mm) at the bottom of the bus bars, two per phase.
3. Remove the bus bars.

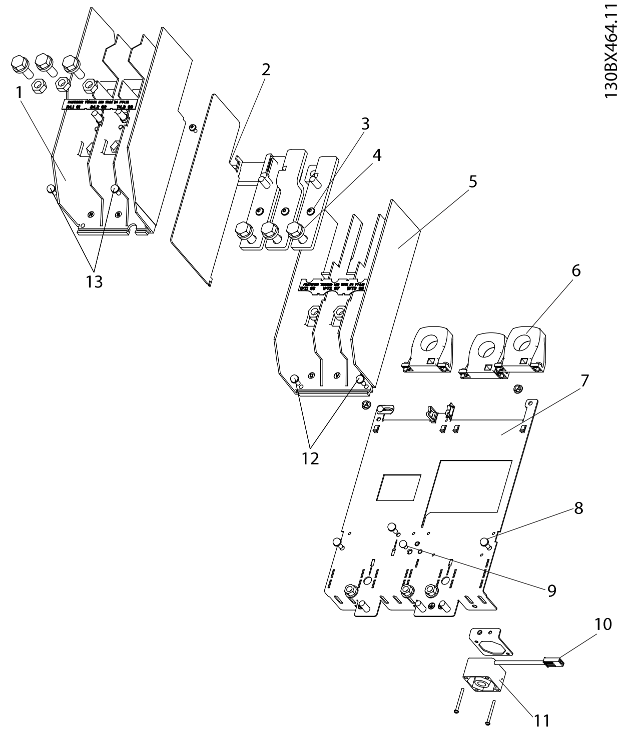
Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.6 Mains Input Terminal Block

See *Illustration 7.4*

1. Disconnect the customer input power wiring.
2. Remove input terminals .
3. Remove the 2 screws (T25) at the bottom of the terminal block.
4. Remove the terminal by sliding it down to disengage it from the metal clips holding it in place.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.



1	Input terminal mounting block	8	T20 screw
2	U output bus bar bolt (not shown)	9	T25 screw
3	Output bus bar support screw (T25)	10	Molex connector
4	Terminal screw	11	Mixing fan
5	Motor terminal mounting block	12	Output terminal block retaining screws (T25)
6	Current sensor	13	Input terminal block retaining screws (T25)
7	Power terminal mounting plate		

Illustration 7.4 Power Terminals

7.3.7 Motor Terminal Block

1. Remove the input terminal block in accordance with *chapter 7.3.6 Mains Input Terminal Block*.
2. Disconnect wiring to motor and brake (if present).
3. Remove the EMC shield, between the mains input and motor terminal blocks, by removing 1 screw (T20).
4. Remove the U output bus bar by removing the 1 screw (T25 thread forming) in the middle of the bus bar, and the 1 bolt (T30) at the current sensor end of the bus bar.
5. Remove the V output bus bar by removing the 1 screw (T25 thread forming) in the middle of the

bus bar, and 1 bolt (T30) at the current sensor end of the bus bar. (Note the V bolt is shorter than U and W)

6. Remove the W output bus bar by removing the 1 screw (T25 thread forming) in the middle of the bus bar, and the 1 bolt (T30) at the current sensor end of the bus bar.
7. Remove the 2 screws (T25) at the bottom of the terminal block.
8. Remove the terminal by sliding it down to disengage it from the metal clips holding it in place.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.8 Power Terminal Mounting Plate

1. Remove the motor terminal in accordance with *chapter 7.3.7 Motor Terminal Block*.
2. Remove the 4 screws (T20 thread cutting), two from each side of the plate.
3. For IP21 (NEMA 1) and IP54 (NEMA 12) enclosures only, remove 3 screws (T25) from the bottom of the frequency converter.
4. Unplug the mixing fan, located under the mounting plate.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.9 Current Sensors

1. Remove power terminal mounting plate in accordance with *chapter 7.3.8 Power Terminal Mounting Plate*.
2. Disconnect the wire harness from each current sensor. Note which connector attaches to each current sensor.
3. Remove 6 screws (T20) connecting the current sensors to the power terminal mounting plate, 2 per current sensor.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note for reassembly: The signal wire plug faces outward since it is important for the current sensor to point in the proper direction.

7.3.10 Mixing Fan

1. Remove the power terminal mounting plate in accordance with *chapter 7.3.8 Power Terminal Mounting Plate*.
2. Remove the 2 screws attaching the fan to the power terminal mounting plate.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.11 Balance/High Frequency Card

7.3.11.1 400 V AC Power Size (includes 460 V)

1. Remove the power terminal mounting plate in accordance with *chapter 7.3.8 Power Terminal Mounting Plate*.
2. Unplug the cable MK 100 on the balance/high frequency card.
3. Remove the 1 standoff (8 mm) from the corner of the card.
4. Remove 3 nuts (8 mm).

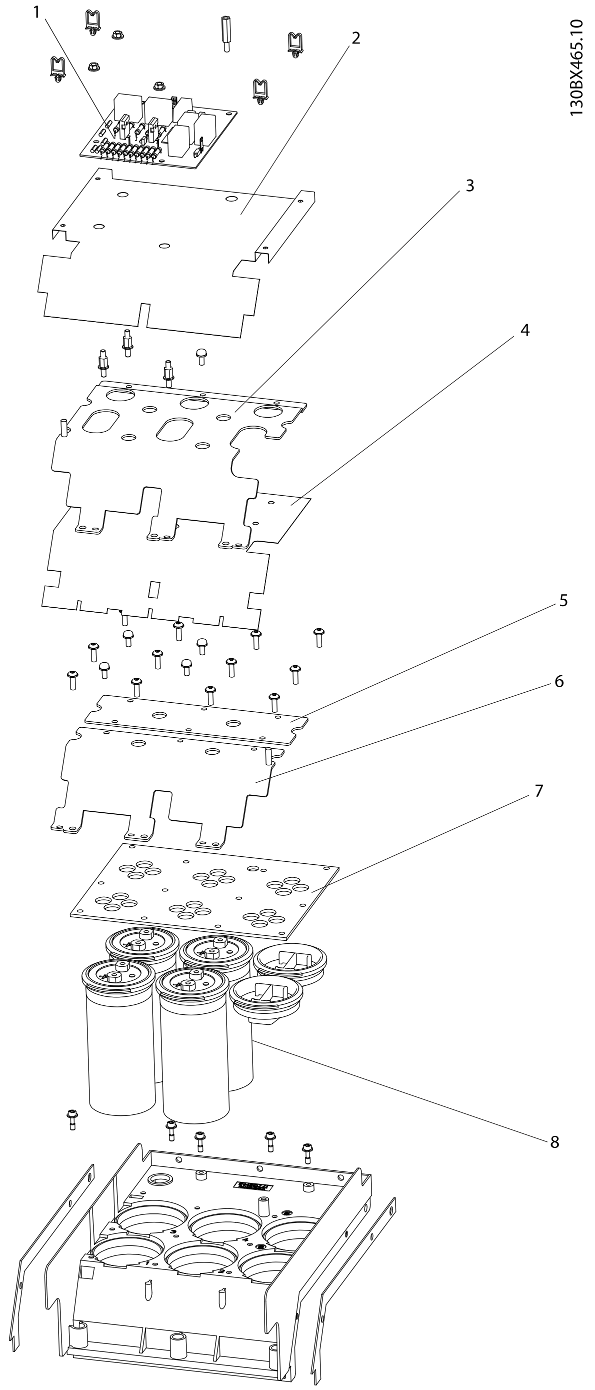
NOTICE

Two of the nuts also hold in place the (+) DC and (-) DC wire harness.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note the wire cable connections on the (+) UDC and (-) UDC terminals.



1	Balance/High frequency card	5	DC centre capacitor plate
2	Capacitor bank cover	6	(+) DC capacitor plate
3	(-) DC capacitor plate	7	Capacitor locking panel
4	Mylar insulator	8	DC capacitor

Illustration 7.5 Balance/High Frequency Card and DC Capacitor Bank
400 V unit shown, 690 V units are slightly different.

7.3.11.2 690 V AC Power Size (includes 575 V)

1. Remove the power terminal mounting plate in accordance with *chapter 7.3.8 Power Terminal Mounting Plate*.
2. Unplug the cable MK 100 on the balance/high frequency card.
3. Remove the 1 standoff (8 mm) from the corner of the card.
4. Remove 3 nuts (8 mm).
5. Remove 1 screw (T20).

NOTICE

The screw and one of the nuts also hold in place the (+) DC and (-) DC wire harness.
Reinstall in reverse order of` this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note the wire cable connections on the (+) UDC and (-) UDC terminals.

7.3.12 DC Bus Rails

1. Remove the power card mounting plate in accordance with *chapter 7.3.3 Power Card Mounting Plate*.
2. Remove the power terminal mounting plate in accordance with *chapter 7.3.8 Power Terminal Mounting Plate*.
3. Remove the 2 screws (T30) at the top end of the bus bar, one per bus bar.
4. From the other end of the bus bar, remove 2 nuts (10 mm), one per bus bar.

NOTICE

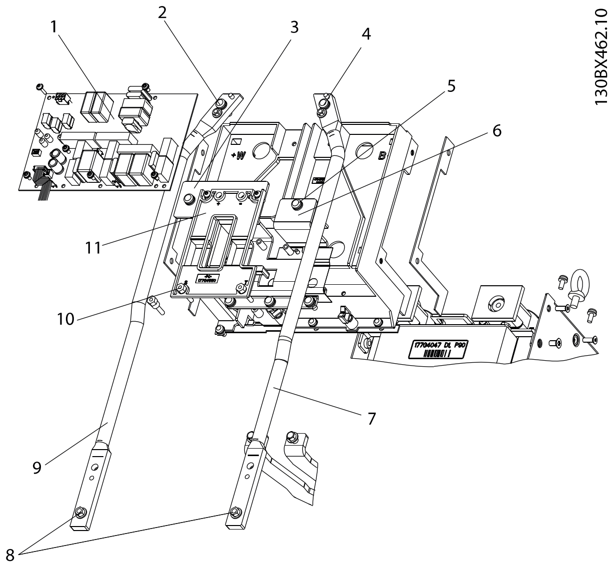
If there is a brake option, remove the 2 brake to DC link bus bars by removing 2 screws (T30), one per bus bar and 2 nuts (10 mm), one per bus bar.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.13 Inrush Card

1. Remove the DC bus rails in accordance with *chapter 7.3.12 DC Bus Rails*.
2. Unplug MK1802.
3. Remove 5 screws (T20)

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.



1	Inrush card	7	(-)DC bus bar DC Coil to Capacitor Bank
2	T30 screw	8	10 mm nut
3	(+) DC bus bar	9	(+)DC bus bar DC Coil to Capacitor Bank
4	T30 screw	10	11 mm threaded standoff
5	T30 screw	11	Inrush Support Bracket
6	(-) DC bus bar		

Illustration 7.6 Inrush Card

7.3.14 IGBT Gate Drive Card

1. Remove the DC bus bars in accordance with *chapter 7.3.12 DC Bus Rails*.
2. (Brake option only) Unplug MK201.
3. Unplug Connectors:
   - 3a MK100
   - 3b MK501
   - 3c MK601
   - 3d MK701
   - 3e MK102
4. Remove 6 screws (T20 thread forming).

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.15 SCR Input Bus Bars

1. Remove the inrush card in accordance with *chapter 7.3.13 Inrush Card*.
2. Remove 3 standoffs (11 mm thread forming) one on each SCR AC input bus bar.
3. Remove the black plastic inrush support by removing 2 screws (T25).
4. Remove 3 screws (T30) connecting the bus bars to the SCR modules, one from each bus bar.
5. Remove bus bars.

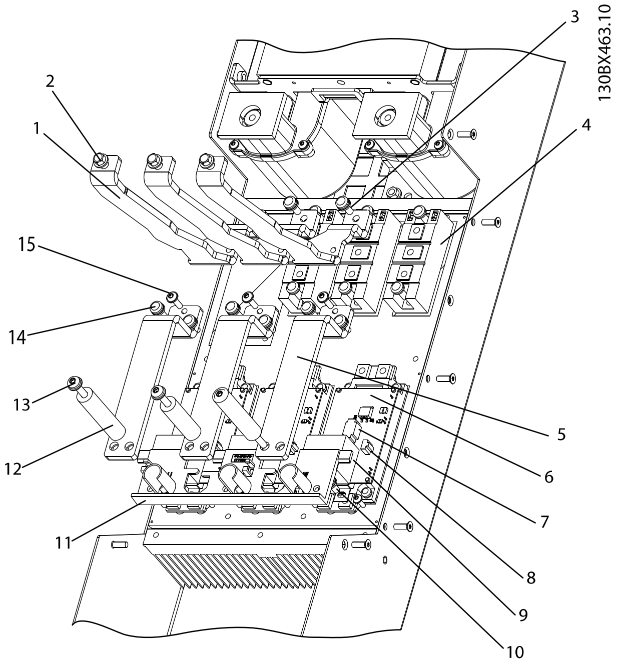
Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note for reassembly: Fasten all components hand-tight and then place the inrush support to align all before tightening the fasteners.

7

7.3.16 SCRs



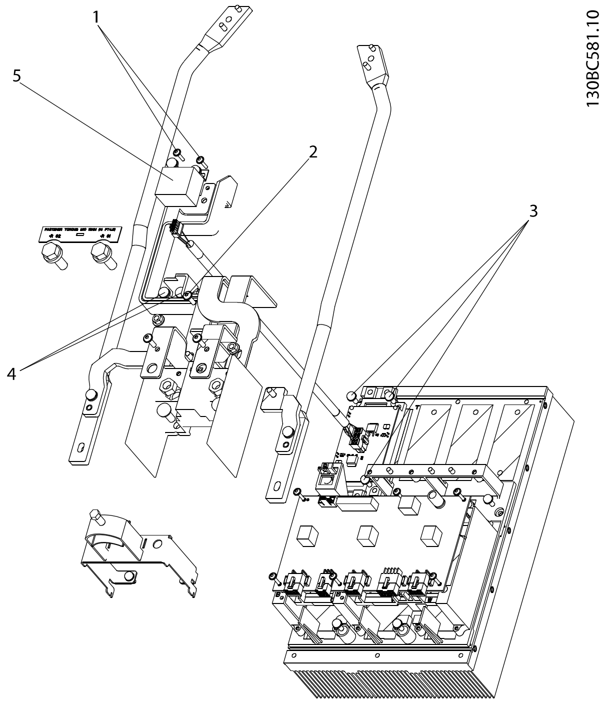
1	SCR input bus bar	9	Snubber capacitor
2	10 mm nut	10	T30 Screw
3	T30 screw	11	Round bus bar support bracket
4	SCR	12	Current sensor cylinder bus bar
5	IGBT output bus bar	13	T30 screw
6	IGBT module (1 of 3)	14	T30 screw
7	IGBT gate signal connector	15	T25 thread-forming screw
8	IGBT thermal sensor connector		

Illustration 7.7 SCRs and IGBTs

1. Remove the SCR input bus bars in accordance with *chapter 7.3.15 SCR Input Bus Bars*.
2. Remove the (+) DC bus bar SCR to DC coil by first removing 1 screw (T30) that attaches the bus bar to the DC inductor.
3. Remove 1 screw (T30) from each SCR module.
4. Remove the Mylar insulator and retain it for reassembly.
5. Remove the (-) DC bus bar SCR to DC coil following the same procedure as with the (+) DC.
6. Disconnect the gate leads, one from each SCR module.
7. Remove 1 screw (T30) from either side of each SCR module.

