E·T·N | **Cutler-Hammer**

SPI9000 Inverter Unit FI9 – FI14
User Manual

September 2006

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Cover Photo: Cutler-Hammer® SPI9000 Inverter Unit.

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Safety

Definitions and Symbols

⚠ WARNING

This symbol indicates high voltage. It calls your attention to items or operations that could be dangerous to you and other persons operating this equipment. Read the message and follow the instructions carefully.

⚠ WARNING

This symbol is the "Safety Alert Symbol." It occurs with either of two signal words: CAUTION or WARNING, as described below.

⚠ WARNING

Indicates a potentially hazardous situation which, if not avoided, can result in serious injury or death.

⚠ CAUTION

Indicates a potentially hazardous situation which, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the CAUTION may, if not avoided, lead to serious results. Important safety measures are described in CAUTION (as well as WARNING).

Hazardous High Voltage

⚠ WARNING

Motor control equipment and electronic controllers are connected to hazardous line voltages. When servicing drives and electronic controllers, there may be exposed components with housings or protrusions at or above line potential. Extreme care should be taken to protect against shock.

Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure equipment is properly grounded. Wear safety glasses whenever working on electronic controllers or rotating machinery.

Warnings, Cautions and Notices

Read this manual thoroughly and make sure you understand the procedures before you attempt to install, set up, or operate this Cutler-Hammer® SPI9000 Inverter Unit from Eaton's electrical business.

Warnings

> ⚠ **WARNING**
>
> Only a competent electrician may carry out the electrical installation.

> ⚠ **WARNING**
>
> The components of the power unit of the inverter are live when the SPI9000 inverter is connected to DC supply. Coming into contact with this voltage is extremely dangerous and may cause death or severe injury. The control unit is isolated from mains potential.

> ⚠ **WARNING**
>
> The supply and motor terminals are live when the inverter is connected to DC supply, even if the motor is not running.

> ⚠ **WARNING**
>
> The control I/O-terminals are isolated from the mains potential. However, the relay outputs and other I/O-terminals may have dangerous control voltage present even when the inverter unit is disconnected from the DC supply.

> ⚠ **WARNING**
>
> The inverter has a large capacitive leakage current.

> ⚠ **WARNING**
>
> If the inverter is used as a part of a machine, the machine manufacturer is responsible for providing the machine with a main switch (EN 60204-1).

> ⚠ **WARNING**
>
> Only spare parts delivered by Eaton can be used.

Cautions

⚠ CAUTION

The SPI9000 inverter is meant for fixed installations only.

⚠ CAUTION

Do not perform any measurements when the inverter is connected to the DC supply.

⚠ CAUTION

After having disconnected the inverter from the DC supply, wait until the fan stops and the indicators on the keypad go out (if no keypad is attached see the indicator through the keypad base). Wait 5 more minutes before doing any work on inverter connections. Do not even open the cover before this time has expired.

⚠ CAUTION

Do not perform any voltage withstand tests on any part of inverter. There is a certain procedure according to which the tests shall be performed. Ignoring this procedure may result in damaged product.

⚠ CAUTION

Prior to measurements on the motor or the motor cable, disconnect the motor cable from the inverter.

⚠ CAUTION

Do not touch the components on the circuit boards. Static voltage discharge may damage the components.

⚠ CAUTION

Before connecting the inverter to DC supply, make sure that the inverter front and cable covers are closed.

⚠ CAUTION

Ensure that the jumper positions are correct. Running the motor with signal settings that differ from the jumper positions will not harm the inverter but may harm the motor.

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Grounding and ground fault protection

The SPI9000 inverter must always be grounded with a ground conductor connected to the ground terminal.

The ground fault protection inside the inverter only protects the inverter against ground faults in the motor or the motor cable.

Due to the high capacity currents present in the inverter, fault current protective switches may not function properly. If fault current protective switches are used, they need to be tested with ground fault currents present during possible fault situations.

Motor and Equipment Safety

⚠ CAUTION

Before starting the motor, check that the motor is mounted properly and ensure that the machine connected to the motor allows the motor to be started.

⚠ CAUTION

Set the maximum motor speed (frequency) according to the motor and the machine connected to it.

⚠ CAUTION

Before reversing the motor, make sure that this can be done safely.

⚠ CAUTION

Make sure that no power correction capacitors are connected to the motor cable.

⚠ CAUTION

Make sure that the motor terminals are not connected to mains potential.

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Chapter 1 — Overview

Receiving and Inspection

Cutler-Hammer® SPI9000 Inverter Units from Eaton's electrical business have undergone scrupulous tests and quality checks at the factory before they are delivered to the customer. However, after unpacking the product, check that no sign of transportation damage is to be found on the product and that the delivery is complete (compare the type designation of the product to the code below, see **Table 1-1**).

If the drive has been damaged during shipping, please contact the cargo insurance company or the carrier.

If the delivery does not correspond to your order, contact the supplier immediately.

Table 1-1: FI9 – FI14 Inverter Unit Catalog Numbering System

S P I 0 1 6 A 0 – 4 A 1 N 1

Product Family

SPI = Inverter Unit

Current Rating	
380 – 500V	
140 = 140A	**730** = 730A
170 = 170A	**820** = 820A
205 = 205A	**920** = 920A
245 = 245A	**H10** = 1030A
300 = 300A	**H11** = 1150A
385 = 385A	**H13** = 1300A
460 = 460A	**H16** = 1600A
520 = 520A	**H19** = 1940A
590 = 590A	**H23** = 2300A
650 = 650A	
525 – 690V	
100 = 100A	**502** = 502A
125 = 125A	**590** = 590A
144 = 144A	**650** = 650A
170 = 170A	**820** = 820A
208 = 208A	**920** = 920A
261 = 261A	**H10** = 1030A
325 = 325A	**H13** = 1300A
385 = 385A	**H15** = 1500A
460 = 460A	**H19** = 1900A

Board Modifications

1 = Standard Boards

Brake Chopper Options

N = No Brake Chopper Circuit

Input Options

1 = Three-Phase

Keypad

A = Alphanumeric

Voltage Rating

4 = 380 – 500V AC
5 = 525 – 690V AC

Enclosure Rating

0 = Chassis

Software Series

A = Standard

For more information visit: **www.EatonElectrical.com**

Standard Features of SPI Inverter Units

- Air cooling
- Standard board
- Alphanumeric control panel with fiber connection
- EMC Class T (EN 61800-3 for IT networks)
- Safety CE / UL
- External charging required
- I/O Modules A1 and A2
- IP00

Storage

If the inverter is to be stored before use, make sure that the ambient conditions are acceptable.

Storage temperature: -40 to 158°F (-40 to 70°C)

Relative humidity: <95%, no condensation

If the inverter is stored for over 12 months, contact Eaton before connecting the inverter to the power supply.

Maintenance

In normal conditions, Cutler-Hammer inverters are maintenance-free. However, we recommend cleaning the heatsink with compressed air whenever necessary. The cooling fan can easily be changed if required.

It may also be necessary to check the tightening torques of terminals at certain intervals.

Technical Data

Figure 1-1 presents the block diagram of the SPI9000 inverter. The inverter mechanically consists of two units, the Power Unit and the Control Unit.

The Power Unit contains an inverter bridge which consists of IGBT switches and produces symmetrical, three-phase PWM-modulated AC voltage to the motor.

The Motor and Application Control Block is based on microprocessor software. The microprocessor controls the motor based on the information it receives through measurements, parameter settings, control I/O and the control keypad. The motor and application control block control the motor control ASIC which, in turn, calculates the IGBT positions. Gate drivers amplify these signals for driving the IGBT inverter bridge.
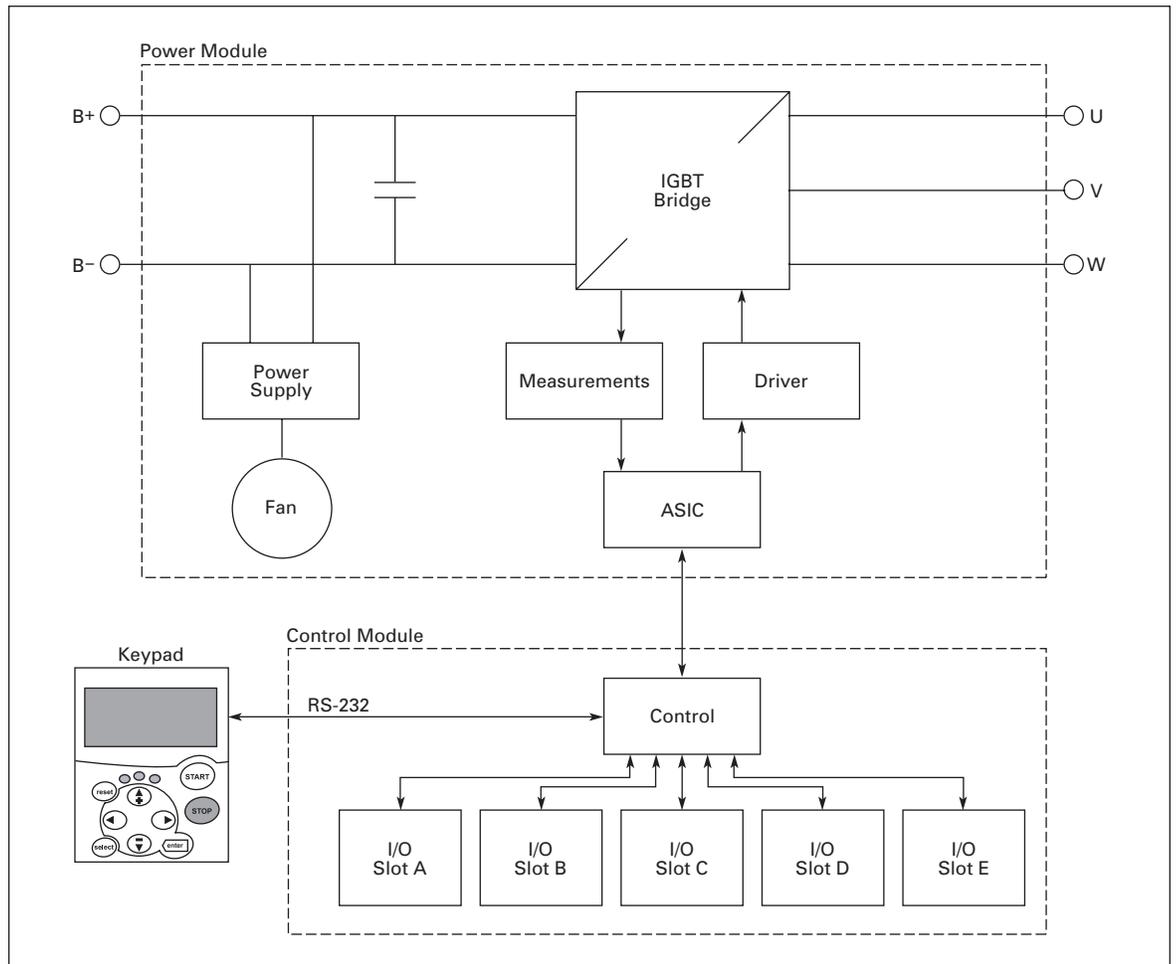
Figure 1-1: SPI9000 Inverter Unit Block Diagram