For reassembly, use the replacement SCR instructions.

7.3.17 Brake IGBT Module



1	T20 thread forming screws	4	T30 screws
2	T25 thread forming screw	5	Snubber capacitor
3	T25 screws		

Illustration 7.8 Brake IGBT module

1. Remove the IGBT gate drive board in accordance with *chapter 7.3.14 IGBT Gate Drive Card*.
2. Remove the mains terminal and motor terminal in accordance with *chapter 7.3.6 Mains Input Terminal Block* and *chapter 7.3.7 Motor Terminal Block*.
3. Remove the 2 brake to DC link bus bars in accordance with *chapter 7.3.12 DC Bus Rails*.
4. Remove 2 thread-forming screws (T20) from the top of the brake IGBT module.
5. Remove the brake snubber capacitor by removing 2 screws (T30), one from each bus bar.
6. Remove 2 screws (T30) from the bottom of the brake IGBT module.
7. Remove 1 thread-forming retaining screw (T25).
8. Remove 4 screws (T25), one from each corner of the IGBT module.

For reassembly, follow the replacement IGBT instructions.

7.3.18 IGBTs

7.3.18.1 400 V AC Power Size (includes 460 V)

1. Remove the gate drive card in accordance with *chapter 7.3.14 IGBT Gate Drive Card*.
2. Remove the SCR input bus bars in accordance with *chapter 7.3.15 SCR Input Bus Bars*.
3. Remove the balance/high frequency card in accordance with *chapter 7.3.11 Balance/High Frequency Card*.
4. Remove the Mylar cover from the capacitor bank.
5. Remove the round bus bar support bracket by removing 3 screws (T30).
6. Remove 1 screw (T25 thread forming) from each IGBT output bus bar, one bus bar per IGBT module.
7. Remove the IGBT output bus bar by removing 2 screws (T30), from each IGBT output bus bar, one bus bar per IGBT module.
8. Remove the IGBT temperature cable by discon-necting the cable from each IGBT module.
9. Remove the gate leads, one from each IGBT module.
10. Remove the snubber capacitor from each IGBT module by removing the 2 screws (T30) mounting the capacitor to the IGBT module.
11. Remove the (-) DC plate by removing:
    - 11a 3 screws (T20 thread forming), next to the IGBT modules
    - 11b 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 3
    - 11c Screws (T25) connecting the plate to the negative terminals of capacitors 4 and 5. Number of T25 screws varies based on the size of the frequency converter
12. Remove the Mylar insulator between the (-) DC plate and the (+) DC and DC centre capacitor plate. The screws connecting the (+) DC and DC centre plates to the capacitors may have to be removed to remove the insulator.
13. Remove the (+) DC plate by removing:
    - 13a 3 screws (T20 thread forming) next to the IGBT modules
    - 13b 1 standoff (8 mm) connecting the plate to the positive terminal of capacitor 2
    - 13c screws (T25) connecting the plate to the positive terminals of capacitors 1 and 6. Number of T25 screws varies based on the size of the frequency converter.
14. Remove the plastic IGBT support (not shown) by removing 4 screws (T25).
15. Remove the IGBTs by removing 4 screws (T25) from each.

For reassembly, use the replacement IGBT instructions.

See *Illustration 7.7*

7.3.18.2 690 V AC Power Size (includes 575 V)

1. Remove the gate drive card in accordance with *chapter 7.3.14 IGBT Gate Drive Card*.
2. Remove the SCR input bus bars in accordance with *chapter 7.3.15 SCR Input Bus Bars*.
3. Remove the balance/high frequency card in accordance with *chapter 7.3.11 Balance/High Frequency Card*.
4. Remove the Mylar cover from the capacitor bank.
5. Remove the round bus bar support bracket by removing 3 screws (T30).
6. Remove 1 screw (T25 thread forming) from each IGBT output bus bar, one bus bar per IGBT module.
7. Remove the IGBT output bus bar by removing 2 screws (T30) from each IGBT output bus bar, one bus bar per IGBT module.
8. Remove the IGBT temperature cable by discon-necting the cable from each IGBT module.
9. Remove the gate leads, one from each IGBT.
10. Remove the snubber capacitor from each IGBT module by removing the 2 screws (T30) mounting the capacitor to the IGBT module.
11. Remove the (-) DC plate by removing:
    - 11a 3 screws (T20 thread forming) next to the IGBT modules
    - 11b 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 1
    - 11c 1 screw (T25) from the negative terminal of capacitor 3
    - 11d 1 round plastic alignment cap.
12. Remove the Mylar insulator between the (-) DC plate and the (+) DC plate. The screws connecting 1 of the 2 DC centre plates to the capacitors may have to be removed to remove the insulator.

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13. Remove the (+) DC plate by removing 3 screws (T20 thread forming) next to the IGBT modules and 2 screws (T25) connecting the plate to the positive terminals of capacitors 5 and 6.
14. Remove the plastic IGBT support (not shown) by removing 4 screws (T25).
15. Remove the IGBTs by removing 4 screws (T25) from each.

For reassembly, use the replacement IGBT instructions.

7.3.19 DC Capacitors

NOTICE

When performing this procedure, always replace the entire capacitor bank, even if only one capacitor has failed.

7

7.3.19.1 400 V AC Power Size (includes 460 V)

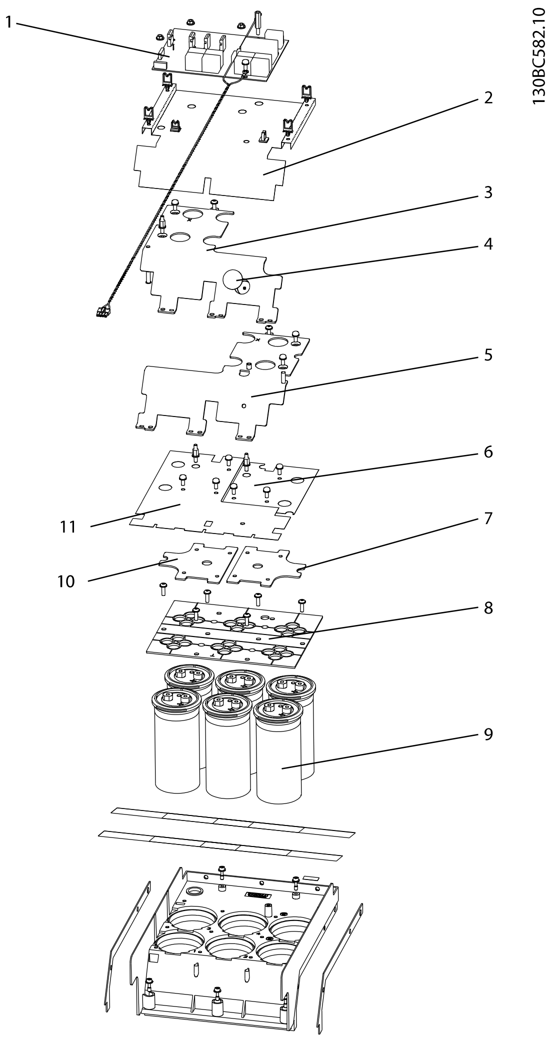
1. Remove the gate drive card in accordance with *chapter 7.3.14 IGBT Gate Drive Card*
2. Remove the balance/high frequency card in accordance with *chapter 7.3.11 Balance/High Frequency Card*.
3. Remove the Mylar cover from the capacitor bank.
4. Remove the round bus bar support bracket by removing 3 screws (T30).
5. Remove 1 screw (T25 thread forming) from each IGBT output bus bar, one bus bar per IGBT module.
6. Remove the IGBT bus bar by removing 2 screws (T30) from each IGBT output bus bar, one bus bar per IGBT module.
7. Remove the snubber capacitor, one from each IGBT module by removing 2 screws (T30).
8. Remove the (-) DC plate by removing:
   - 8a 3 screws (T20 thread forming) next to the IGBT modules
   - 8b 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 3
   - 8c Screws (T25) connecting the plate to the negative terminals of capacitors 4 and 5. Number of T25 screws varies based on the size of the frequency converter.
9. Remove the Mylar insulator between the (-) DC plate and the (+) DC and DC centre plates. The screws connecting the (+) DC and DC centre plates to the capacitor may have to be removed to remove the insulator.
10. Remove the (+) DC plate by removing:
    - 10a 3 screws (T20 thread forming) adjacent to the IGBT modules
    - 10b 1 standoff (8 mm) connecting the plate to the positive terminal of capacitor 2
    - 10c Screws (T25) connecting the plate to the positive terminals of capacitors 1 and 6. Number of T25 screws varies based on the size of the frequency converter.
11. Remove the DC centre capacitor plate by removing 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 1 and the screws (T25) connecting the plate to the remaining capacitors. Number of T25 screws varies based on the size of the frequency converter.
12. Remove the capacitor locking panel by removing 12 screws (T25 thread forming).

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note for reassembly: DC capacitor must fit into the retaining stud at the bottom.

7.3.19.2 690 V AC Power Size (includes 575 V)



1	Balance/High frequency card	7	DC centre plate 1
2	Capacitor bank cover	8	Capacitor locking panel
3	(-) DC plate	9	DC capacitors
4	Plastic alignment cap	10	DC center plate 2
5	(+) DC plate	11	Mylar insulator
6	Mylar insulator		

Illustration 7.9 DC Capacitors, 690 V Example

1. Remove the gate drive card in accordance with *chapter 7.3.14 IGBT Gate Drive Card*
2. Remove the balance/high frequency card in accordance with *chapter 7.3.11 Balance/High Frequency Card*.
3. Remove the Mylar cover from the capacitor bank.
4. Remove the round bus bar support bracket by removing 3 screws (T30).
5. Remove 1 screw (T25 thread forming) from each IGBT output bus bar, one bus bar per IGBT module.
6. Remove the IGBT bus bar by removing 2 screws (T30) from each IGBT output bus bar, one bus bar per IGBT module.
7. Remove the snubber capacitor, one from each IGBT module by removing 2 screws (T30), mounting the capacitor to the IGBT module.
8. Remove the (-) DC plate by removing:
   - 8a 3 screws (T20 thread forming) next to the IGBT modules
   - 8b 1 standoff (8 mm) from the negative terminal of capacitor 1
   - 8c 1 screw (T25) from negative terminal of capacitor 3
   - 8d 1 round plastic alignment cap
9. Remove the Mylar insulator between the (-) DC plate and the (+) DC plate. The screws connecting one of the 2 DC centre plates may have to be removed to remove the insulator.
10. Remove the (+) DC plate by removing 3 screws (T20 thread forming) next to the IGBT modules and 2 screws (T25) connecting the plate to the positive terminals of capacitors 5 and 6.
11. Remove the small Mylar insulator between the (+) DC plate and one of the DC centre plates. The screws connecting one of the 2 DC centre plates may have to be removed to remove the insulator.
12. Remove DC centre plate 1 by removing 1 standoff (8 mm) from the positive terminal of capacitor 4 and 3 screws (T25) from the positive terminal of capacitor 2 and negative terminals of capacitors 5 and 6.
13. Remove DC centre plate 2 by removing 1 standoff (8 mm) from the positive terminal of capacitor 3 and 3 screws (T25) from the positive terminal of capacitor 1 and the negative terminals of capacitors 2 and 4.
14. Remove the capacitor locking panel by removing 6 screws (T25 thread forming).

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note for reassembly: DC capacitor must fit into the retaining stud at the bottom.

7

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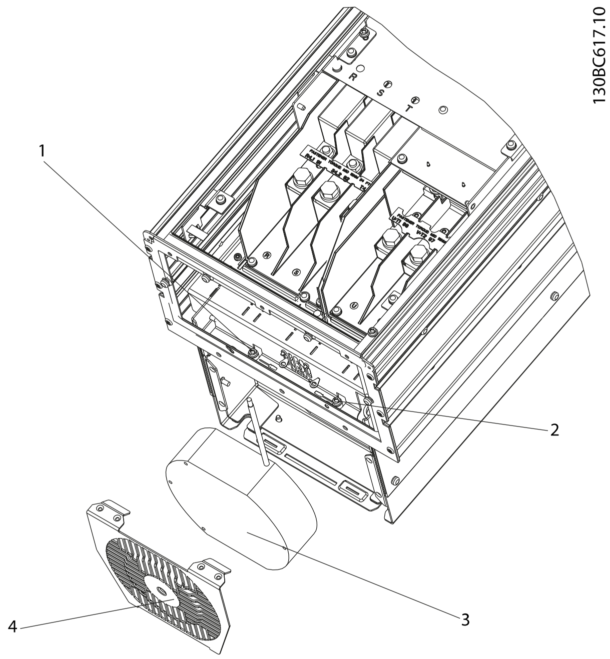
7.3.20 Heatsink Fan



1	Captive screw (T25)	3	Fan
2	Captive screw (T25)	4	Fan cover

Illustration 7.10 Heatsink Fan

1. Remove the fan cover by removing the 2 captive screws (T25).
2. Unplug the fan electrical connector.
3. Remove the fan by pulling it free from the mounting studs.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

If there is an options cabinet connected to the frequency converter, see *chapter 7.5.2 Removing the Heatsink Fan with Options Cabinet Present* for fan removal instructions.

7.3.21 Door Fan: IP21 (NEMA 1) or IP54 (NEMA 12) Enclosures Only

1. Unplug the fan electrical connection.
2. Remove the door fan by removing 4 nuts (7 mm), using an open-ended wrench.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.3.22 Top Fan: (IP20 Enclosures Only)

1. Remove 2 screws (T25).
2. Slide the fan and bracket forward and pull them out.
3. Unplug the inline connector (not shown).