The control keypad constitutes a link between the user and the inverter. The control keypad is used for parameter setting, reading status data and giving control commands. It is detachable and can be operated externally and is connected via a cable to the inverter. Instead of the control keypad, a PC can be used to control the inverter if connected through a similar cable.

The basic control interface and the parameters (the Basic Application) are easy to use. If a more versatile interface or parameters are required, a more suitable application can be chosen. See the application manual for more information on the different applications.

Optional I/O expander boards that increase the number of inputs and outputs to be used are also available. For more information, contact Eaton.

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Power Ratings

Supply Voltage 465 – 800V DC, Motor Voltage 380 – 500V AC

High overload = Maximum current IS, 2 sec./20 sec., 150% overloadability, 1 min./10 min.

Following continuous operation at rated output current, 150% rated output current (I_H) for 1 min, followed by a period of load current less than rated current, and of such duration that the r.m.s output current, over the duty cycle, does not exceed rated output current (I_H)

Low overload = Maximum current IS, 2 sec./20 sec., 110% overloadability, 1 min./10 min.

Following continuous operation at rated output current, 110% rated output current (I_L) for 1 min, followed by a period of load current less than rated current, and of such duration that the r.m.s output current, over the duty cycle, does not exceed rated output current (I_L)

Table 1-2: 380 – 500V AC, 50/60 Hz, Three-Phase Inverters Ratings

| | Loadability | | | | | Motor Shaft Power | | | |
| | Low | | High | | | 675V DC Supply | | | |
Nominal Current	Rated Cont. Current I_L (A)	10% Over-load Current (A)	Rated Cont. Current I_H (A)	50% Over-load Current (A)	Max Current I_S	10% Over-load 40°C P (kW)	50% Over-load 50°C P (kW)	Frame	Dimensions and Weight W x H x D/Wt. in in./lbs. (mm/kg)
140	170	187	140	210	280	110	90	FI9	9.4 x 40.6 x 14.6/143 (239 x 1030 x 372/65)
170	205	226	170	255	336	132	110		
205	261	287	205	308	349	160	132		
245	300	330	245	368	444	200	160		
300	385	424	300	450	540	250	200	FI10	9.4 x 40.6 x 21.7/220 (239 x 1030 x 552/100)
385	460	506	385	578	693	315	250		
460	520	572	460	690	828	355	315		
520	590	649	520	780	936	400	355	FI12	2x9.4 x 40.6 x 21.7/440 (2x239 x 1030 x 552/200)
590	650	715	590	885	1062	450	400		
650	730	803	650	975	1170	500	450		
730	820	902	730	1095	1314	560	500	FI12	2x9.4 x 40.6 x 21.7/440 (2x239 x 1030 x 552/200)
820	920	1012	820	1230	1476	630	560		
920	1030	1133	920	1380	1656	710	630		
1030	1150	1265	1030	1545	1854	800	710	FI13	27.9 x 40.6 x 21.8/665 (708 x 1030 x 553/302)
1150	1300	1430	1150	1725	2070	900	800		
1300	1450	1595	1300	1950	2340	1000	900		
1600	1770	1947	1600	2400	2880	1200	—	FI14	2x27.9 x 40.6 x 21.8/665 (2x708 x 1030 x 553/302)
1940	2150	2365	1940	2910	3492	1500	—		
2300	2700	2970	2300	3287	3933	1800	—		

Note: The rated currents in given ambient temperatures are achieved only when the switching frequency is equal to or less than the factory default.

For more information visit: **www.EatonElectrical.com**

Supply Voltage 640 – 1100V DC, Motor Voltage 525 – 690V AC

High overload = Max current IS, 2 sec/20 sec, 150% overloadability, 1 min/10 min

Following continuous operation at rated output current, 150% rated output current (I_H) for 1 min, followed by a period of load current less than rated current, and of such duration that the r.m.s output current, over the duty cycle, does not exceed rated output current (I_H)

Low overload = Max current IS, 2 sec/20 sec, 110% overloadability, 1 min/10 min

Following continuous operation at rated output current, 110% rated output current (I_L) for 1 min, followed by a period of load current less than rated current, and of such duration that the r.m.s output current, over the duty cycle, does not exceed rated output current (I_L)

All frames are available as IP21 and IP54.

Table 1-3: 525 – 690V AC, 50/60 Hz, Three-Phase Inverters Ratings

| Nominal Current | Loadability | | | | | Motor Shaft Power | | Frame | Dimensions and Weight W x H x D/Wt. in in./lbs. (mm/kg) |
| | Low | | High | | | 930V DC Supply | | | |
	Rated Cont. Current I_L (A)	10% Over-load Current (A)	Rated Cont. Current I_H (A)	50% Over-load Current (A)	Max Current I_S	10% Over-load 40°C P (kW)	50% Over-load 50°C P (kW)		
100 125 144 170	125 144 170 208	138 158 187 229	100 125 144 170	150 188 216 255	200 213 245 289	110 132 160 200	90 110 132 160	FI9	9.4 x 40.6 x 14.6/143 (239 x 1030 x 372/65)
208 261 325 325	261 325 385 416	287 358 424 458	208 261 325 325	312 392 488 488	375 470 585 585	250 315 355 400	200 250 315 355	FI10	9.4 x 40.6 x 21.7/220 (239 x 1030 x 552/100)
385 460 502	460 502 590	506 552 649	385 460 502	578 690 753	693 828 904	450 500 560	400 450 500	FI12	2x9.4 x 40.6 x 21.7/441 (2x239 x 1030 x 552/200)
590 650 650	650 750 820	715 825 902	590 650 650	885 975 975	1062 1170 1170	630 710 800	560 630 710	FI12	2x9.4 x 40.6 x 21.7/441 (2x239 x 1030 x 552/200)
820 920 1030	920 1030 1180	1012 1133 1298	820 920 1030	1230 1380 1464	1476 1656 1755	900 1000 1200	800 900 1000	FI13	27.9 x 40.6 x 21.8/665 (708 x 1030 x 553/302)
1300 1500 1900	1500 1900 2250	1650 2090 2475	1300 1500 1900	1950 2250 2782	2340 2700 3335	1500 1800 2000	1300 1500 1800	FI14	2x27.9 x 40.6 x 21.8/665 (2x708 x 1030 x 553/302)

Note: The rated currents in given ambient temperatures are achieved only when the switching frequency is equal to or less than the factory default.

Table 1-4: Technical Information

Description	Specification
Supply Connection	
Input Voltage V_{in}	465 – 800V DC; 380 – 500V AC (-0%. to +0%)
	640 – 1100V DC; 525 – 690V AC (-0% to +0%)
	The waviness of the inverter supply voltage, which is formed in rectification of the electric network's alternating voltage in basic frequency, must be less than 50V peak-to-peak.
Input Current I_{in}	$(sqrt3 \times U_{mot} \times I_{mot} \times cos\varphi) / (V_{in} \times 0.98)$
DC Bank Capacitance	FI9 380 – 500V: 4950 μF; FI9 525 – 690V: 3733 μF
	FI10 380 – 500V: 9900 μF; FI10 525 – 690V: 7467 μF
	FI12 380 – 500V: 19800 μF; FI12 525 – 690V: 14933 μF
	FI13 380 – 500V: 29700 μF; FI13 525 – 690V: 22400 μF
Starting Delay	5 seconds (FI9 and greater)
Motor Connection	
Output Voltage	$3 \sim 0 – V_{in} / 1.4$
Continuous Output Current	I_H: Ambient temperature max. +50°C, overload 1.5 x I_H (1 min./10 min.) I_L: Ambient temperature max. +40°C, overload 1.1 x I_L (1 min./10 min.)
Starting Torque	I_S for two seconds (torque motor dependent)
Peak Current	I_S for 2 seconds every 20 seconds
Output Frequency	0 – 320 Hz; 7200 Hz (special)
Frequency Resolution	Application dependent
Control Characteristics	
Control Method	Frequency control V/f
	Open loop: Sensorless vector control
	Closed loop: Frequency control
	Closed loop: Vector control
Switching Frequency (See Parameter 2.6.9)	380 – 500V, 1 – 10 kHz; Factory default 3.6 kHz
	525 – 690V, 1 – 6 kHz; Factory default 1.5 kHz
Frequency Reference Analog Input Panel Reference	Resolution 0.1% (10 bits); Accuracy ±1% Resolution 0.01 Hz
Field Weakening Point	30 – 320 Hz
Acceleration Time	0 – 3000 sec
Deceleration Time	0 – 3000 sec
Braking Torque	DC brake: 30% * T_N (without brake)
Ambient Conditions	
Ambient Operating Temperature	-10°C (no frost) to +40°C: I_H -10°C (no frost) to +40°C: I_L
Storage Temperature	-40 to 158°F (-40 to 70°C)
Relative Humidity	0 – 95% RH, non-condensing, non-corrosive, no dripping water
Air Quality: – Chemical Vapors – Mechanical Particles	IEC 721-3-3, unit in operation, Class 3C2 IEC 721-3-3, unit in operation, Class 3S2
Altitude	100% load capacity (no derating) up to 1,000m 1% derating for each 100m above 1000 (maximum, 3000m)

Table 1-4: Technical Information, continued

Description	Specification
Ambient Conditions, continued	
Vibration EN 50178/EN 60068-2-6	5 – 150 Hz Displacement amplitude: 1 mm (peak) at 3 – 15.8 Hz Maximum acceleration amplitude: 1G at 15.8 – 150 Hz
Shock EN 50178, EN 60068-2-27	UPS Drop Test (for applicable UPS weights) Storage and shipping: Maximum 15G, 11 ms (in package)
Cooling Capacity Required	P_{loss}[kW] approx. P_{mat}[kW] x 0,025
Cooling Air Required	FI9, 677 cfm; FI10, 824 cfm; FI12, 1648 cfm; FI13, 2472 cfm
Unit Enclosure Class	IP00
EMC (at Default Settings)	
Immunity	Fulfill all EMC immunity requirements
Safety	
	CE, UL, CUL EN 61800-5-1 (2003) See unit nameplate for more detailed approvals.
Control Connections	
Analog input voltage	0 to +10V, R_i = 200kΩ, (–10V to +10V joystick control) Resolution 0.1%; Accuracy ±1%
Analog input current	0(4) – 20 mA, R_i = 250Ω differential
Digital inputs (6)	Positive or negative logic; 18 – 30V DC
Auxiliary voltage	+24V, ±15%, max. 250 mA
Output reference voltage	+10V, +3%, max. load 10 mA
Analog output	0(4) – 20mA; R_L max. 500Ω Resolution 10 bits; Accuracy ±2%
Digital outputs	Open collector output, 50 mA/48V
Relay outputs	2 programmable change-over relay outputs Switching capacity: 24V DC/8A, 250V AC/8A, 125V DC/0.4A Minimum switching load: 5V/10 mA
Protections	
Overvoltage Protection Undervoltage Protection	500V inverters: 911V DC; 690V inverters: 1200V DC 500V inverters: 333V DC; 690V inverters: 460V DC
Ground Fault Protection	In case of ground fault in motor or motor cable, only the inverter is protected.
Motor Phase Supervision	Trips if any of the output phases are missing.
Overcurrent Protection	Yes
Unit Overtemperature Protection	Yes
Motor Overload Protection	Yes
Motor Stall Protection	Yes
Motor Underload Protection	Yes
Short Circuit Protection of +24V and +10V Reference Voltages	Yes

Table 1-5: DC Currents for 465 – 800V DC Supply Voltage

Structure	Inom (Output)	Motor COS	IDC (Input)
FI9	261	.89	304
	300	.89	350
FI10	385	.9	454
	460	.9	542
	520	.9	613
FI12	590	.9	695
	650	.9	766
	730	.91	870
	820	.91	977
	920	.91	1096
	1030	.91	1227
FI13	1150	.91	1370
	1300	.91	1549
	1450	.91	1727
FI14	1770	.92	2132
	2150	.92	2590
	2700	.92	3252

Table 1-6: DC Currents for 640 – 1100V DC Supply Voltage

Structure	Inom (Output)	Motor COS	IDC (Input)
FI9	125	.89	146
	144	.89	168
	170	.89	198
	208	.9	245
FI10	261	.9	308
	325	.9	383
	385	.9	454
	416	.9	490
F12	460	.91	548
	502	.91	598
	590	.91	703
	650	.91	774
	750	.91	894
	820	.91	977
FI13	920	.91	1096
	1030	.91	1227
	1180	.92	1421
FI14	1500	.92	1807
	1900	.93	2313
	2250	.93	2739

Chapter 2 — Mounting

Dimensions

The inverter can be mounted in a vertical position on the back plane of a cubicle. Enough space must be reserved around the inverter to ensure sufficient cooling, see **Figure 2-5**. You must follow the minimum dimensions for installation, see **Tables 2-5** and **2-6**. Also make sure that the mounting plane is relatively even. The inverter is fixed with four screws (or bolts, depending on the unit size). The following pages show the dimensions for the IP00 power module.
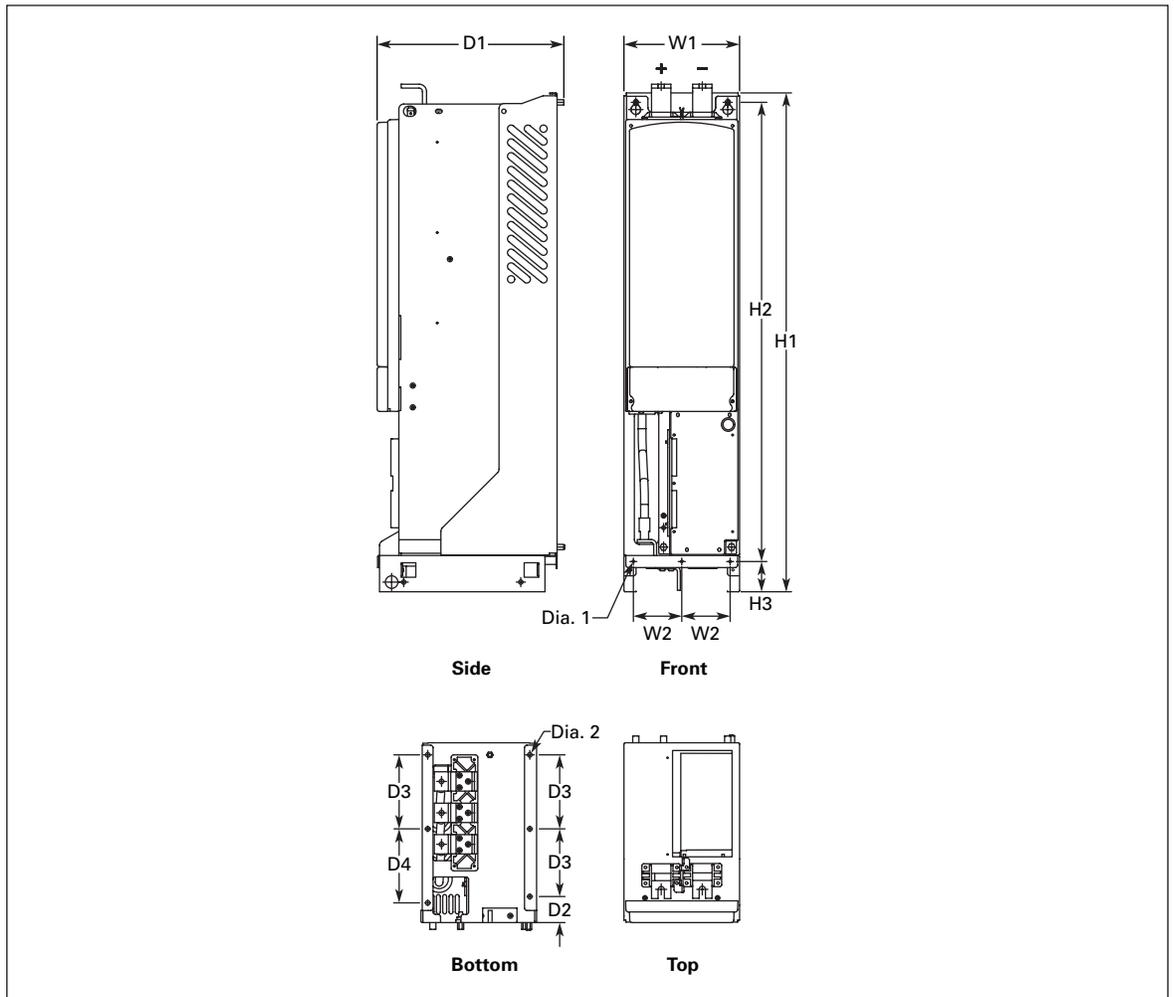
Figure 2-1: SPI9000 FI9 Inverter Dimensions