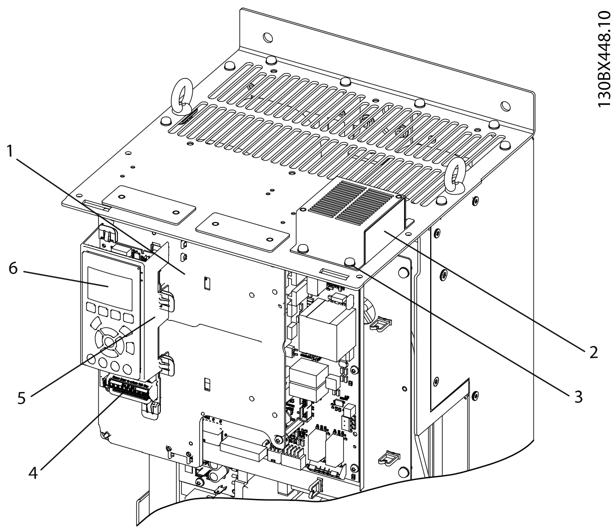
Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4 D2h/D4h Disassembly and Assembly Instructions

7.4.1 General Information

Note that these disassembly instructions are based on the IP20 enclosure. Some details may vary for the IP21 (NEMA 1) IP54 (NEMA 12) enclosure.

7.4.2 Control Card and Control Card Mounting Plate



1	Control card mounting plate	4	Control terminals
2	Top fan	5	LCP cradle
3	T25 screw	6	LCP

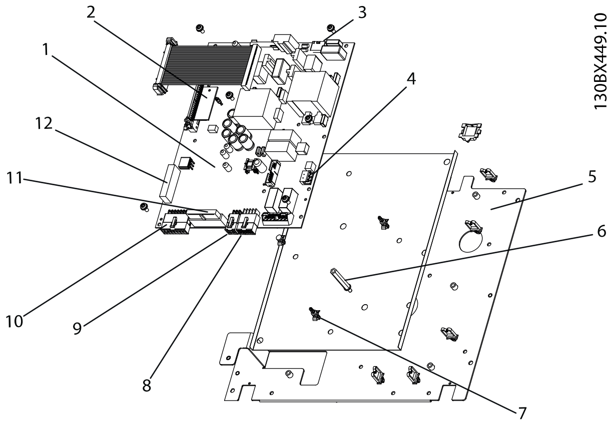
Illustration 7.11 Control Card and Control Card Mounting Plate

1. Open the front panel door or remove the front cover, depending on the enclosure type.
2. Remove the LCP cradle. The LCP cradle can be removed by hand.
3. Remove any customer control wiring from the control card terminal blocks and option cards.
4. Remove the 4 screws (T20) from the corners of the control card mounting plate.

5. Unplug the ribbon cable connecting the control card and the power card.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.3 Power Card Mounting Plate



1	Power card PCA3	7	Plastic standoff
2	Scaling card	8	MK501
3	MK902	9	MK502
4	MK106	10	MK101
5	Power card mounting plate	11	MK103
6	8 mm standoff	12	MK104

Illustration 7.12 Power Card and Power Card Mounting Plate

1. Remove the control card mounting plate in accordance with *chapter 7.4.2 Control Card and Control Card Mounting Plate*.
2. The power card mounting plate can be removed with the power card still attached. If the power card is to be removed, remove it in accordance with *chapter 7.4.4 Power Card*.
3. To remove the power card mounting plate with the power card attached, unplug connectors:
   - 3a MK101
   - 3b MK103
   - 3c MK501
   - 3d MK502
   - 3e MK902
4. If customer connections are present, unplug connectors MK500 and MK106.
5. Remove the 4 screws (T25), one from each corner of the mounting plate.
6. Remove the one screw (T25) from the top center of the mounting plate.

NOTICE

Note that the IP21 (NEMA 1) and IP54 (NEMA 12) versions have a different type and number of fasteners. When installing the power card, ensure that the insulator sheet is installed behind the power card.
Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.4 Power Card

1. Remove the control card mounting plate in accordance with *chapter 7.4.2 Control Card and Control Card Mounting Plate*.
2. Unplug the power card connectors:
   - 2a MK101
   - 2b MK103
   - 2c MK501
   - 2d MK502
   - 2e MK902
3. If customer connections are present, unplug connectors MK500 and MK106.
4. Remove the 5 power card mounting screws (T20).
5. Remove the 2 standoffs (8 mm).
6. Remove the power card from the 3 plastic standoffs.
7. Remove the current scaling card from the power card by pushing in the retaining clips on the standoffs. The scaling card controls signals operating specifically with this frequency converter. The scaling card is not part of the replacement power card.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.
When installing the power card, ensure that the insulator sheet is installed behind the power card.

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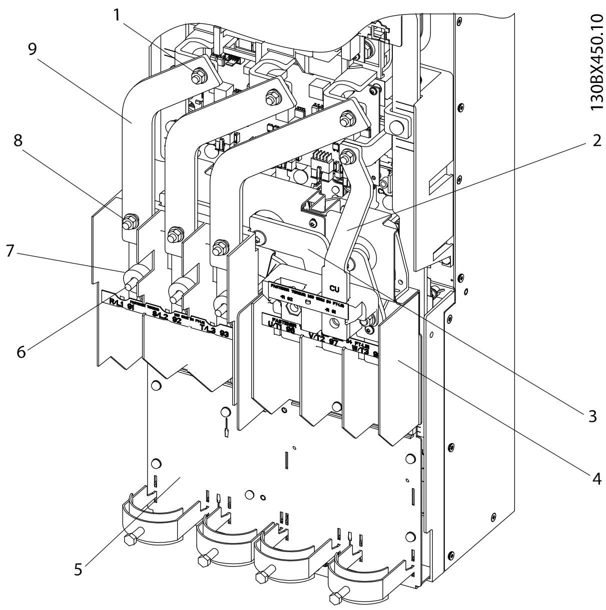
7.4.5 AC Input Bus Bars



1	Top 13 mm nut	6	Mains input terminal
2	Brake bus bar (optional)	7	Fuse spacer
3	Motor terminal bus bar	8	Bottom 13 mm nut
4	Motor terminal block	9	Input power bus bar
5	Power terminal mounting plate		

Illustration 7.13 Power Terminals

1. Remove the air baffle by removing the 4 screws (T25) and 2 nuts (13 mm).
2. The next step differs based on options. See *chapter 7.4.5.1 Mains Fuses Only*, *chapter 7.4.5.2 RFI Only*, *chapter 7.4.5.3 Fuses and RFI*, and *chapter 7.4.5.4 No Options* for more details.

7.4.5.1 Mains Fuses Only

1. Remove mains fuses by removing 6 nuts (13 mm), one at each end of each fuse.
2. Remove 3 nuts (13 mm) at the top of the bus bars. One per phase.
3. Remove the bus bars.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.5.2 RFI Only

1. Remove 3 nuts (13 mm) at the top of the RFI filter, one per bus phase.
2. Remove 6 nuts (13 mm) at the bottom of the RFI filter, two per phase.
3. Remove 4 mounting screws (T20 thread cutting) connecting the RFI filter to the side channels of the frequency converter.
4. Remove the RFI filter and unplug the RFI cable from MK100 on the printed circuit board assembly.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.5.3 Fuses and RFI

1. Remove mains fuses by removing 6 nuts (13 mm), one at each end of each fuse.
2. Remove 3 nuts (13 mm) at the top of the RFI filter, one per phase.
3. Remove 4 mounting screws (T20 thread cutting) connecting the RFI filter to the side channels of the frequency converter.
4. Remove the RFI filter and unplug the RFI cable from MK100 on the printed circuit board assembly.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.5.4 No Options

1. Remove 3 nuts (13 mm) at the top of the bus bars, one per phase.
2. Remove 6 nuts (13 mm) at the bottom of the bus bars, two per phase.
3. Remove the bus bars.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.6 Mains Input Terminal Block

1. Disconnect the customer input power wiring.
2. Remove the AC input bus bars in accordance with *chapter 7.4.5 AC Input Bus Bars*.
3. Remove the 2 screws (T25) at the bottom of the terminal block.
4. Free current sensor wiring from the captive retaining clips (not shown).
5. Remove the terminal by sliding it down to disengage it from the metal clips holding it in place.

Refer to *Illustration 7.13*.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.7 EMC Shield

1. Remove 1 screw (T20).
2. Remove the EMC shield.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.8 Brake Terminal (optional)

1. Disconnect the customer brake wiring.
2. Remove the R(+) terminal by removing 1 screw (T25 thread forming) at the terminal block, and 1 screw (T40).
3. Remove the R(-) terminal by removing 1 screw (T25 thread forming) at the terminal block, and 1 nut (13 mm).
4. Remove the brake terminal block by removing 2 nuts (13 mm).

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

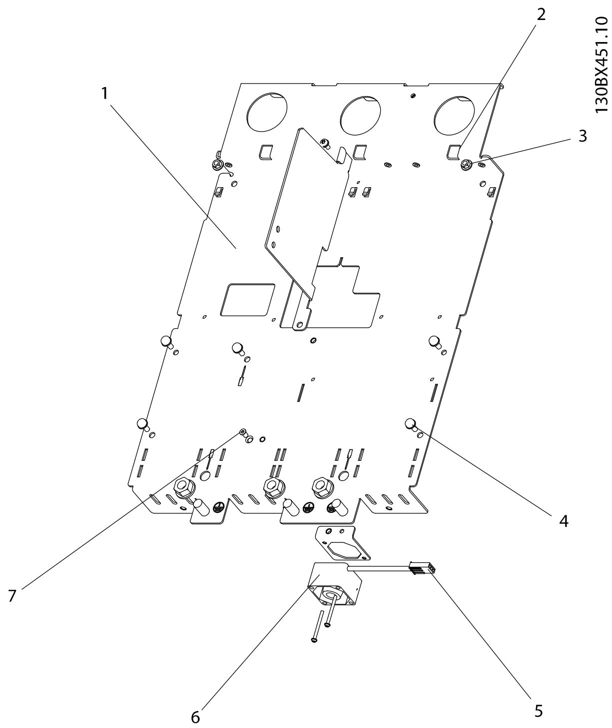
7.4.9 Motor Terminal Block

1. Remove the input terminal block in accordance with *chapter 7.4.6 Mains Input Terminal Block* and the brake terminal (if equipped) in accordance with *chapter 7.4.8 Brake Terminal (optional)*.
2. Disconnect customer motor wiring.
3. Remove the U output bus bar by removing the 1 screw (T25 thread forming) in the centre of the bus bar and the 1 bolt (T40) at the current sensor end.
4. Remove the V output bus bar by removing the 1 screw (T25 thread forming) in the centre of the bus bar and the 1 bolt (T40).
5. Remove the W output bus bar by removing the 1 screw (T25 thread forming) in the centre of the bus bar and the 1 bolt (T40).
6. Remove the 3 current sensor cylinders.
7. Remove the 2 screws (T25) located at the bottom of the terminal block.
8. Remove the terminal by sliding it down to disengage it from the metal clips holding it in place.

Refer to *Illustration 7.13*.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.10 Power Terminal Mounting Plate



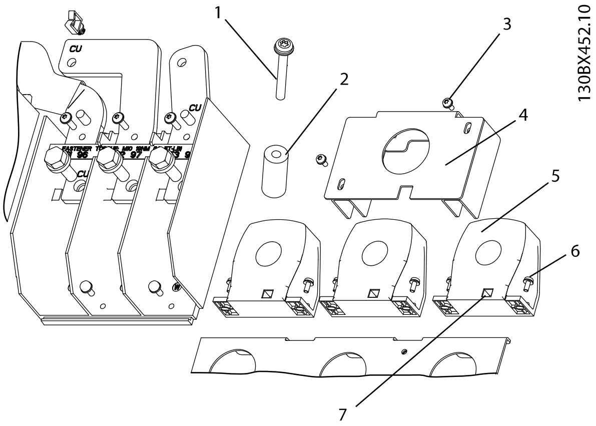
1	Power terminal mounting plate	5	Mixing fan cable
2	Current sensor cable routing	6	Mixing fan
3	8 mm nut	7	Fan retaining screw
4	T25 screw		

Illustration 7.14 Power Terminal Mounting Plate

1. Remove the motor terminal in accordance with *chapter 7.4.9 Motor Terminal Block*.
2. Remove the 5 screws (T25 thread cutting) from the top of the plate. The fan screw may remain in place.
3. Remove two 8 mm nuts.
4. Remove the current sensor (signal) cables.
5. While pulling the plate up, unplug the mixing fan, located under the mounting plate.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.11 Current Sensors



1	Attaching bolt	5	Current sensor
2	Cylinder	6	T20 screw
3	T20 screw	7	Cable connector
4	Current sensor shield		

Illustration 7.15 Current Sensors

1. Remove power terminal mounting plate in accordance with *chapter 7.4.10 Power Terminal Mounting Plate*.
2. Remove the 2 screws (T20) from each of the three current sensors.
3. The center current sensor is covered by a shield. Remove the 2 screws (T20) screws to take it off.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note for reassembly: For the current sensor to face in the proper direction, point the signal wire plug outward.

7.4.12 Mixing Fan

1. Remove the power terminal mounting plate in accordance with *chapter 7.4.10 Power Terminal Mounting Plate*.
2. Remove the 2 screws (T25) to detach the fan from the power terminal mounting plate.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.13 Balance/High Frequency Card

7.4.13.1 400 V AC Power Size (includes 460 V)

1. Remove the power terminal mounting plate in accordance with *chapter 7.4.10 Power Terminal Mounting Plate*.
2. Unplug the cable MK 100 on the balance/high frequency card.
3. Remove the 1 standoff (8 mm) from the corner of the card.
4. Remove 3 nuts (8 mm).