Table 2-1: SPI9000 FI9 Inverter Dimensions

Inverters	Voltage	Approximate Dimensions in Inches (mm)										
		W1	W2	H1	H2	H3	D1	D2	D3	D4	Dia. 1	Dia. 2
SPI100 – 170	480V/575V	9.41 (239)	3.94 (100)	40.63 (1032)	37.40 (950)	2.46 (62.5)	15.20 (386)	2.12 (53.9)	5.51 (140)	6.03 (153.1)	.18 (4.6)	.37 (9.5)
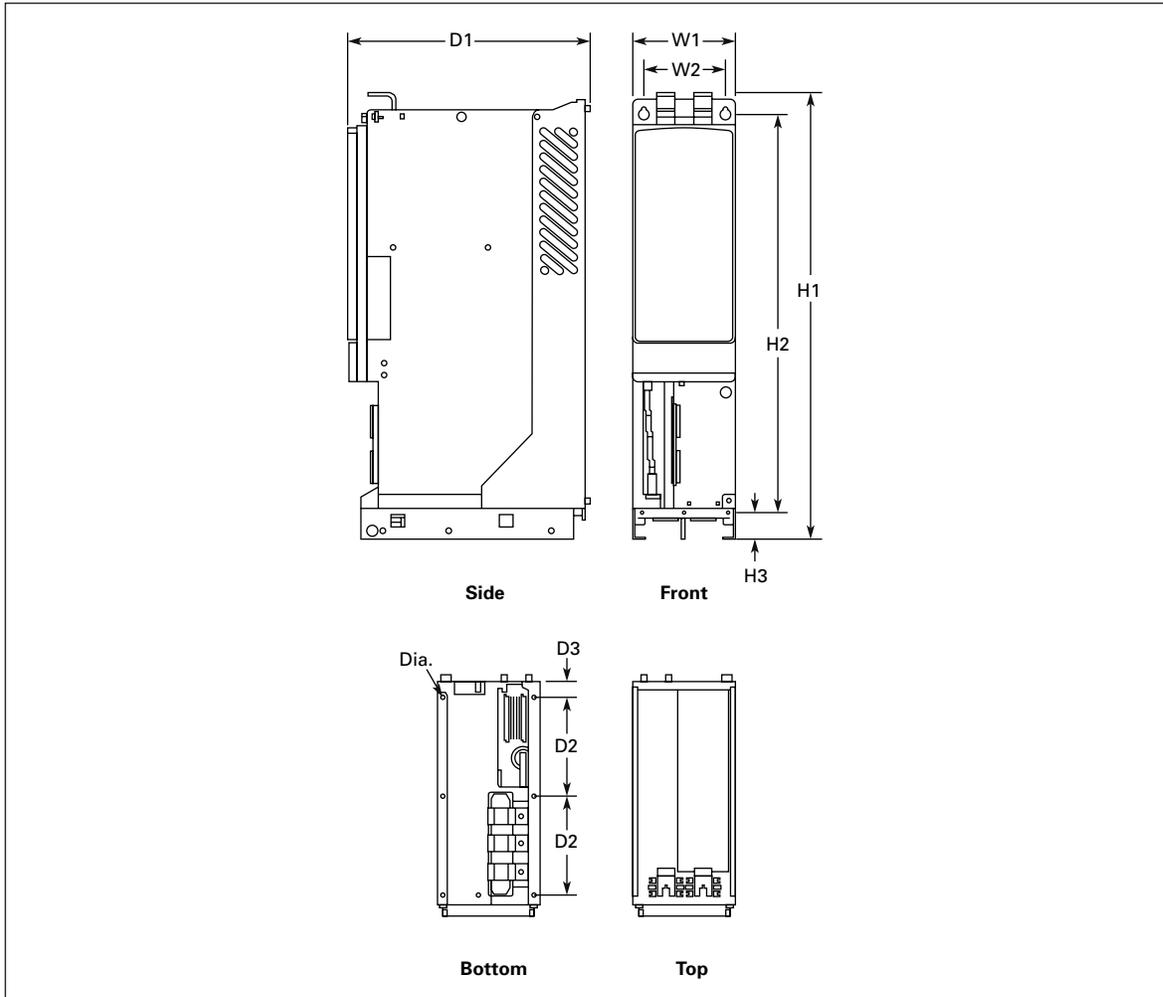
Figure 2-2: SPI9000 FI10 Inverter Dimensions

Table 2-2: SPI9000 FI10 Inverter Dimensions

Inverters	Voltage	Approximate Dimensions in Inches (mm)								
		W1	W2	H1	H2	H3	D1	D2	D3	Dia.
SPI208 – 325	480V/575V	9.4 (239)	7.9 (200)	41.3 (1050)	37.5 (952)	2.4 (60.5)	22.3 (566)	9.1 (230)	1.6 (41)	.37 (9.5)
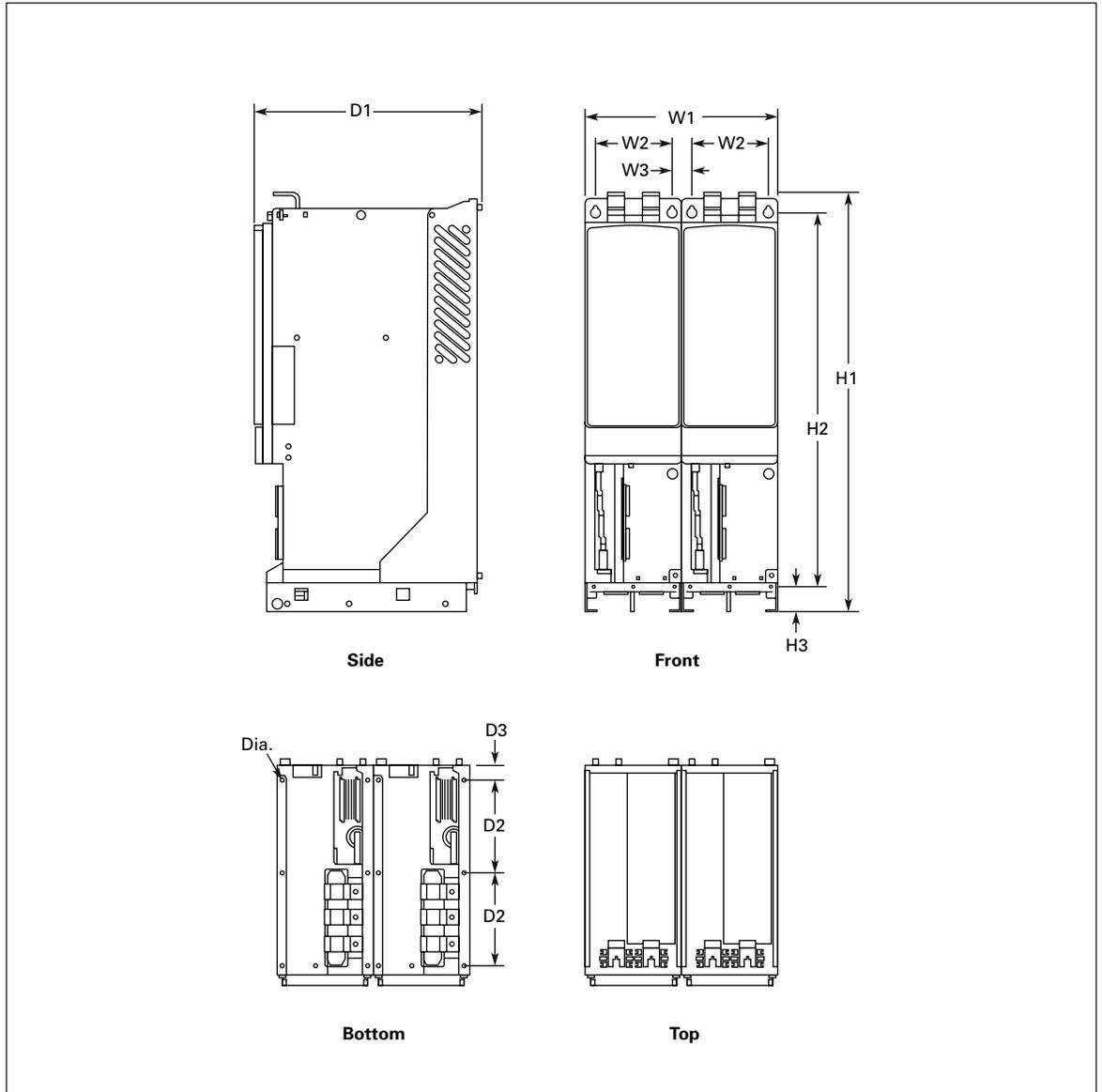
Figure 2-3: SPI9000 FI12 Inverter Dimensions

Table 2-3: SPI9000 FI12 Inverter Dimensions

Inverters	Voltage	Approximate Dimensions in Inches (mm)									
		W1	W2	W3	H1	H2	H3	D1	D2	D3	Dia.
SPI385 – 650	480V	18.8 (478)	7.9 (200)	1.1 (28)	41.3 (1050)	37.5 (952)	2.4 (60.5)	22.3 (566)	9.1 (230)	1.6 (41)	.37 (9.5)
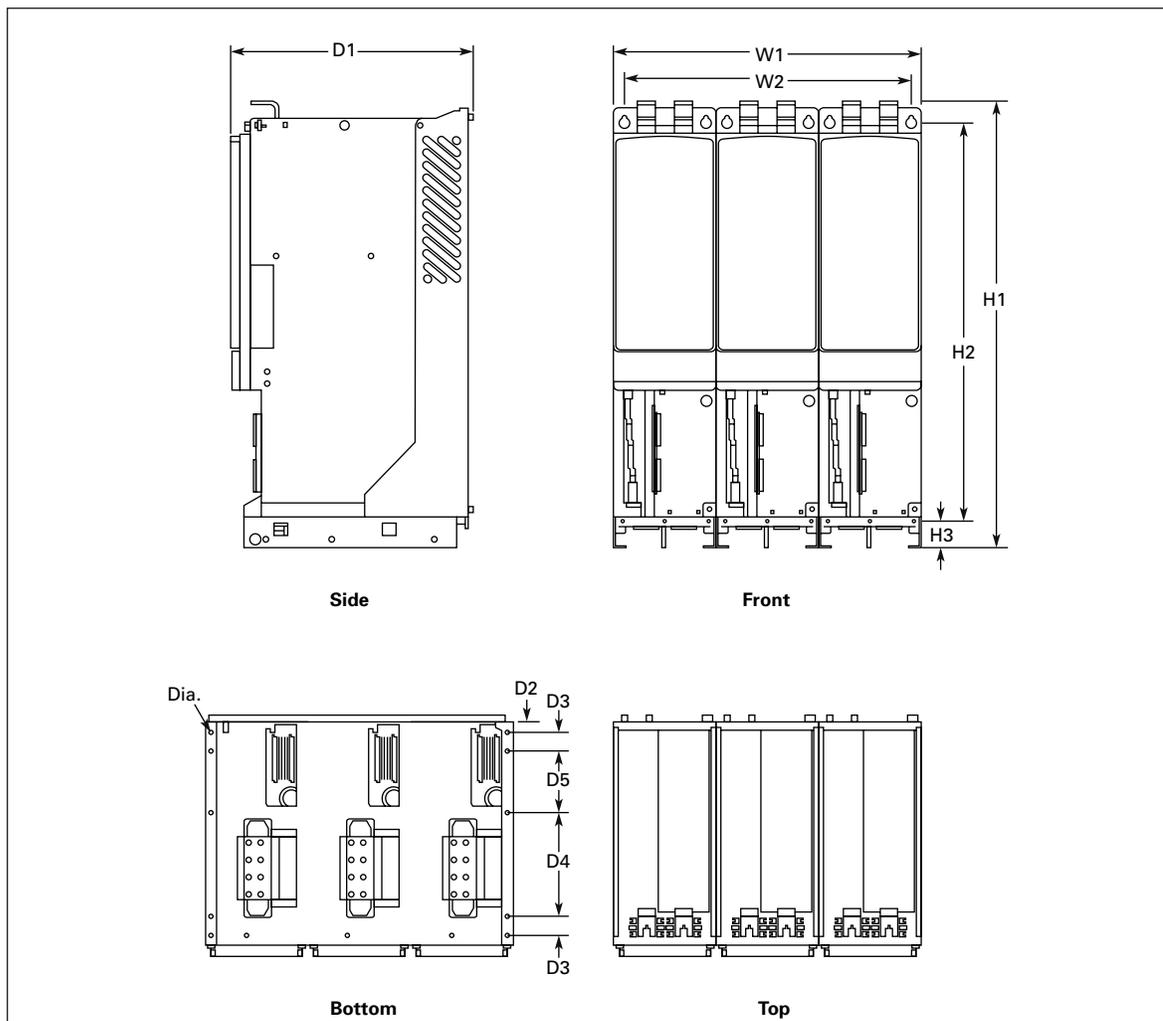
Figure 2-4: SPI9000 FI13 Inverter Dimensions (FI14 Is a Double FI13)