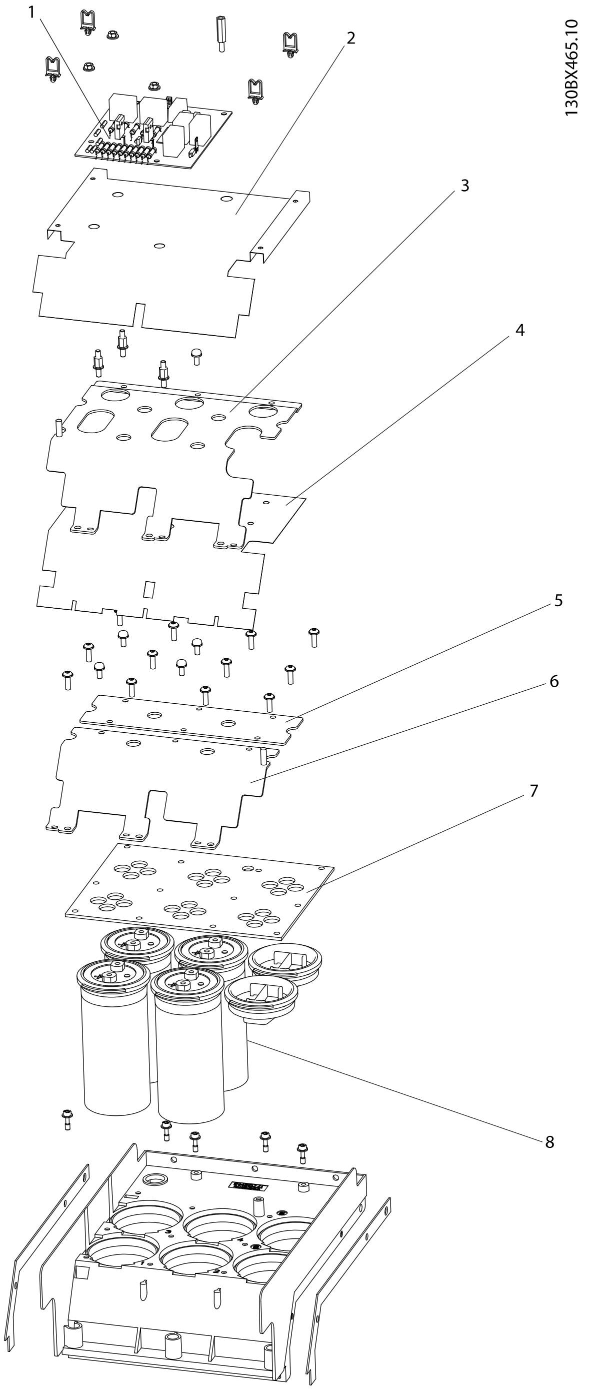
NOTICE

Two of the nuts also hold in place the (+) DC and (-) DC wire harness.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note the wire cable connections on the (+) UDC and (-) UDC terminals.



1	Balance/High frequency card	5	DC centre capacitor plate
2	Capacitor bank cover	6	(+) DC capacitor plate
3	(-) DC capacitor plate	7	Capacitor locking panel
4	Mylar insulator	8	DC capacitor

Illustration 7.16 Balance/High Frequency Card and DC Capacitor Bank
400 V unit shown, 690 V units are slightly different.

7.4.13.2 690 V AC Power Size (includes 575 V)

1. Remove the power terminal mounting plate in accordance with *chapter 7.4.10 Power Terminal Mounting Plate*.
2. Unplug the cable MK 100 on the balance/high frequency card.
3. Remove the 1 standoff (8 mm) from the corner of the card.
4. Remove 3 nuts (8 mm).
5. Remove 1 screw (T20).

NOTICE

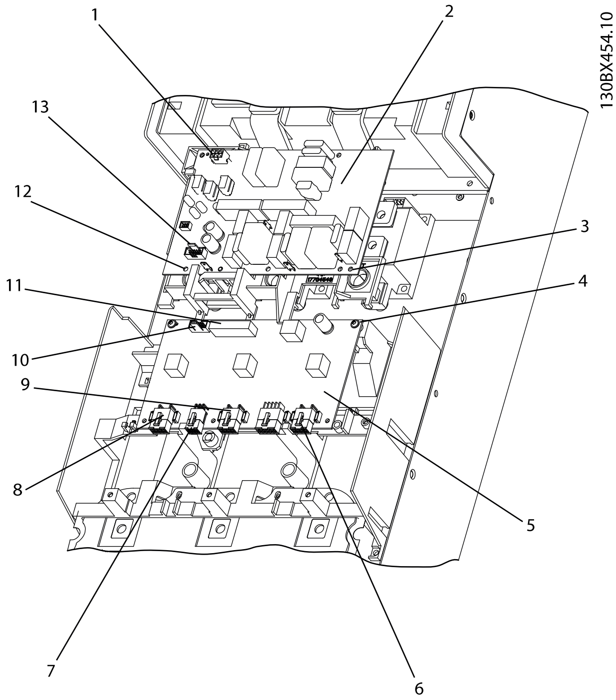
The screw and one of the nuts also hold in place the (+) DC and (-) DC wire harness.
Reinstall in reverse order of` this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note the wire cable connections on the (+) UDC and (-) UDC terminals.

7

7.4.14 IGBT Gate Drive Card



1	MK1802	8	MK501
2	Inrush card	9	MK601
3	T20 screw	10	MK102
4	T20 screw	11	MK101
5	Gate drive card	12	T20 screw
6	MK701	13	MK1800
7	MK100		

Illustration 7.17 IGBT Gate Drive Card

1. Remove the AC input bus bars or RFI option (not shown) in accordance with the procedure.
2. (Brake option only) Unplug MK201.
3. Unplug connections:
   - 3a MK100
   - 3b MK501
   - 3c MK601
   - 3d MK701
   - 3e MK102
4. Remove 6 screws (T20 thread forming).

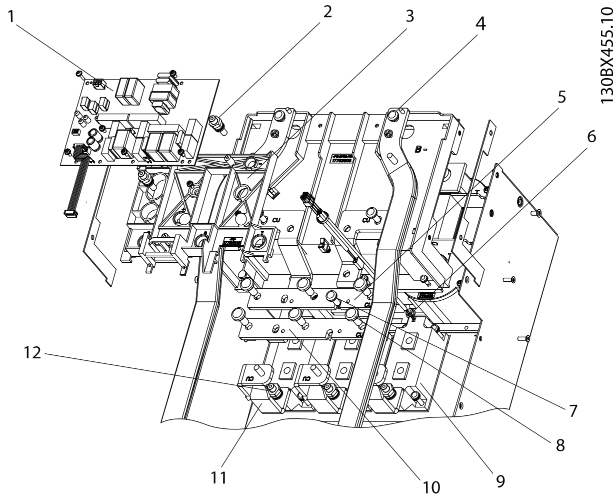
Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.15 Inrush Card

1. Remove the power card mounting plate in accordance with *chapter 7.4.3 Power Card Mounting Plate*.
2. Unplug MK1802.
3. Remove 2 screws (T20 thread forming).
4. Remove 5 screws (T20).

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.16 SCR Input Bus Bars



1	Inrush card	7	T30 screw
2	16 mm standoff	8	T50 screw
3	Inrush support bracket	9	SCR
4	T40 screw	10	(+) DC bus bar
5	(-) DC bus bar	11	SCR input bus bar
6	Gate lead	12	19 mm standoff

Illustration 7.18 SCRs and SCR Input Bus Bars

1. Remove the inrush card in accordance with *chapter 7.4.15 Inrush Card*.
2. Remove 2 screws (T20) from the middle of the inrush card mounting bracket.
3. Remove 2 standoffs (16 mm) from the inrush card mounting bracket.
4. Remove 3 standoffs (19 mm) connecting the bus bars to the SCR modules, one for each SCR input bus bar.
5. Remove the bus bars.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

Note for reassembly: Fasten all components hand-tight and then place the inrush support to align all before tightening the fasteners.

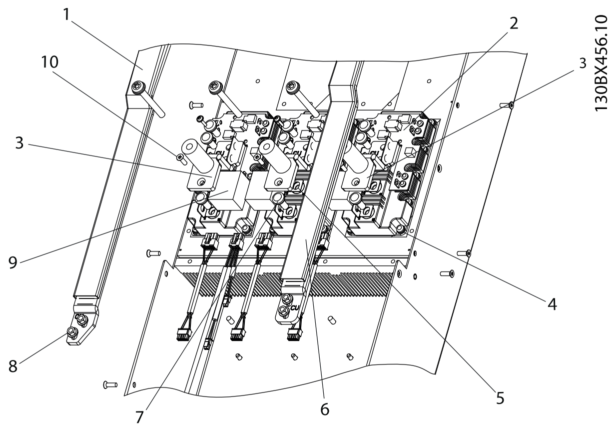
7.4.17 SCRs

1. Remove the SCR input bus bars in accordance with *chapter 7.4.16 SCR Input Bus Bars*.
2. Remove the (+) DC bus bar by removing the 3 screws (T50), one from each SCR module.
3. Remove the (-) DC bus bar by removing the 1 screw (T30) and 3 screws (T50) one from each SCR modle.
4. Disconnect the gate leads, one from each SCR module.
5. Remove 1 screw (T30) from each of the four corners of each SCR module.

For reassembly, follow the replacement SCR instructions.

7.4.18 DC Bus Rails

7.4.18.1 Without Optional Brake



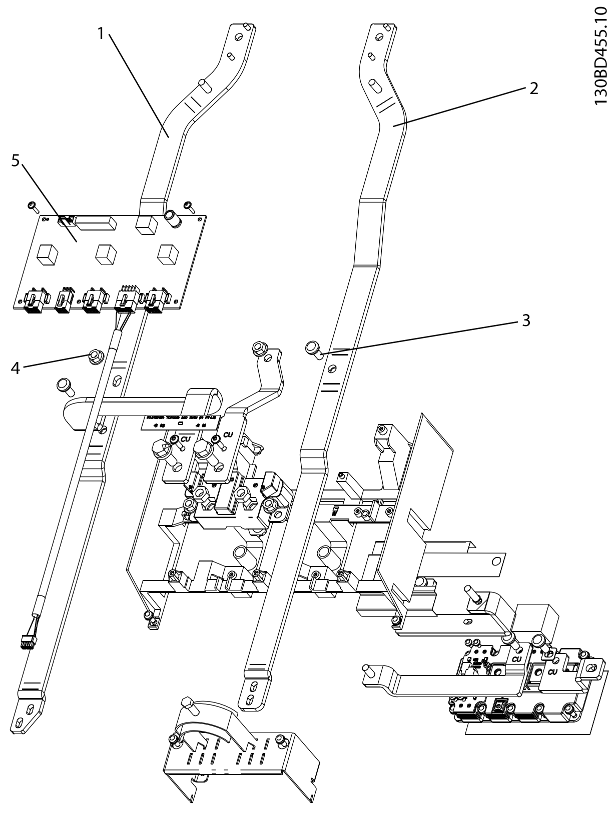
1	(+) DC bus rail	6	(-) DC bus rail
2	IGBT module	7	T40 IGBT terminal screw
3	IGBT output bus bar	8	10 mm nut
4	T25 IGBT mounting screw	9	Snubber capacitor
5	T40 IGBT terminal screw	10	T20 screw

Illustration 7.19 DC bus rails without brake option

1. Remove the power card mounting plate in accordance with *chapter 7.4.3 Power Card Mounting Plate*.
2. Remove the power terminal mounting plate in accordance with *chapter 7.4.10 Power Terminal Mounting Plate*.
3. Remove the 2 screws (T40) at the top end of the bus bar, one per bus bar.
4. From the other end of the bus bar, remove the 4 nuts (10 mm), two per bus bar.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.18.2 With Optional Brake



1	(+) DC bus rail
2	(-) DC bus rail
3	T40 screw
4	13 mm nut
5	IGBT gate drive card

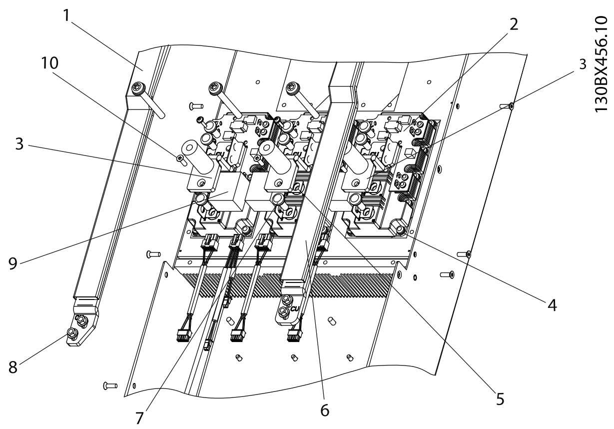
Illustration 7.20 DC bus rails with brake option

1. Remove the power card mounting plate in accordance with *chapter 7.4.3 Power Card Mounting Plate*.
2. Remove the power terminal mounting plate in accordance with *chapter 7.4.10 Power Terminal Mounting Plate*.
3. Remove the 2 screws (T40) at the top end of the bus bar, one per bus bar.

4. From the other end of the bus bar, remove the 4 nuts (10 mm), two per bus bar.
5. Remove 1 nut (13 mm) on the (+) DC bus rail, near the center.
6. Remove 1 screw (T40) from the (-) DC bus rail, near the center.
7. Remove the IGBT gate drive card in accordance with *chapter 7.4.14 IGBT Gate Drive Card*.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.19 IGBTs



1	(+) DC bus rail	6	(-) DC bus bar
2	IGBT	7	T40 IGBT terminal screw
3	IGBT output bus bar	8	10 mm nut
4	T25 IGBT mounting screw	9	Snubber capacitor
5	T40 IGBT terminal screw	10	T20 screw

Illustration 7.21 IGBTs

7.4.19.1 400 V AC Power Size (includes 460 V)

1. Remove the gate drive card in accordance with *chapter 7.4.14 IGBT Gate Drive Card*.
2. Remove the balance/high frequency card in accordance with *chapter 7.4.13 Balance/High Frequency Card*.
3. Remove the DC bus rails in accordance with *chapter 7.4.18 DC Bus Rails*.
4. Remove the Mylar cover from the capacitor bank.
5. Remove the 1 screw (T20 thread forming) from each IGBT output bus bar.
6. Remove the IGBT output bus bar by removing 2 screws (T40) connecting the bus bar to the IGBT module.
7. Remove the IGBT temperature cable by disconnecting the cable from each IGBT module.
8. Remove the gate leads, one from each IGBT.
9. Remove the snubber capacitor from each IGBT module by removing 2 screws (T40).
10. Remove the (+)DC plate by removing 1 standoff (8 mm) connecting the plate to the positive terminal of capacitor 3, and screws (T25) connecting the plate to the positive terminals of capacitors 1, 2, 4, 9, and 12. Number of T25 screws varies based on the size of the frequency converter.
11. Remove the insulator between the (+)DC Plate and the (-)DC Plate. The screws connecting the (-)DC plate and the DC centre plate to the capacitors may have to be removed to remove the insulator.
12. Remove the (-)DC plate by removing 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 6, and screws (T25) connecting the plate to the negative terminals of capacitors 5, 7, 8, 10, and 11. Number of T25 screws varies based on the size of the frequency converter.
13. Remove the plastic IGBT support (not shown) by removing 7 screws (T25), and removing the IGBT modules from beneath the support.
14. Remove the IGBTs by removing 10 screws (T25) from each IGBT module.

For reassembly, use the replacement IGBT instructions.

7.4.19.2 690 V AC Power Size (includes 575 V)

1. Remove the gate drive card in accordance with *chapter 7.4.14 IGBT Gate Drive Card*.
2. Remove the balance/high frequency card in accordance with *chapter 7.4.13 Balance/High Frequency Card*.
3. Remove the DC bus rails in accordance with *chapter 7.4.18 DC Bus Rails*.
4. Remove the Mylar cover from the capacitor bank.
5. Remove the 1 screw (T20 thread forming) from each IGBT output bus bar.
6. Remove the IGBT output bus bar by removing 2 screws (T40) connecting the bus bar to the IGBT module.

7. Remove the IGBT temperature cable by disconnecting the cable from each IGBT module.
8. Remove the gate leads, one from each IGBT.
9. Remove the snubber capacitor from each IGBT module by removing 2 screws (T40).
10. Remove the (+)DC plate by removing 2 screws (T20 thread forming), and screws (T25) connecting the plate to the positive terminals of capacitors 4, 8, 10, and 12. Number of T25 screws varies based on the size of the frequency converter.
11. Remove the Mylar insulator between the (+)DC plate and the (-)DC plate. The screws connecting (-)DC Plate and the two DC centre plates to the capacitors may have to be removed to remove the insulator.
12. Remove the (-)DC plate by removing 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 2, and screws (T25) connecting the plate to the negative terminals of capacitors 1, 5 and 6. Number of T25 screws varies based on the size of the frequency converter.
13. Remove the plastic IGBT support (not shown) by removing 7 screws (T25), and removing the IGBT modules from beneath the support.
14. Remove the IGBTs by removing 10 screws (T25) from each IGBT module.

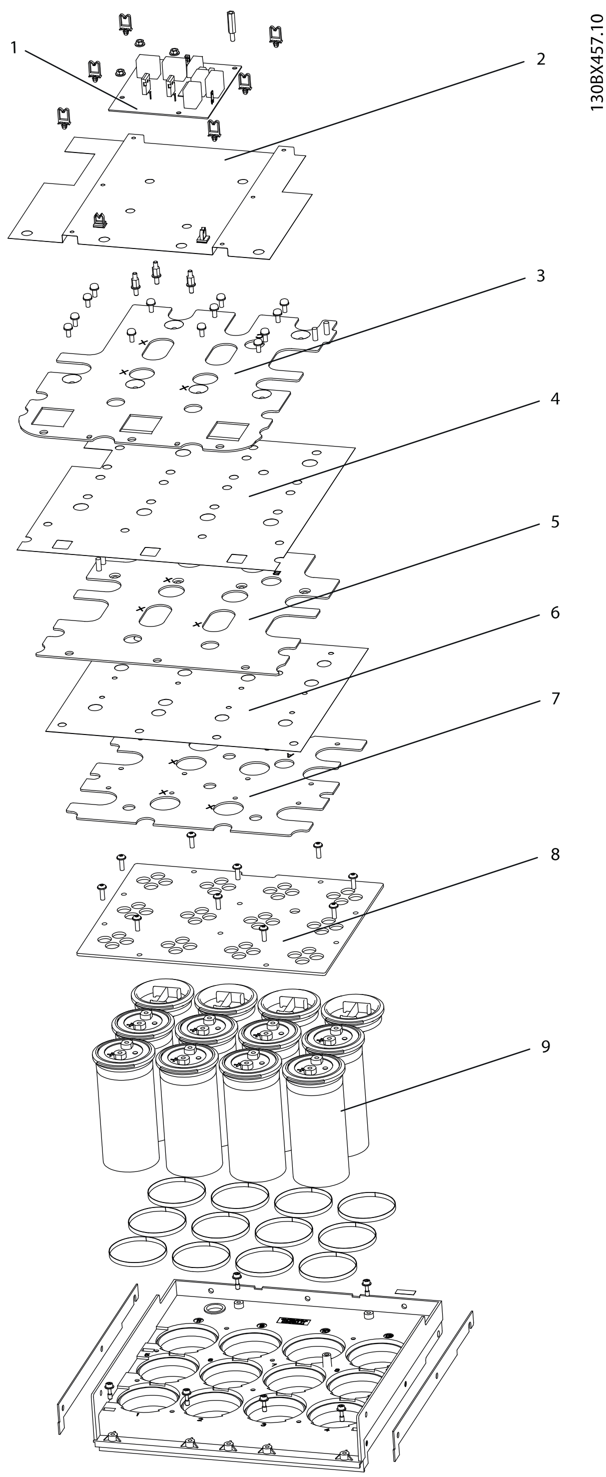
For reassembly, use the replacement IGBT instructions.

7.4.20 DC Capacitors

7.4.20.1 400 V AC Power Size (includes 460 V)

NOTICE

When performing this procedure, always replace the entire capacitor bank, even if only one capacitor has failed.



1	Balance/High frequency card	6	Mylar insulator
2	Capacitor bank cover	7	DC centre capacitor plate
3	(+) DC plate	8	Capacitor locking plate
4	Mylar insulator	9	DC capacitor
5	(-) DC plate		

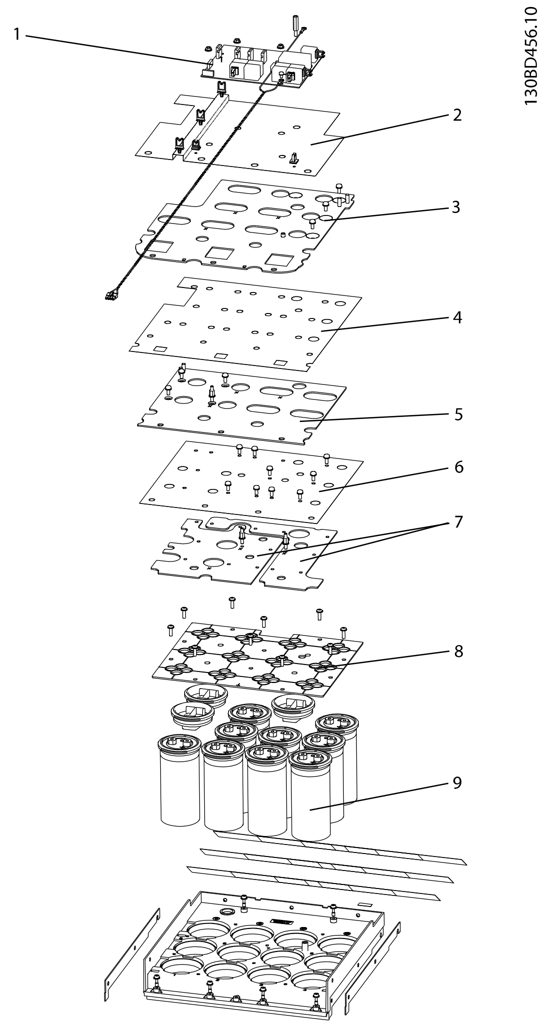
Illustration 7.22 DC Capacitors for 400 V AC units

7

1. Remove the gate drive card in accordance with *chapter 7.4.14 IGBT Gate Drive Card*.
2. Remove the balance/high frequency card in accordance with *chapter 7.4.13 Balance/High Frequency Card*.
3. Remove the DC bus rails in accordance with *chapter 7.4.18 DC Bus Rails*.
4. Remove the Mylar cover from the capacitor bank.
5. Remove the IGBT output bus bars by removing 3 screws (T20 thread forming), one per bus bar, and 6 screws (T40), two per bus bar.
6. Remove the snubber capacitors, one from each IGBT module, by removing 2 screws (T40).
7. Remove the (+)DC plate by removing 1 standoff (8 mm) connecting the plate to the positive terminal of capacitor 3, and screws (T25) connecting the plate to the positive terminals of capacitors 1, 2, 4, 9, and 12. Number of T25 screws varies based on the size of the frequency converter.
8. Remove the insulator between the (+)DC plate and the (-)DC plate. The screws connecting (-)DC plate and the DC centre plate to the capacitors may have to be removed to remove the insulator.
9. Remove the (-)DC plate by removing 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 6, and screws (T25) connecting the plate to the negative terminals of capacitors 5, 7, 8, 10, and 11. Number of T25 screws varies based on the size of the frequency converter.
10. Remove the Mylar insulator between the (-)DC plate and the DC centre plate. The screws connecting the DC centre plate to the capacitors may have to be removed to remove the insulator.
11. Remove the DC centre plate by removing:
    - 11a 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 2
    - 11b Screws (T25) connecting the plate to the negative terminal of capacitors 1, 3, 4, 9 and 12
    - 11c Screws (T25) connecting the plate to the positive terminal of capacitors 5, 6, 7, 8, 10 and 11. Number of T25 screws varies based on the size of the frequency converter.
12. Remove the capacitor locking panel by removing the 10 screws (T25 thread forming).

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.20.2 690 V AC Power Size (includes 575 V)



1	Balance/High frequency card	6	Mylar insulator
2	Capacitor bank cover	7	DC centre plates
3	(+) DC plate	8	Capacitor locking panel
4	Mylar Insulator	9	DC capacitors
5	(-) DC plate		

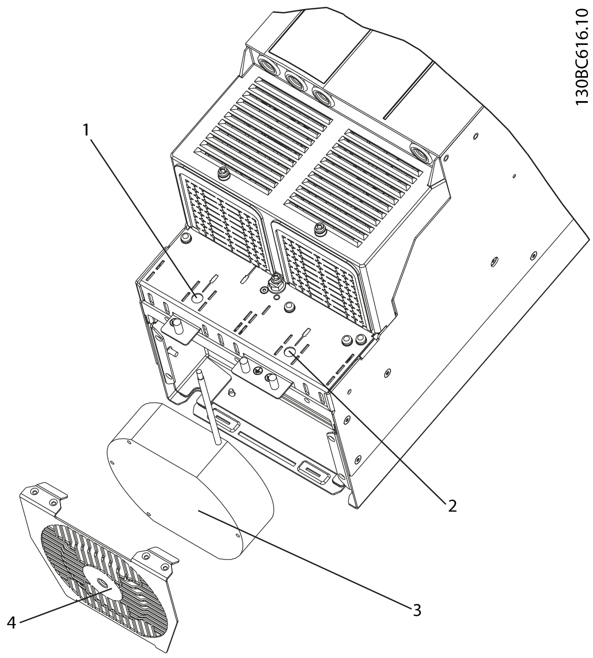
Illustration 7.23 DC Capacitors for 690 V AC units

1. Remove the gate drive card in accordance with *chapter 7.4.14 IGBT Gate Drive Card*.
2. Remove the balance/high frequency card in accordance with *chapter 7.4.13 Balance/High Frequency Card*.
3. Remove the DC bus rails in accordance with *chapter 7.4.18 DC Bus Rails*.
4. Remove the Mylar cover from the capacitor bank.

5. Remove the IGBT output bus bars by removing 3 screws (T20 thread forming), one per bus bar, and 6 screws (T40), two per bus bar.
6. Remove the snubber capacitors, one from each IGBT module, by removing 2 screws (T40).
7. Remove the (+)DC plate by removing 2 screws (T20 thread forming), and screws (T25) connecting the plate to the positive terminals of capacitors 4, 8, 10, and 12. Number of T25 screws varies based on the size of the frequency converter.
8. Remove the Mylar insulator between the (+)DC plate and the (-)DC plate. The screws connecting (-)DC plate and the two DC centre plates to the capacitors may have to be removed to remove the insulator.
9. Remove the (-)DC plate by removing 1 standoff (8 mm) connecting the plate to the negative terminal of capacitor 2, and screws (T25) connecting the plate to the negative terminals of capacitors 1, 5 and 6. Number of T25 screws varies based on the size of the frequency converter.
10. Remove the Mylar insulator between the (-)DC plate and the two DC centre plates. The screws connecting the two DC centre plates to the capacitors may have to be removed to remove the insulator.
11. Remove DC centre plate 1 by removing:
    - 11a 1 standoff (8 mm) connecting the plate to the positive terminal of capacitor 7
    - 11b Screws (T25) connecting the plate to the negative terminal of capacitors 4, 8, 10 and 12
    - 11c Screws (T25) connecting the plate to the positive terminals of capacitors 3, 9 and 11. Number of T25 screws varies based on the size of the frequency converter
12. Remove DC centre plate 2 by removing:
    - 1 standoff (8 mm) connecting the plate to the positive terminal of capacitor 6
    - Screws (T25) connecting the plate to the negative terminal of capacitors 3, 7, 9 and 11
    - Screws (T25) connecting the plate to the positive terminals of capacitors 1, 2 and 5. Number of T25 screws varies based on the size of the frequency converte
13. Remove the capacitor locking panel by removing 10 screws (T25 thread forming).

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.21 Heatsink Fan



1	Captive screw (T25)	3	Fan
2	Captive screw (T25)	4	Fan cover

Illustration 7.24 Heatsink Fan

1. Remove the fan cover by removing the 2 captive screws (T25).
2. Unplug the fan electrical connector.
3. Remove the fan by pulling it free from the mounting studs.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

NOTICE

If there is an options cabinet connected to the frequency converter, see *chapter 7.6.2 Replacing the Heatsink Fan with Options Cabinet Present* for fan removal instructions.

7.4.22 Door Fan: IP21 (NEMA 1) or IP54 (NEMA 12) Enclosures Only

1. Unplug the fan electrical connection.
2. Remove the door fan by removing 4 nuts (7 mm), using an open-ended wrench.

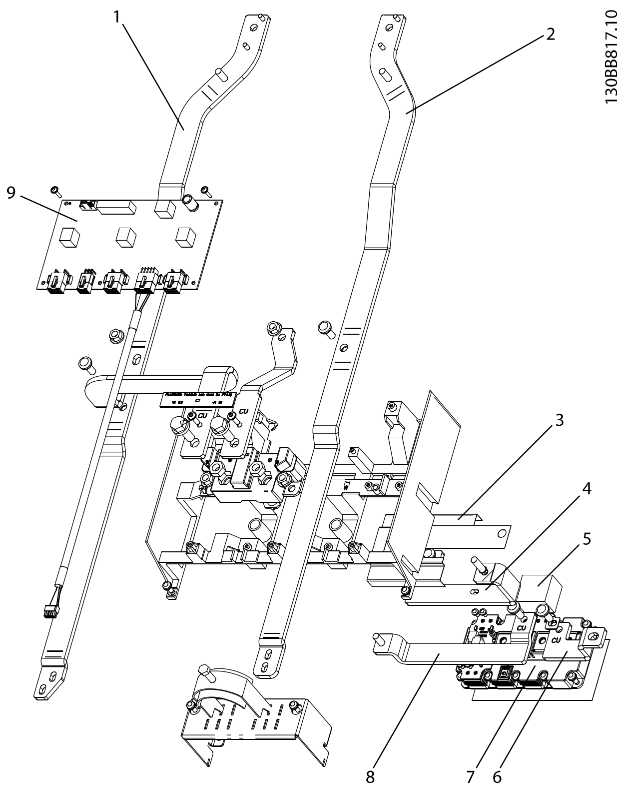
Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.23 Top Fan (IP20 Enclosures only)

1. Remove 2 screws (T25).
2. Slide the fan and bracket forward and pull them out.
3. Unplug the inline connector (not shown).