Table 2-4: SPI9000 FI13 Inverter Dimensions (FI14 Is a Double FI13)

Inverters	Voltage	Approximate Dimensions in Inches (mm)										
		W1	W2	H1	H2	H3	D1	D2	D3	D4	D5	Dia.
SPI820 – H10	480V	27.9 (708)	26.7 (677)	41.5 (1055)	37.4 (950)	2.46 (62.5)	22.3 (566)	1.1 (27)	1.6 (40)	9.6 (245)	5.9 (150)	.37 (9.5)

Fan Cooling

Frames FI9 to FI14

Enough free space must be left around the inverter to ensure sufficient air circulation and cooling. You will find the required dimensions for free space **Table 2-5**.

If several units are mounted on top of each other, the required free space equals **2 * C** (see **Figure 2-5**). Moreover, the outlet air used for cooling by the lower unit must be directed away from the air intake of the upper unit. When planning the cooling for the space, take into consideration that the inverter's heat loss is 2.5% of the nominal capacity.
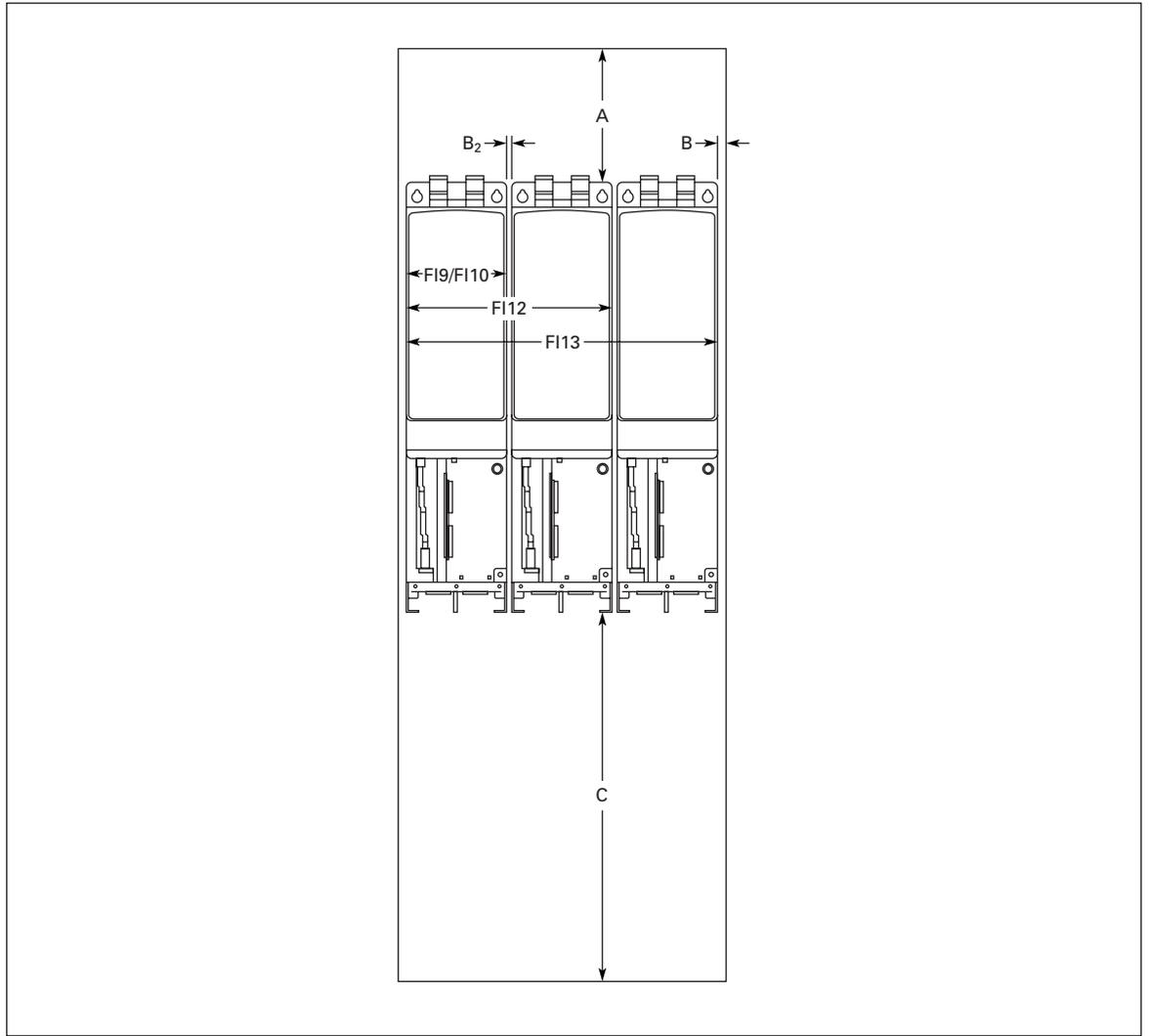
Figure 2-5: Installation Space

Table 2-5: Mounting Space Requirements

Frame	Voltage	Approximate Dimensions in Inches (mm)			
		A	B	B_2	C
FI9	380 – 500V 525 – 690V	7.9 (200)	.79 (20)		3.9 (100)
FI10	380 – 500V 525 – 690V	7.9 (200)	.79 (20)		3.9 (100)
FI12	380 – 500V 525 – 690V	7.9 (200)	.79 (20)	0	3.9 (100)
FI13	380 – 500V 525 – 690V	7.9 (200)	.79 (20)	0	3.9 (100)
FI14	380 – 500V 525 – 690V	7.9 (200)	.79 (20)	0	3.9 (100)

A = free space above the inverter
B = distance between inverter and cabinet wall
B_2 = distance between two inverters
C = free space underneath of the inverter

Table 2-6: Required Cooling Air

Frame	Voltage	Greatest Possible Heat Loss (kW)	Cooling Air Required (cfm)	Minimum Air Exhausting Hole on Switchgear (in^2)
FI9	380 – 500V 525 – 690V	4.8 4.6	677	77.5
FI10	380 – 500V 525 – 690V	8.3 9.1	824	93
FI12	380 – 500V 525 – 690V	16.5 18.0	1648	186
FI13	380 – 500V 525 – 690V	23.0 26.0	2472	279
FI14	380 – 500V 525 – 690V	46.0 52.0	2 x 2472	2 x 279

Power Losses

Raising the switching frequency of the drive, to reduce motor noise for example, inevitably affects the power losses and cooling requirements. For more information, contact Eaton.

Chapter 3 — Power Wiring

The following wiring diagrams show the supply and motor connections.
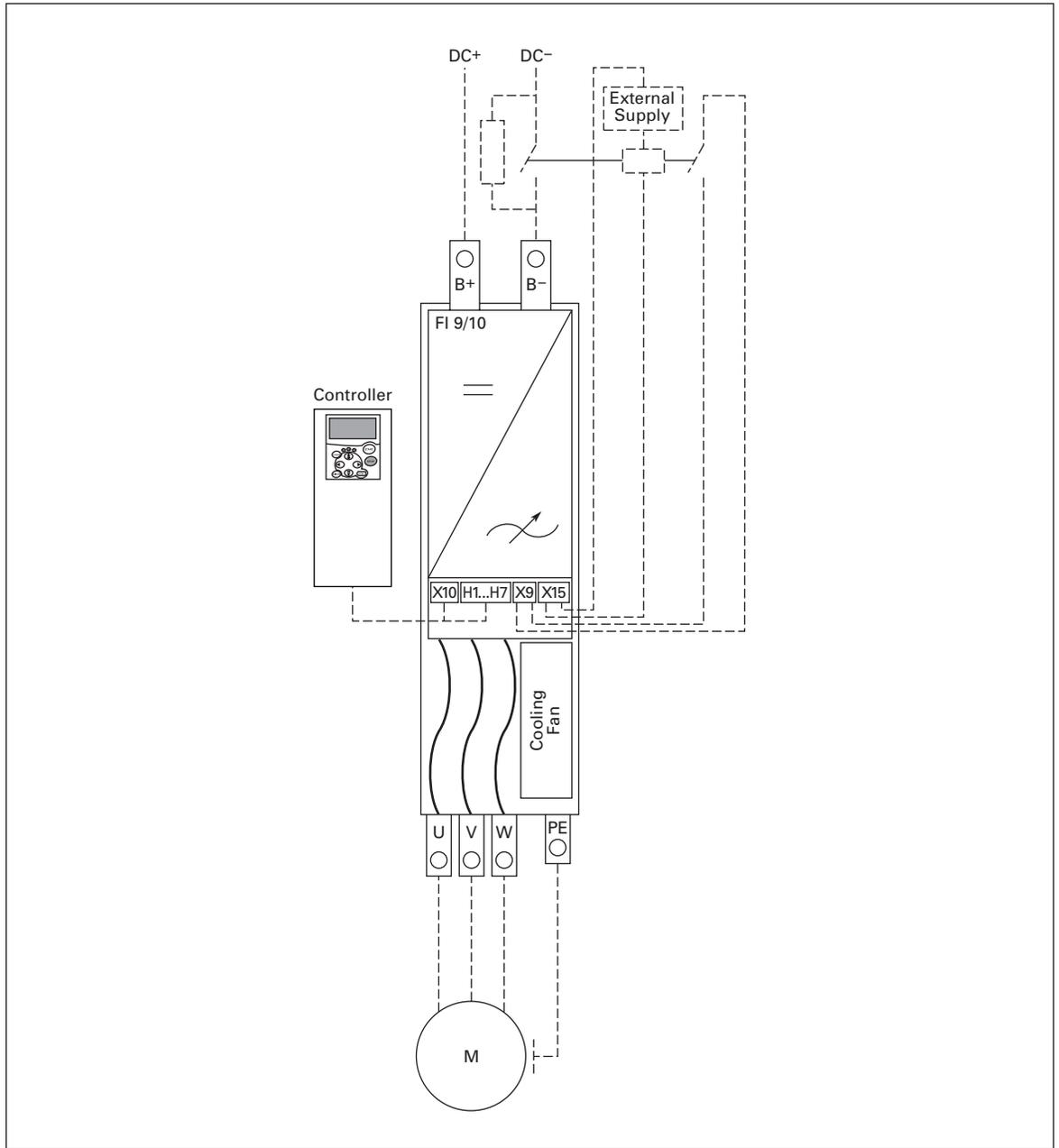
Figure 3-1: FI9/FI10 Basic Wiring Diagram with Charging