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.4.24 Brake IGBT Module



1	(+) DC bus rail	6	(-) DC to brake IGBT
2	(-) DC bus rail	7	Brake IGBT
3	Mylar shield	8	(+) DC to brake IGBT
4	Brake IGBT output to R(-) terminal	9	IGBT gate drive card
5	Snubber capacitor		

Illustration 7.25 Brake IGBT Module

1. Remove the IGBT gate drive card in accordance with *chapter 7.4.14 IGBT Gate Drive Card*.
2. Remove the DC bus rails in accordance with *chapter 7.4.18 DC Bus Rails*.
3. Remove the snubber capacitor and 3 bus bars from the brake IGBT by removing 3 screws (T40)
4. Remove the Mylar shield by removing 2 plastic standoffs.
5. Remove the SCR input bus bars in accordance with *chapter 7.4.16 SCR Input Bus Bars*.
6. Remove the brake IGBT by removing 10 screws (T25).

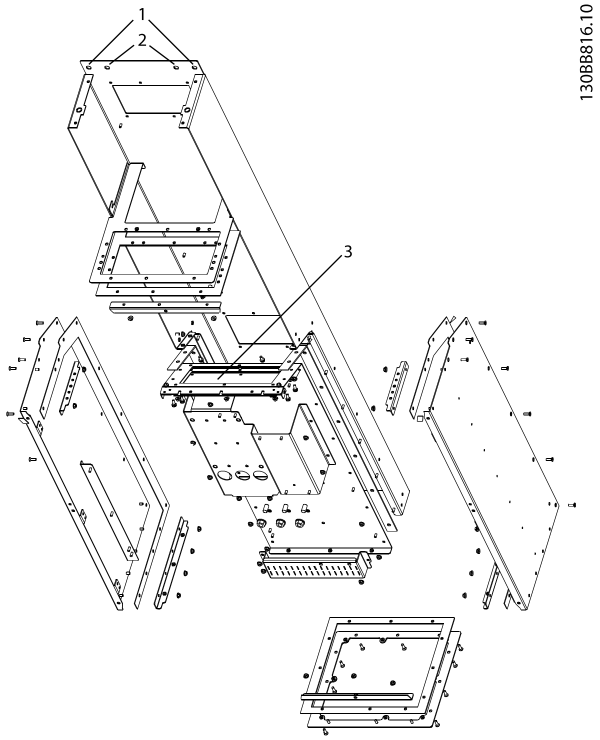
For reassembly, use the replacement IGBT instructions.

7.5 D6h Disassembly and Assembly Instructions

7.5.1 Overview

The D8h is a D2h frequency converter with a larger options cabinet. The unit profiled here includes a contactor, disconnect and brake option, and is 690 V power range. Some of the procedures here are applicable to all options configurations but some may have slight variations depending on the size of the unit, options cabinet, and the selected options.

7.5.2 Removing the Heatsink Fan with Options Cabinet Present



1	Options cabinet to wall fastener
2	Options cabinet to frequency converter fastener
3	Heatsink fan access panel

Illustration 7.26 Options Cabinet, Exploded View

1. Remove the air baffle covering the interior components.
2. Remove the EMC shield by removing 2 screws (T25).
3. Remove the jumper bus bars between the main enclosure and the options cabinet by removing 2 nuts (8 mm) at the bottom of the bus bars, one per bus bar.
4. Remove 2 screws (17 mm) from the top of the brake bus bars, one per bus bar.
5. Remove the 3 motor output jumper bus bars between the main enclosure and the options cabinet by removing 3 nuts (13 mm) at the bottom of the bus bar, one per bus bar.
6. Remove 3 screws (17 mm) at the top of the bus bar, one per bus bar.
7. Remove the input jumper bus bars between the main enclosure and the options cabinet by removing 3 screws (17 mm) from the top of the bus bars, one per bus bar.
8. Remove 3 nuts (13 mm) from the bottom of the input bus bars, one per bus bar.
9. Remove the fan access panel by removing 6 nuts (8 mm) from the bottom of the panel.
10. Remove the heatsink fan in accordance with *chapter 7.3.20 Heatsink Fan*.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.5.3 Removing the Frequency Converter from the Options Cabinet

NOTICE

When removing the fasteners from the top flange, remove only the center two, which hold the frequency converter and options cabinet together. The outer fasteners continue to support the options cabinet after the frequency converter has been removed.

1. Remove the input, output and brake (if present) bus bars in accordance with *chapter 7.5.2 Removing the Heatsink Fan with Options Cabinet Present*.
2. Remove the ground tie plate by removing 3 nuts (13 mm) at the top of the plate inside the main enclosure, and 3 nuts (8 mm) at the bottom of the plate inside the option cabinet.
3. Remove 5 nuts (8 mm) inside the option cabinet on the bottom of the three brackets between the option cabinet and the main enclosure.
4. Remove 2 connector plates from the top of the frequency converter.
5. Lift the frequency converter away from the options cabinet.

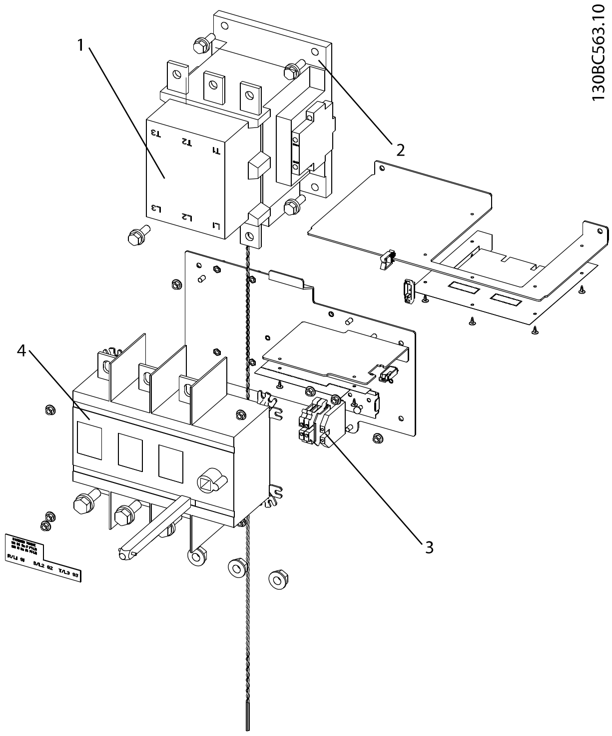
NOTICE

The frequency converter is heavy. Removing it from the options cabinet is a two-person maneuver.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.
See *Illustration 7.26*.

7

7.5.4 Contactor



1	Contactor	2	Contactor Bracket
3	A1/A2 terminals	4	Disconnect

Illustration 7.27 D6h Contactor and Disconnect

1. Remove the input bus bars in accordance with *chapter 7.5.2 Removing the Heatsink Fan with Options Cabinet Present*.
2. Remove fuses by removing 3 nuts (13 mm)
3. Remove the contactor coil wires from terminals A1 and A2.
4. Remove the contactor by removing 4 bolts (13 mm) attaching the contactor to the contactor bracket.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.5.5 Disconnect

1. Remove the fuses in accordance with *chapter 7.5.4 Contactor*.
2. Remove the air baffle by removing 2 nuts (8 mm).
3. Remove the 4 nuts (8 mm), one from each corner to remove the disconnect.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.
See *Illustration 7.27*.

7.6 D8h Disassembly and Assembly Instructions

7.6.1 Overview

The D8h is a D2h frequency converter with a larger options cabinet. The unit profiled here includes a contactor, disconnect and brake option, and is 690 V power range. Some of the procedures here are applicable to all options configurations but some may have slight variations depending on the size of the unit, options cabinet, and the selected options.

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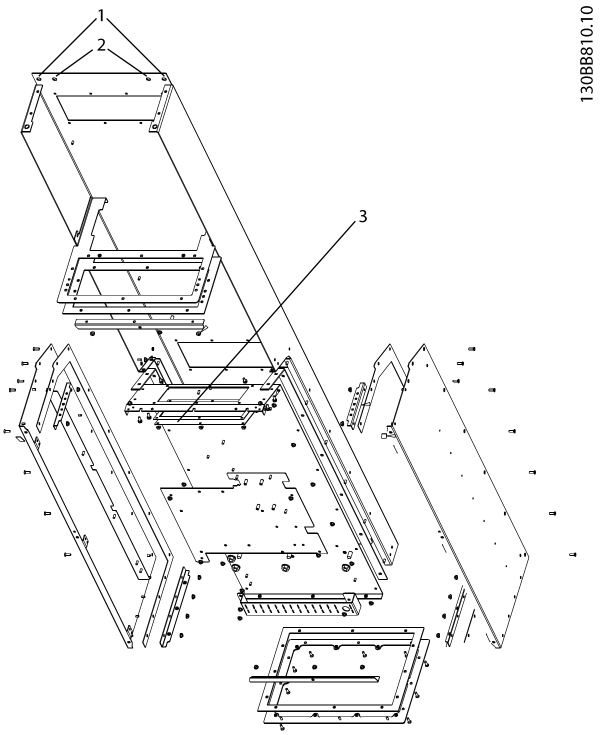
7.6.2 Replacing the Heatsink Fan with Options Cabinet Present



1	Options cabinet to wall fastener
2	Options cabinet to frequency converter fastener
3	Heantsink fan access panel

Illustration 7.28 D8h Options Cabinet, Exploded View

1. Remove the air baffle covering the interior components.
2. Remove the EMC shield by removing 2 screws (T25).
3. Remove the brake jumper bus bars between the main enclosure and the options cabinet by removing 2 nuts (8 mm) that attach the bus bars to the standoffs, one per bus bar.
4. Remove 2 nuts (17 mm) from the bottom end of the bus bars, one per bus bar.
5. Remove 2 screws (17 mm) from the top end of the bus bars, one per bus bar.
6. Remove the 3 output jumper bus bars between the main enclosure and the options cabinet by removing 3 screws (17 mm) from the top of the bus bars, one per bus bar.
7. Remove 3 nuts (17 mm) at the bottom of the bus bars, one per bus bar.
8. Remove the input jumper bus bars between the main enclosure and the options cabinet by removing 3 screws (17 mm) from the tops of the bus bars, one per bus bar.
9. Remove 3 screws (17 mm) from the bottom of the input bus bars, one per bus bar.
10. Remove the fan access panel by removing 6 nuts (8 mm) from the bottom of the panel.
11. Remove the fan in accordance with *chapter 7.4.21 Heatsink Fan*.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.6.3 Removing the Frequency Converter from the Options Cabinet

NOTICE

When removing the fasteners from the top flange, remove only the center two, which hold the frequency converter and options cabinet together. The outer fasteners continue to support the options cabinet after the frequency converter has been removed.

1. Remove the input, output and brake (if present) bus bars in accordance with *chapter 7.6.2 Replacing the Heatsink Fan with Options Cabinet Present*
2. Remove the ground bracket by removing 2 nuts (17 mm) from the ground studs on the left side of the plate, 1 screw (T25) from the center, and 2 nuts (8 mm) from the bottom.
3. Remove 6 nuts (8 mm) inside the option cabinet on the bottom of the three brackets between the option cabinet and the main enclosure.
4. Remove 2 connector plates on the top of the frequency converter by removing 8 screws (T25), 4 from each plate.
5. Lift the frequency converter away from the options cabinet.

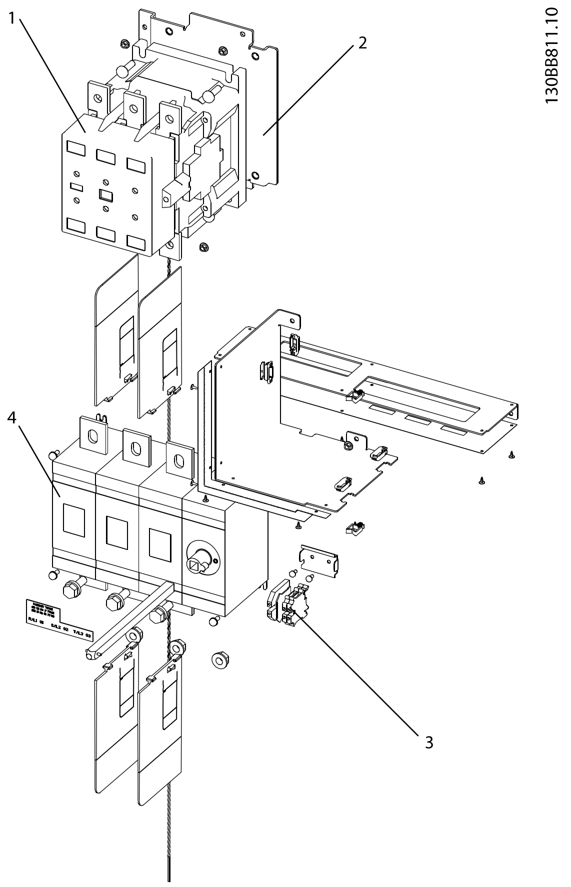
NOTICE

The frequency converter is heavy. Removing it from the options cabinet is a two-person maneuver.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.
See *Illustration 7.28*.

7

7.6.4 Contactor



1	Contactor	2	Contactor bracket
3	A1/A2 Terminals	4	Disconnect

Illustration 7.29 Contactor and Disconnect

1. Remove the input bus bars in accordance with *chapter 7.6.2 Replacing the Heatsink Fan with Options Cabinet Present*
2. Remove the fuses (not shown) by removing 3 nuts (17 mm) from above the fuses and 3 screws (17 mm) from below the fuses.
3. Remove the contactor to fuse bus bars by removing 3 nuts (17 mm).
4. Remove the contactor coil wires from terminals A1 and A2.
5. Remove 4 bolts (13 mm) from the contactor bracket and lift the contactor out.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*.

7.6.5 Disconnect

1. Remove the fuses in accordance with *chapter 7.6.4 Contactor*.
2. Remove 4 screws (T25), one from each corner of the disconnect.
3. Remove the disconnect by pulling it downward and out of the cabinet.

Reinstall in reverse order of this procedure and tighten hardware according to *chapter 1.7 General Torque Tightening Values*
See *Illustration 7.29*.

7.7 Heatsink Access Panel

7.7.1 Removing the Heatsink Access Panel

The frequency converter has an optional access panel for accessing the heatsink.

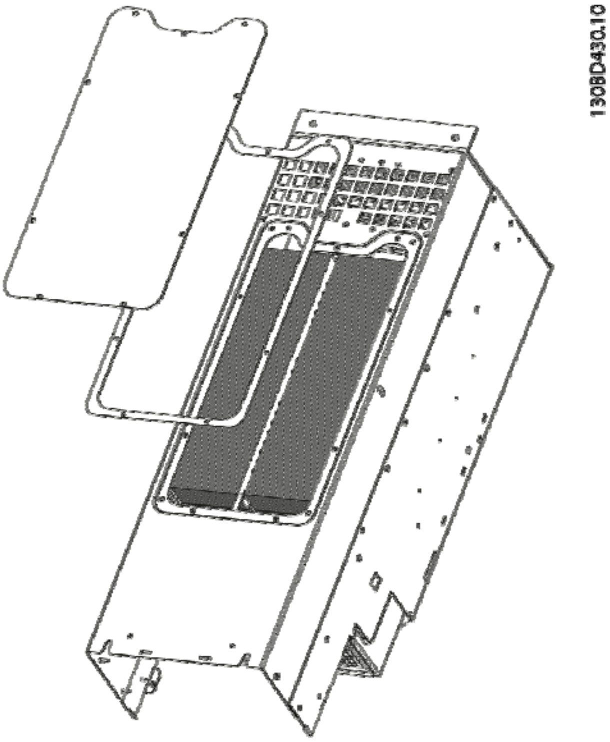


Illustration 7.30 Heatsink Access Panel

1. Do not run the frequency converter during heatsink access panel removal.
2. If the frequency converter is mounted on a wall, or the back of it is otherwise inaccessible, reposition it so that the back is fully accessible.
3. Remove the screws (3 mm internal hex) connecting the access panel to the back of the enclosure. There are 5 or 9 screws depending on the size of the frequency converter.

Reinstall in reverse order of this procedure and tighten fasteners according to *chapter 1.7 General Torque Tightening Values*.

7

8 Special Test Equipment

8.1 Test Equipment

Test tools have been developed to aid in troubleshooting these products. These tools are required to perform some of the procedures outlined in this manual. Test equipment described in this section is available from Trane. See for part numbers.

8.1.1 Split Bus Power Supply

In Split Bus Mode, the DC bus is split into two parts. One connects to the power card to power up the SMPS on the power card. By powering only the SMPS, the various logic circuits can be tested without the danger of damaging the power components.

The other connection can be used to provide low voltage power to the DC capacitors and the output IGBTs for test purposes. A low voltage power supply connected to the DC bus allows testing the functionality of the output section safely.

Connecting the frequency converter in split bus mode:

1. Ensure that AC power has been removed and all DC capacitors are fully discharged. Wait 20 minutes to ensure full discharge time.
2. Unplug the cable to connector MK902 on the power card.
3. Connect the power card supply cable from the split bus power supply to connector MK902 on the power card.
4. Connect the DC bus supply cable from the split bus power supply to the cable that was unplugged from MK902.

NOTICE

Do not apply AC mains voltage to the frequency converter when it is wired in split bus mode.

The power card supply should provide between 610 and 750 V DC of power. The Trane split bus power supply provides 650 V DC with a capacity of 250 mA.
The DC bus supply should provide a low level DC voltage. The Trane split bus power supply provides 24 V DC with a capacity of 2 amps.

8.1.2 Signal Test Board (p/n 176F8437)

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

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 unit will need the DC bus enabled and operating a load to verify some test signals.

Table 8.1 is a description of the signals available on the signal test board. of this manual describes when these tests would be called for and what the signal should be at that given test point.

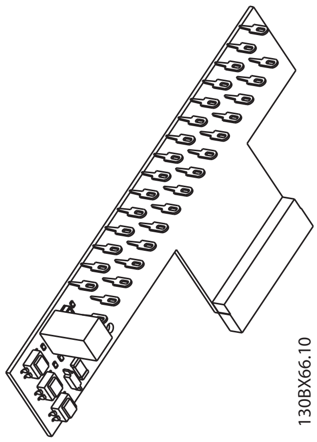


Illustration 8.1 Signal Test Board

8.1.3 Signal Test Board Extension

The signal test board extension is designed to be used with the signal test board. The extension can be plugged into the connector where the signal test board would normally connect. The signal test board will then plug into the extension board. When the extension board is used, the measurement terminals on the signal test board are easier to reach.

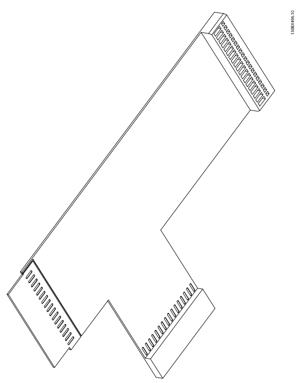
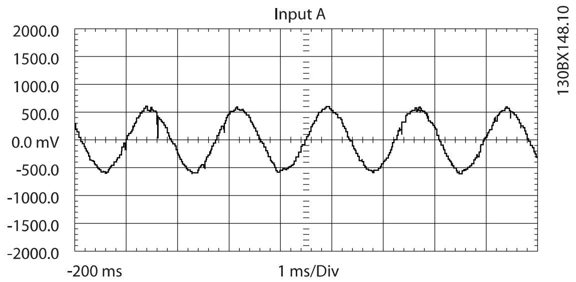


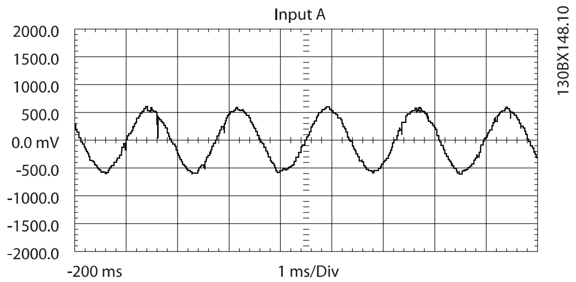
Illustration 8.2 Signal Test Board Extension

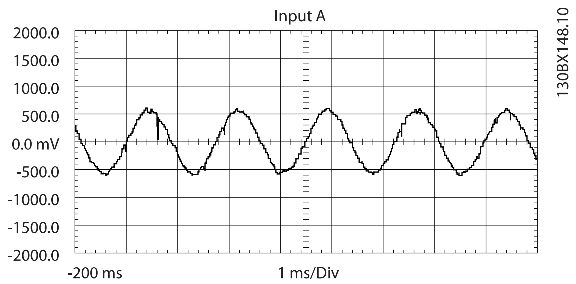
8.1.4 Signal Test Board Pin Outs

Table 8.1 lists 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 of this manual. Other than power supply measurements, most of the signals being measured are made up of waveforms.

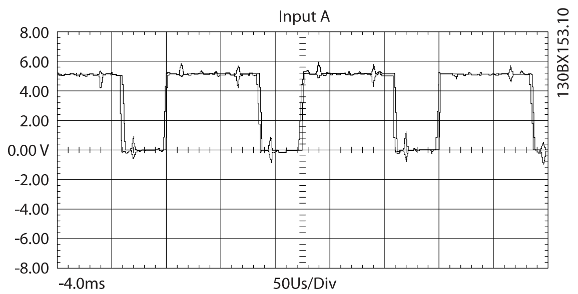
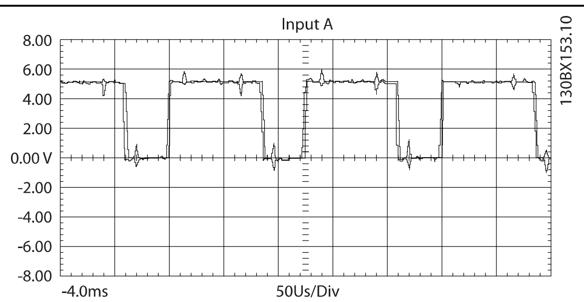
Although in some cases, a digital voltmeter can be used to verify the presence of such signals, it cannot be relied upon to verify that the waveform is correct. An oscilloscope is the preferred instrument. When similar signals are being measured at multiple points, a digital voltmeter can be used with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

<table>
<tr><th>Pin No.</th><th>Schematic acronym</th><th>Function</th><th>Description</th><th>Reading using a digital Voltmeter</th></tr>
<tr><td>1</td><td>IU1</td><td>Current sensed, U phase, not conditioned</td><td>


Approx 400 mV RMS @100% load</td><td>.937 VACpeak @ 165% of CT current rating. AC waveform @ output frequency of the filter.</td></tr>
<tr><td>2</td><td>IV1</td><td>Current sensed, V phase, not conditioned</td><td>


Approx 400 mV RMS @100% load</td><td>.937 VACpeak @ 165% of CT current rating. AC waveform @ output frequency of the filter.</td></tr>
<tr><td>3</td><td>IW1</td><td>Current sensed, W phase, not conditioned</td><td>


Approx 400 mV RMS @100% load</td><td>.937 VACpeak @ 165% of CT current rating. AC waveform @ output frequency of the filter.</td></tr>
<tr><td>4</td><td>COMMON</td><td>Logic common</td><td>This common is for all signals.</td><td></td></tr>
<tr><td>5</td><td></td><td>Not used</td><td></td><td></td></tr>
<tr><td>6</td><td></td><td>Not used</td><td></td><td rowspan="2">3.3 V DC – Inrush mode
0 V DC – Run mode</td></tr>
<tr><td>7</td><td>INRUSH</td><td>Control Card signal</td><td>Signal from the control card to start gating the SCR front end</td></tr>
<tr><td>8</td><td></td><td>Not used</td><td></td><td rowspan="2"></td></tr>
<tr><td>9</td><td></td><td>Not used</td><td></td></tr>
<tr><td>10</td><td></td><td>Not used</td><td></td><td></td></tr>
</table>

Pin No.	Schematic acronym	Function	Description	Reading using a digital Voltmeter
11	VPOS	(+)18 V DC regulated supply (+)16.5 to 19.5 V DC	The red LED indicates voltage is present between VPOS and VNEG terminals.	(+)18 V DC regulated supply (+)16.5 to 19.5 V DC
12	VNEG	(-) 18 V DC regulated supply (-) 16.5 to 19.5 V DC	The red LED indicates voltage is present between VPOS and VNEG terminals.	(-)18 V DC regulated supply (-)16.5 to 19.5 V DC
13		Not used		
14		Not used		
15		Not used		
16		Not used		
17		Not used		
18		Not used		
19		Not used		
20	INV_DIS	Control signal from Power Card	Disables IGBT gate voltages	5 V DC – inverter disabled 0 V DC – inverter enabled
21		Not used		
22	UINVEX	Bus Voltage scaled down	Signal proportional to UDC	0 V switch must be off (-) 1 V DC =250 V DC
23	VDD	(+) 24 V DC power supply	Yellow LED indicates voltage is present.	(+) 24 V DC regulated supply (+) 23 to 25 V DC
24	VCC	(+) 5.0 V DC regulated supply. (+) 4.75 to 5.25 VDC	The green LED indicates voltage is present.	(+) 5.0 V DC regulated supply (+) 4.75 to 5.25 V DC
25	GUP_T	IGBT gate signal, buffered, U phase, positive. Signal originates on Control Card.	 2v/div 100us/div Run@10 Hz	2.2–2.5 V DC Equal on all phases TP25-TP30
26	GUN_T	IGBT gate signal, buffered, U phase, negative. Signal originates on control card.	 2v/div 100us/div Run@10 Hz	2.2–2.5 V DC Equal on all phases TP25-TP30

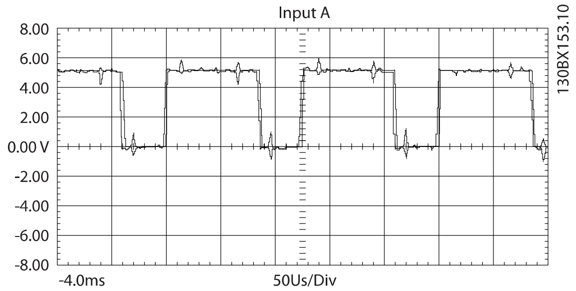
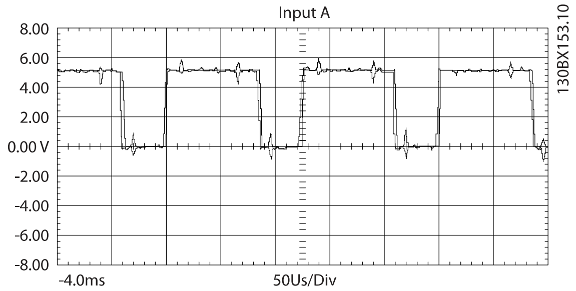
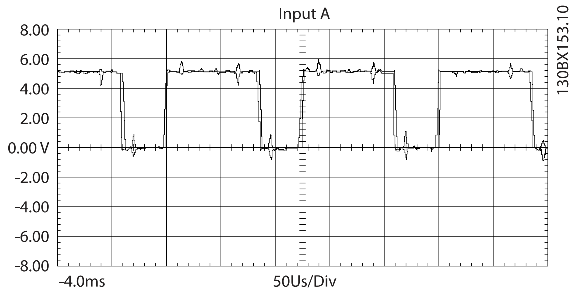
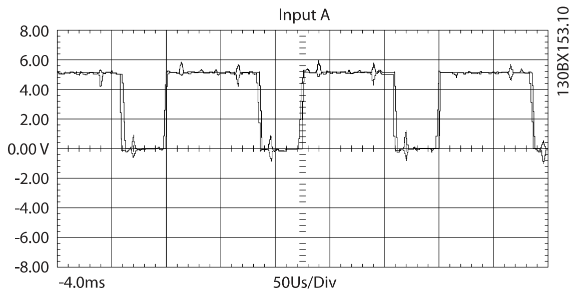
Pin No.	Schematic acronym	Function	Description	Reading using a digital Voltmeter
27	GVP_T	IGBT gate signal, buffered, V phase, positive. Signal originates on control card.	 2v/div 100us/div Run@10 Hz	2.2–2.5 V DC Equal on all phases TP25-TP30
28	GVN_T	IGBT gate signal, buffered, V phase, negative. Signal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

Table 8.1 Signal Test Board Pins

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9 Spare Parts

9.1 Spare Parts

9.1.1 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 plated copper when available. Plated copper bus bars are useable for all units.