Figure 3-2: FI9/FI10 Basic Wiring Diagram without Charging

Figure 3-3: FI12 Basic Wiring Diagram with Charging

E:T·N | Cutler-Hammer

Figure 3-4: FI12 Basic Wiring Diagram without Charging

DC+ DC−   DC+   DC−   DC+   DC−

External Supply

B+ B−   B+   B−   B+   B−

FI 10 Module U   FI 10 Module V   FI 10 Module W

Controller

X10 | H1-7 | H903 | H900 | X9 | X15   X10 | H1-7 | H903 | H900 | X9 | X15

Cooling Fan   Cooling Fan   Cooling Fan

U   V   W   PE

M

Figure 3-5: FI13 Basic Wiring Diagram with Charging
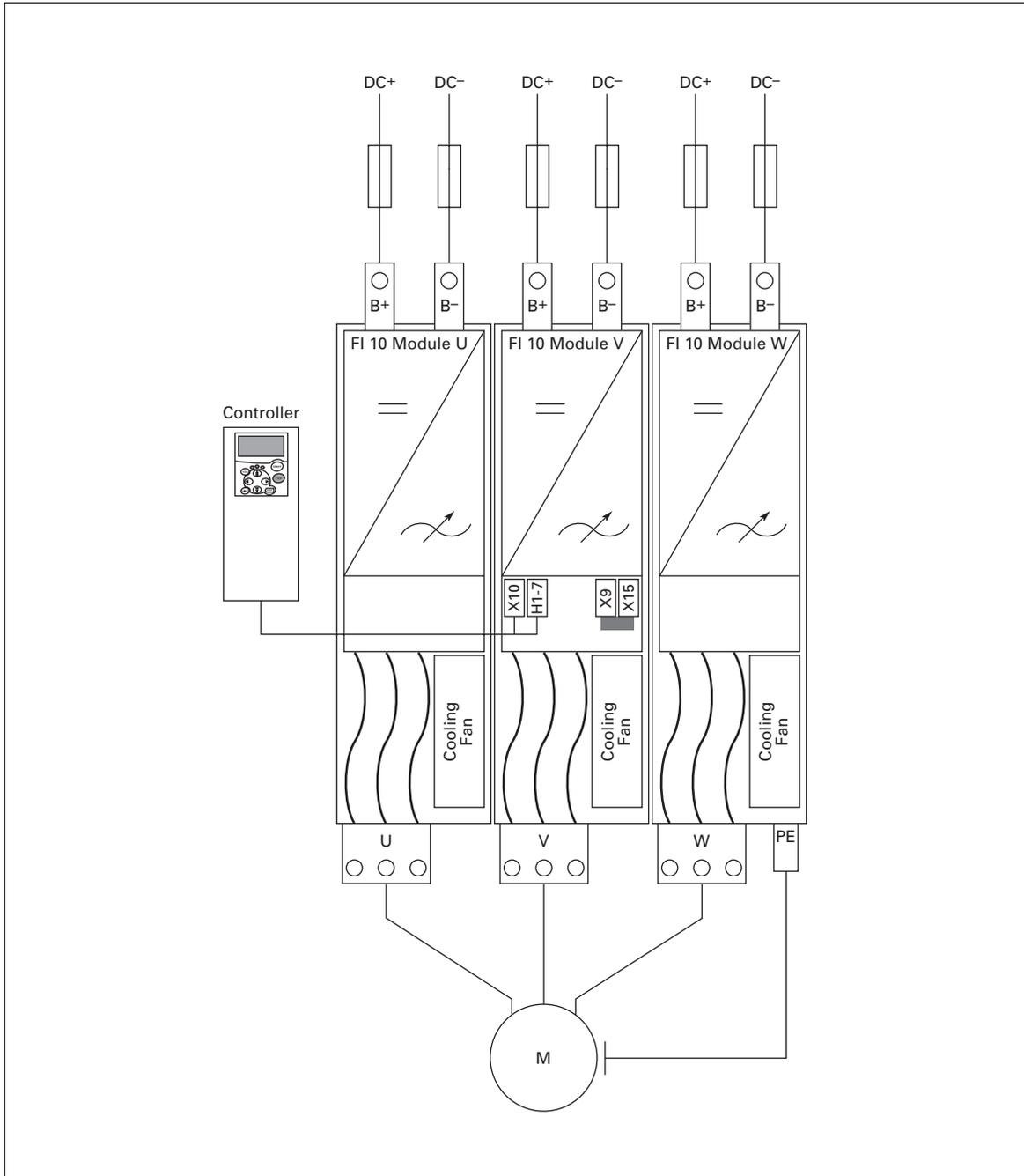
Figure 3-6: FI13 Basic Wiring Diagram without Charging

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DC+   DC−   DC+   DC−   DC+   DC−   DC+   DC−   DC+   DC−   DC+   DC−

External Supply

External Supply

B+   B−   B+   B−   B+   B−   B+   B−   B+   B−   B+   B−

FI 10 Module U   FI 10 Module V   FI 10 Module W   FI 10 Module U   FI 10 Module V   FI 10 Module W

Controller

X10 H1-7 H903 H900 X9 X15

X10 H1-7 H903 H900 X9 X15

Cooling Fan   Cooling Fan   Cooling Fan   Cooling Fan   Cooling Fan   Cooling Fan