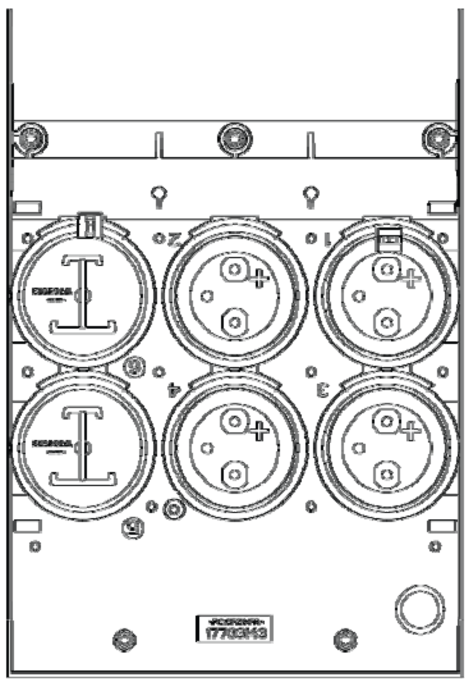
For the latest spare parts list, visit the Danfoss website using the directions below.

Spare Parts Lookup Procedure

1. Go to *www.danfoss.com/*
2. Ensure that the page displayed is the Danfoss global homepage. Depending on your location, home pages may vary.
3. Under the Quick Links menu, select **Configure your frequency converter**.
4. Select **Drive Configurator** at the bottom of the page.
5. Under Configurable Products, select the type of unit. The unit type is displayed on the product label as well as in the first 5 digits of the type code (T/C).
6. Under Configure by Type Code or Code No., enter the unit P/N or T/C. These are displayed on the product label.
7. Select **Configure**.
8. Examine the product description to confirm that it matches the unit as seen in the type code.
9. Select **Accept** at the bottom of the description list.
10. Under Extras, select **Display Spare Parts.**
11. Use the advance page buttons to scroll through the parts list to determine spare part number.

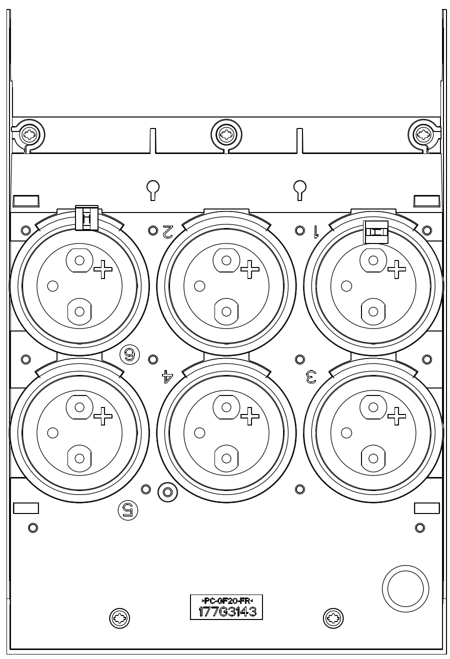
Click on the part number to see a detailed description of the part. Note that this feature is under development and some part descriptions are more complete than others.

9.1.2 DC Capacitor Bank



130BC565.10

Illustration 9.1 DC Capacitor Bank Layout. See *Table 9.1* for Details.



130BC566.10

Illustration 9.2 DC Capacitor Bank Layout. See *Table 9.1* and *Table 9.2* for Details.

9

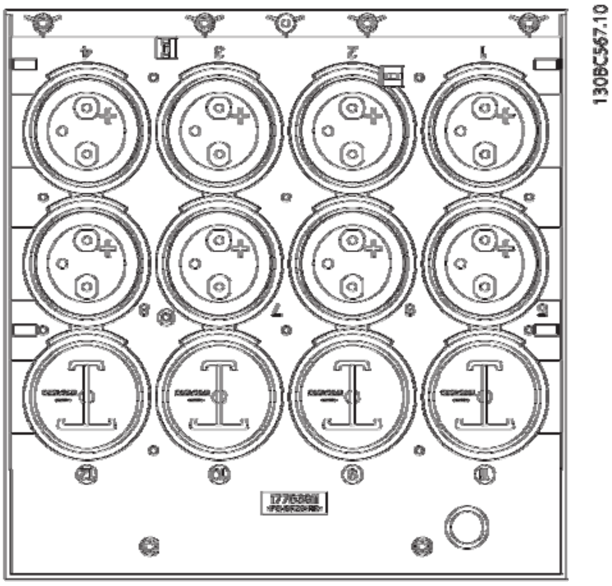


Illustration 9.3 DC Capacitor Bank Layout. See *Table 9.1* for Details.

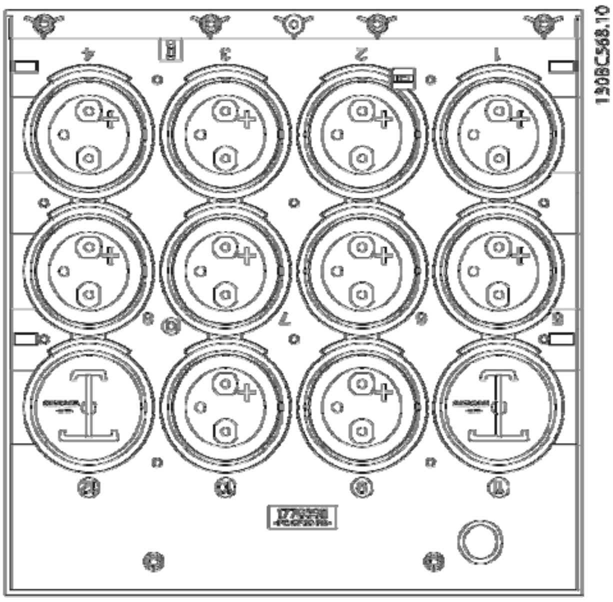


Illustration 9.4 DC Capacitor Bank Layout. See *Table 9.1* for Details.

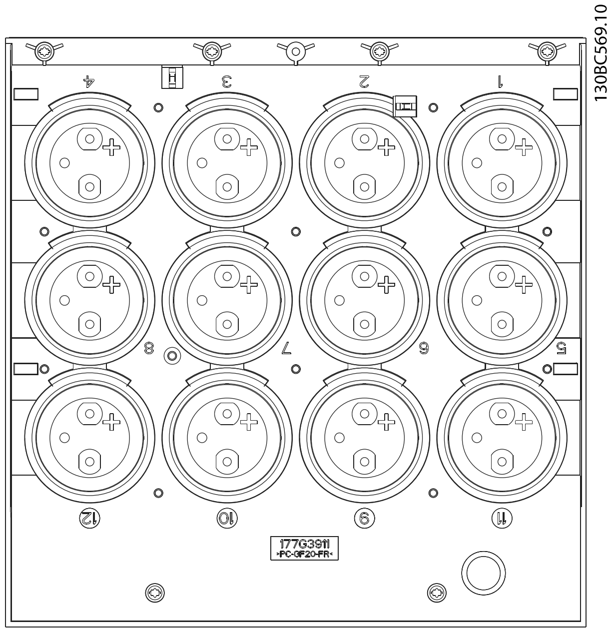


Illustration 9.5 DC Capacitor Bank Layout. See *Table 9.1* for Details.

Graphic Reference	Model	
Illustration 9.1	N110T4	N90kT5
Illustration 9.2	N132T4	N110T5
Illustration 9.2	N160T4	N132T5
Illustration 9.3	N200T4	N160T5
Illustration 9.4	N250T4	N200T5
Illustration 9.5	N315T4	N250T5

Table 9.1 DC Capacitor Bank Layout 380-500 V

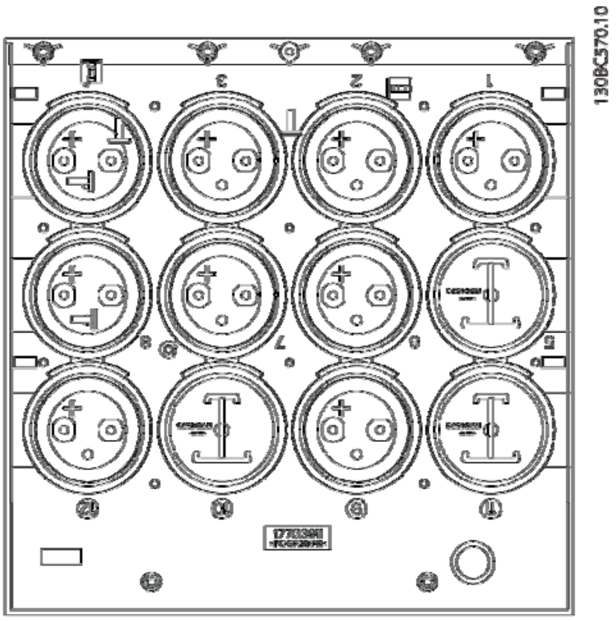


Illustration 9.6 DC Capacitor Bank Layout. See *Table 9.2* for Details.

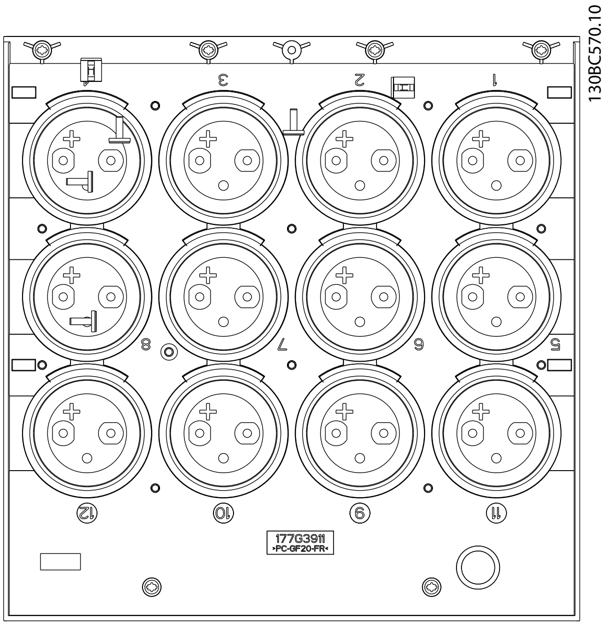


Illustration 9.7 DC Capacitor Bank Layout. See*Table 9.2* for Details.

Graphic Reference	Model	
Illustration 9.2	N75kT7	N55kT7
Illustration 9.2	N90kT7	N75kT7
Illustration 9.2	N110T7	N90kT7
Illustration 9.2	N132T7	N110T7
Illustration 9.2	N160T7	N132T7
Illustration 9.6	N200T7	N160T7
Illustration 9.6	N250T7	N200T7
Illustration 9.7	N315T7	N250T7
Illustration 9.7	N400T7	N315T7

Table 9.2 DC Capacitor Bank Layout 525-690 V

10 Block Diagrams

10.1.1 Block Diagram

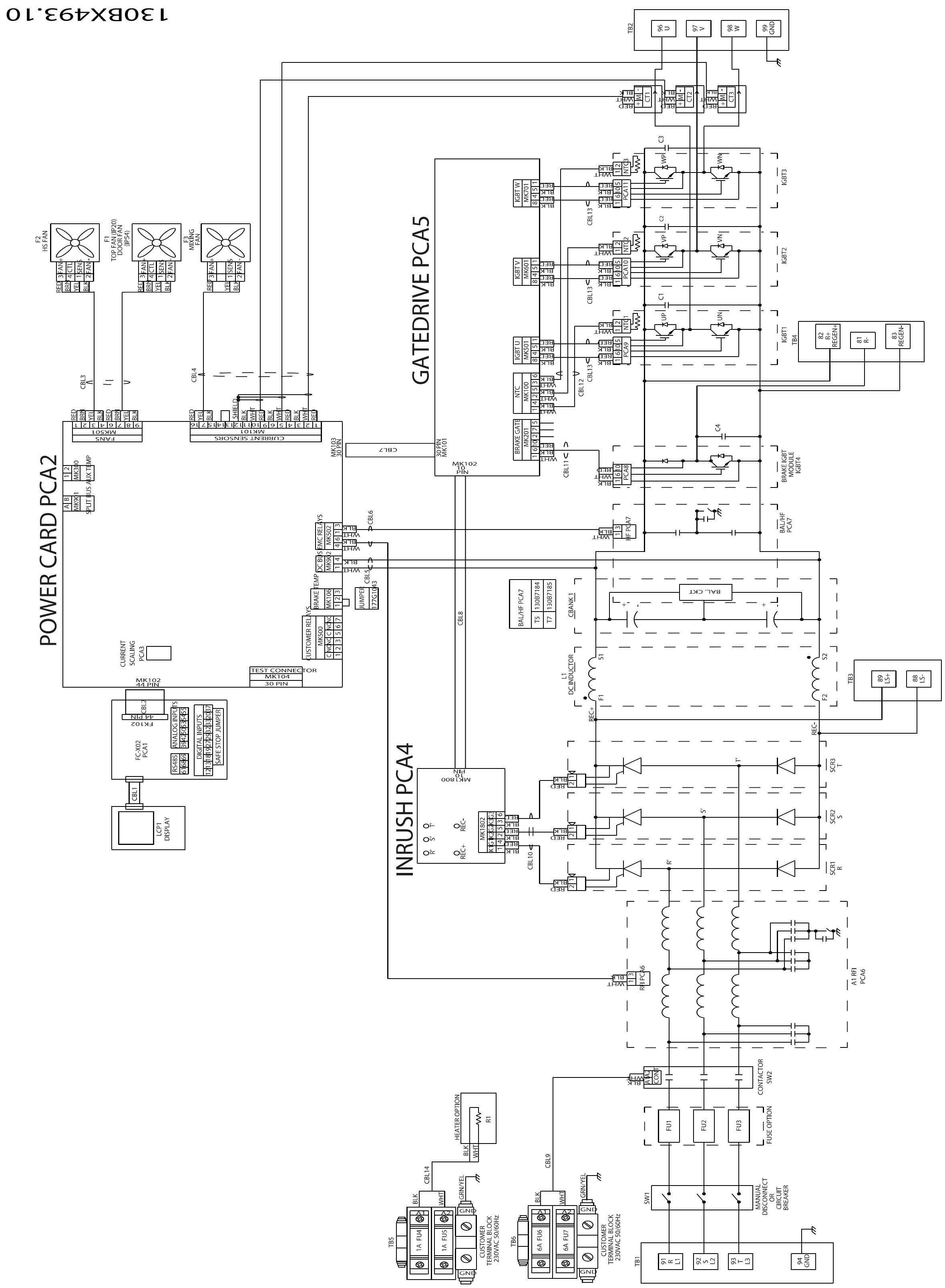


Illustration 10.1 Electrical Block Diagram for All D-frame Frequency Converters

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