U   V   W   PE   U   V   W   PE

Note: Min. Cable Length
(131.2′) 40m

M
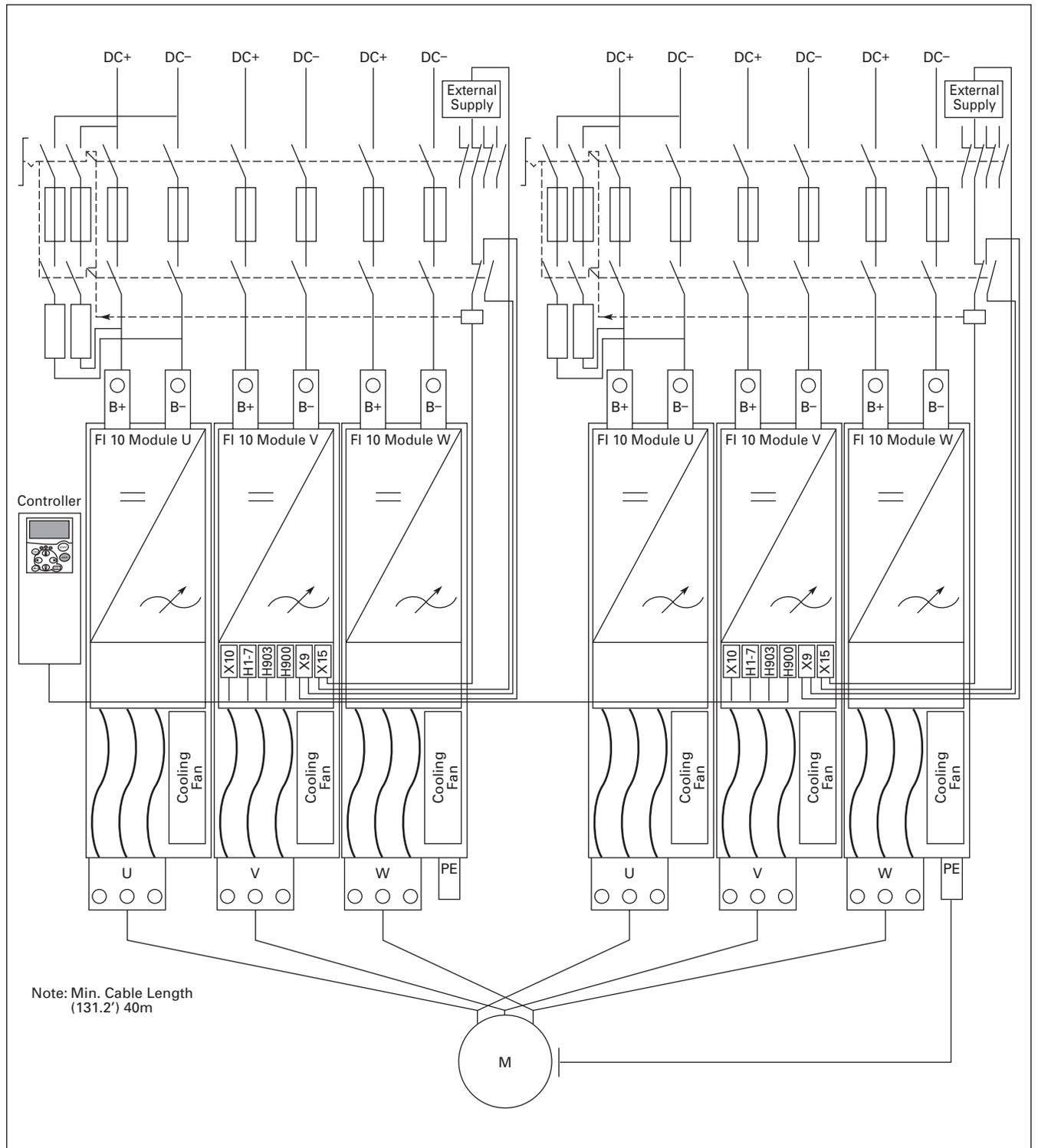
Figure 3-7: FI14 Basic Wiring Diagram with Charging
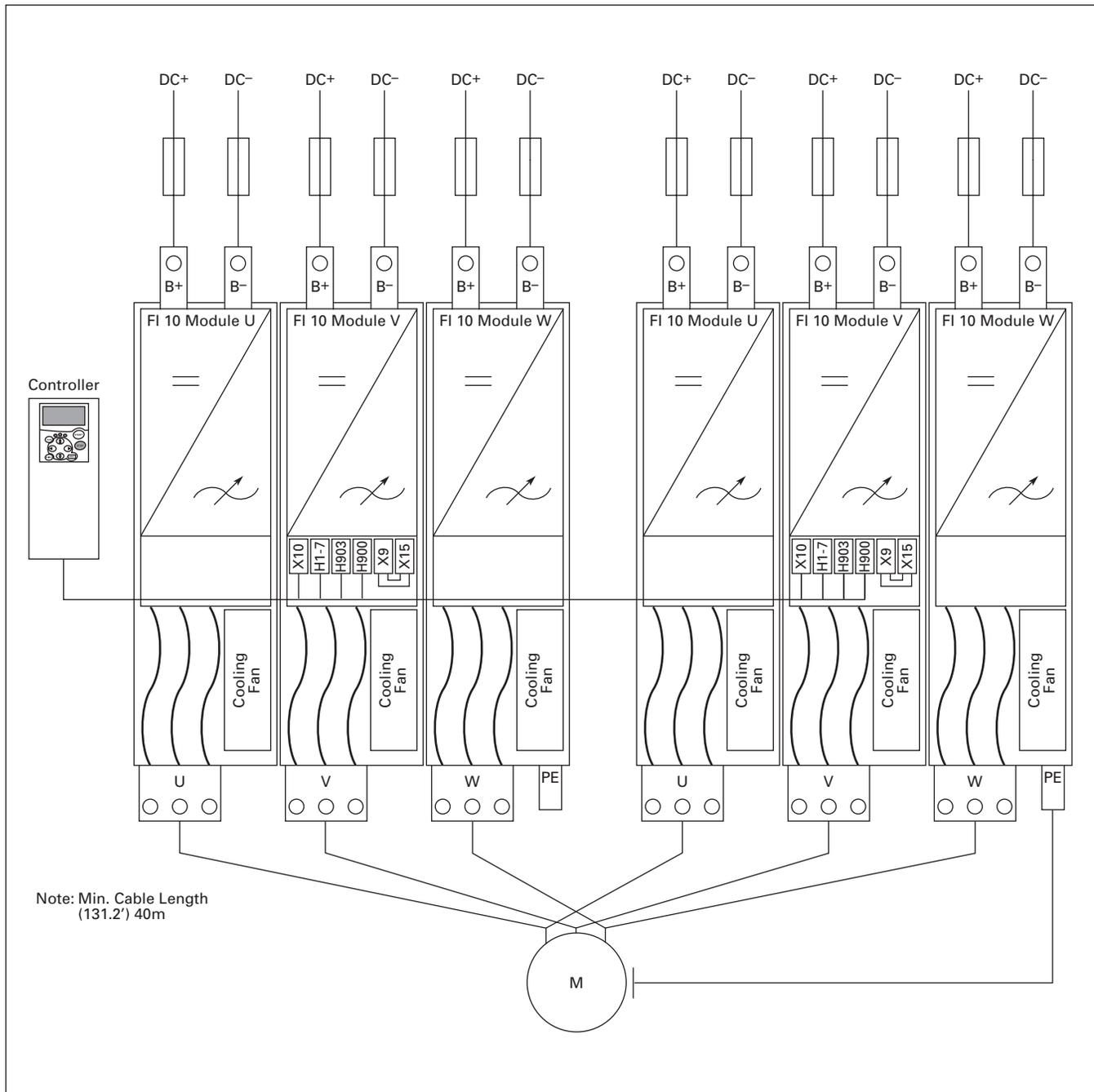
Figure 3-8: FI14 Basic Wiring Diagram without Charging

Power Connections

DC Supply and Motor Cables

The power cables are connected to terminals DC+ and DC- (R+/B+ and DC terminals when using an external charging circuit) and the motor cables to terminals U, V and W. A cable entry gland should be used at the motor cable end to reach the EMC levels, see **Table 3-2**.

Use cables with a heat resistance of at least +60C. The cables and the fuses must be sized according to the inverter nominal output current which you can find on the rating plate. Installation of cables according to UL regulations is presented on **Page 3-17** and aR fuse sizes in **Tables 3-2** and **3-3** below.

If the motor temperature protection of the drive is used as an overload protection, the cable shall be chosen accordingly. If three or more cables are used in parallel for bigger units, each cable requires a separate overload protection.

These instructions apply only to installations with one motor and one cable connection from the inverter to the motor. In any other case, ask the factory for more information.

Table 3-1: Cable Types Required to Meet Standards

Cable Type	EMC Level T
Supply Cable	Power cable intended for fixed installation and the specific DC voltage. Shielded cable not required.
Motor Cable	Power cable equipped with concentric protection wire and intended for the specific mains voltage.
Control Cable	Screened cable equipped with compact low-impedance shield.

Fuses, 465 – 800V DC Inverters

Table 3-2: Fuses Used in 465 – 800V DC Inverters

Nominal Current	Frame	Bussman aR Fuse Type	Fuse Size	Fuse U_n (V)	Fuse I_n (A)	No. of Fuses
140	FI9	170M3819	DIN1	690	400	2
170	FI9	170M3819	DIN1	690	400	2
205	FI9	170M6812	DIN3	690	800	2
245	FI9	170M6812	DIN3	690	800	2
300	FI10	170M8547	3SHT	690	1250	2
385	FI10	170M8547	3SHT	690	1250	2
460	FI10	170M8547	3SHT	690	1250	2
520	FI12	170M8547	3SHT	690	1250	4
590	FI12	170M8547	3SHT	690	1250	4
650	FI12	170M8547	3SHT	690	1250	4
730	FI12	170M8547	3SHT	690	1250	4
820	FI12	170M8547	3SHT	690	1250	4
920	FI12	170M8547	3SHT	690	1250	4
1030	FI13	170M8547	3SHT	690	1250	6
1150	FI13	170M8547	3SHT	690	1250	6
1300	FI13	170M8547	3SHT	690	1250	6
1600	FI14	170M8547	3SHT	690	1250	2 x 6
1940	FI14	170M8547	3SHT	690	1250	2 x 6
2300	FI14	170M8547	3SHT	690	1250	2 x 6

Fuses, 640 – 1100V DC Inverters

Table 3-3: Fuses Used in 640 – 1100V DC Inverters

Nominal Current	Frame	Bussman aR Fuse Type	Fuse Size	Fuse U_n (V)	Fuse I_n (A)	No. of Fuses
100	FI9	170M4199	1SHT	1250	400	2
125	FI9	170M4199	3SHT	1250	400	2
144	FI9	170M4199	3SHT	1250	400	2
170	FI9	170M4199	3SHT	1250	400	2
208	FI10	170M6305	3SHT	1250	700	2
261	FI10	170M6305	3SHT	1250	700	2
325	FI10	170M6277	3SHT	1250	1000	2
325	FI10	170M6277	3SHT	1250	1000	4
385	FI12	170M6305	3SHT	1250	700	4
460	FI12	170M6305	3SHT	1250	700	4
502	FI12	170M6305	3SHT	1250	700	4
590	FI12	170M6277	3SHT	1250	1000	4
650	FI12	170M6277	3SHT	1250	1000	4
650	FI12	170M6277	3SHT	1250	1000	4
820	FI13	170M6305	3SHT	1250	700	6
920	FI13	170M6277	3SHT	1250	1000	6
1030	FI13	170M6277	3SHT	1250	1000	6
1300	FI14	170M6277	3SHT	1250	1000	2 x 6
1500	FI14	170M6277	3SHT	1250	1000	2 x 6
1900	FI14	170M6277	3SHT	1250	1000	2 x 6

Information about fuses:

gR fuses are designed to protect the device against both overcurrent and short circuits.

aR fuses protect the cables of the device against short circuits.

gG fuses are generally used to protect cables against overcurrent and short circuits.

Inverter Supply and Motor Cables — 380 – 500V AC

Table 3-4: Cable Sizes for 380 – 500V AC

Nominal Current	Frame	I_L [A]	Module Supply (DC) (per terminal Cu [mm^2]	Motor Cable [mm^2]
140	FI9	170	2x(1x24) [1]	Cu: 3x95+50 Al: 3x120+70
170		205	2x(1x24) [1]	Cu: 3x150+70 Al: 3x240Al+72Cu
205		261	3x(1x24) [1]	Cu: 3x185+95 Al: 2x(3x120+70)
245		300	6x(1x24) [1]	Cu: 2x(3x120+70) Al: 2x(3x185Al+57Cu)
300	FI10	385	5x40 [2]	Cu: 2x(3x120+70) Al: 2x(3x185Al+57Cu)
385		460	5x40 [2]	Cu: 2x(3x150+70) Al: 2x(3x240Al+72Cu)
460		520	6x40 [2]	Cu: 2x(3x185+95) Al: 2x(3x300Al+88Cu)
520	FI12 [3]	590	5x40 [2]	Cu: 2x(3x240+120) Al: 4x(3x120Al+41Cu)
590		650	5x40 [2]	Cu: 4x(3x95+50) Al: 4x(3x150Al+41Cu)
650		730	5x40 [2]	Cu: 4x(3x120+70) Al: 4x(3x185Al+57Cu)
730		820	5x40 [2]	Cu: 4x(3x150+70) Al: 4x(3x185Al+57Cu)
820		920	5x40 [2]	Cu: 4x(3x150+70) Al: 4x(3x240Al+72Cu)
920		1030	6x40 [2]	Cu: 4x(3x185+95) Al: 4x(3x300Al+88Cu)
1030	FI13	1150	5x40 [2]	Cu: 4x(3x240+170) Al: 6x (3x185Al+57Cu)
1150		1300	5x40 [2]	Cu: 6x(3x150+70) Al: 6x (3x240Al+70Cu)
1300		1450	6x40 [2]	Cu: 6x(3x185+95) Al: 6x (3x240Al+70Cu)
1600	FI14 [3]	1770	5x40 [2]	Cu: 2x 4x(3x240+170) Al: 2x 6x (3x185Al+57Cu)
1940		2150	5x40 [2]	Cu: 2x 6x(3x150+70) Al: 2x 6x (3x240Al+70Cu)
2300		2700	6x40 [2]	Cu: 2x 6x(3x185+95) Al: 2x 6x (3x240Al+70Cu)

[1] Flexible conductor. Minimum temperature endurance for isolation 70°C.

[2] Copper busbar.

[3] The modules require symmetrical parallel cable with minimum length 40m or dU/dt- or sinus filter.

Table valid for enclosure class IP20 cabinets.
Motor cables — EN 60204-1, IEC 60364-5-2/2001

– PVC insulation

– 40°C ambient temperature

– 70°C surface temperature

Terminal Sizes — 380 – 500V AC

Table 3-5: Terminal Sizes for 380 – 500V AC

Nominal Current	Frame	I_L [A]	Approximate Dimensions in Inches (mm)	
			DC Supply Terminal	Motor Cable Terminal
140	FI9	170	PE: M8 x 25	
170		205		
205		261		
245		300		
300	FI10	385	PE: M8 x 25	
385		460		
460		520		
520	FI12	590	PE: M8 x 25	
590		650		
650		730		
730		820		
820		920		
920		1030		
1030	FI13	1150	.51 (13), 1.57 (40), .63 (16), 1.97 (50)	.51 (13), 1.57 (40), .67 (17), 1.50 (38)
1150		1300		
1300		1450		

Inverter Supply and Motor Cables — 525 – 690V AC

Table 3-6: Cable Sizes for 525 – 690V AC

Nominal Current	Frame	I_L [A]	Module Supply (DC) (per terminal Cu [mm^2]	Motor Cable [mm^2]
100	FI9	125	2x(1x24) [1]	Cu: 3x95+50 Al: 3x120+70
125		144	2x(1x24) [1]	Cu: 3x95+50 Al: 3x120+70
144		170	2x(1x24) [1]	Cu: 3x95+50 Al: 3x120+70
170		208	2x(1x24) [1]	Cu: 3150+70 Al: 3x240Al+72Cu
208	FI10	261	3x(1x24) [2]	Cu: 3x185+95 Al: 2x(3x95Al+29Cu)
261		325	5x40 [2]	Cu: 2x(3x95+50) Al: 2x(3x150Al+41Cu)
325		385	5x40 [2]	Cu: 2x(3x120+70) Al: 2x(3x185Al+57Cu)
325		416	5x40 [2]	Cu: 2x(3x150+70) Al: 2x(3x185Al+57Cu)
385	FI12 [3]	460	5x40 [2]	Cu: 2x(3x150+70) Al: 2x(3x240Al+72Cu)
460		502	5x40 [2]	Cu: 2x(3x185+95) Al: 2x(3x300Al+88 Cu)
502		590	5x40 [2]	Cu: 2x(3x240+120) Al: 4x(3x120Al+41Cu)
590		650	5x40 [2]	Cu: 4x(3x95+50) Al: 4x(3x150Al+41Cu)
650		750	5x40 [2]	Cu: 4x(3x120+70) Al: 4x(3x150Al+41Cu)
650		820	5x40 [2]	Cu: 4x(3x150+70) Al: 4x(3x185Al+57Cu)
820	FI13	920	5x40 [2]	Cu:4x(3x150+70) Al:4x(3x2405+72Cu)
920		1030	5x40 [2]	Cu:4x(3x185+95) Al:5x(3x185+57Cu)
1030		1180	5x40 [2]	Cu:5x(3x185+95) Al:6x(3x185+72Cu)
1300	FI14 [3]	1500	5x40 [2]	Cu: 2x4x(3x120+70) Al: 2x4x(3x150Al+41Cu)
1500		1900	5x40 [2]	Cu: 2x4x(3x185+95) Al: 2x5x(3x185+57Cu)
1900		2250	5x40 [2]	Cu: 2x5x(3x185+95) Al: 2x6x(3x185+72Cu)

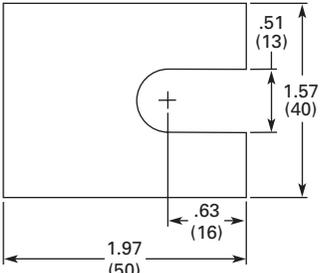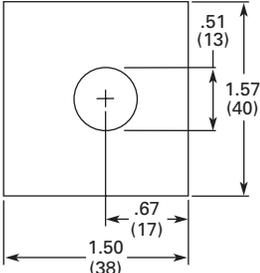[1] Flexible conductor. Minimum temperature endurance for isolation 70°C.
[2] Copper busbar.
[3] The modules require symmetrical parallel cable with minimum length 40m or dU/dt- or sinus filter.

Table valid for enclosure class IP20 cabinets.
Motor cables — EN 60204-1, IEC 60364-5-2/2001
  – PVC insulation
  – 40°C ambient temperature
  – 70°C surface temperature

Terminal Sizes — 525 – 690V AC

Table 3-7: Terminal Sizes for 525 – 690V AC

Nominal Current	Frame	I_L [A]	Approximate Dimensions in Inches (mm)	
			DC Supply Terminal	Motor Cable Terminal
100	FI9	125	.51 (13); 1.57 (40); .63 (16); 1.38 (35)	.51 (13); 1.57 (40); .67 (17); 1.50 (38)
125		144		
144		170		
170		208		
208	FI10	261	.51 (13); 1.57 (40); .63 (16); 1.97 (50)	.51 (13); 1.57 (40); .67 (17); 1.50 (38)
261		325		
325		385		
325		416		
385	FI12	460	.51 (13); 1.57 (40); .63 (16); 1.97 (50)	.51 (13); 1.57 (40); .67 (17); 1.50 (38)
460		502		
502		590		
590		650		
650		750		
650		820		
820	FI13	920	.51 (13); 1.57 (40); .63 (16); 1.97 (50)	.51 (13); 1.57 (40); .67 (17); 1.50 (38)
920		1030		
1030		1180		

Installation Instructions

1. Before starting the installation, check that none of the components of the inverter are live.

2. If the inverter is installed outside the cubicle, cabinet or device space, you need to install a separate inverter cover in accordance with protection class IP21 requirements (see **Page 3-16**. There is no need to install the inverter cover if the inverter is installed in a cubicle, separate cabinet or device space.

3. Place the motor cables sufficiently far from other cables:
   – Avoid placing the motor cables in long parallel lines with other cables
   – If the motor cables runs in parallel with other cables, note the minimum distances between the motor cables and other cables given in **Table 3-8**.
   – The given distances also apply between the motor cables and signal cables of other systems.
   – The maximum length of the motor cables is 984 feet (300m) (units with power greater than 1.5 kW) and 328 feet (100m) (units with power from 0.75 to 1.5 kW).
   – The motor cables should cross other cables at an angle of 90 degrees.

Table 3-8: Cable Distances

Distance Between Cables in Inches (m)	Shielded Cable in Feet (m)
11.8 (.3) 39.4 (1.0)	≥ 193 (59) ≤ 656 (200)

4. If cable insulation checks are needed, see **Page 3-17**.

5. Connect the cables:
   – Strip the motor and DC supply cables.
   – Remove the screws of the cable protection plate. Do not open the cover of the power unit!
   – Make holes into and pass the cables through the rubber grommets on the bottom of the power unit. The rubber grommets are delivered in a separate bag.
   – Connect the DC supply, motor and control cables into their respective terminals.
   – For information on the installation of greater units, please contact Eaton or your local distributor.
   – For Information on cable installation according to UL regulations, see **Page 3-17**.
   – For information on cable installation according to EMC regulations, see **Table 3-1**.
   – Make sure that the control cable wires do not come in contact with the electronic components of the unit.
   – If an external brake resistor (optional) is used, connect its cable to the appropriate terminal.
   – Check the connection of the ground cable to the motor and the inverter terminals marked with ⏚ .
   – Connect the separate shield of the power cable to the ground terminals of the inverter, motor and the supply center.
   – Attach the cable protection plate with the screws.
   – Ensure that the control cables or the cables of the unit are not trapped between the frame and the protection plate.

Frame Sizes

Inverter Frame FI9, Protection Class IP00

Inverter Frame FI10, Protection Class IP00

Inverter Frame FI12, Protection Class IP00

Inverter Frame FI13, Protection Class IP00

Cable Installation and the UL Standards

To meet the UL (Underwriters Laboratories) regulations, a UL approved copper cable with a minimum heat-resistance of +60/75°C must be used.

The tightening torques of the terminals are given below in **Table 3-9**.

Table 3-9: Terminal Tightening Torques

Nominal Current	Voltage	Frame	Tightening Torque in in-lb (Nm) [1]
140 – 245 100 – 170	380 – 500V 525 – 690V	FI9	340 (40)
300 – 460 208 – 325	380 – 500V 525 – 690V	FI10	340 (40)
520 – 920 385 – 650	380 – 500V 525 – 690V	FI12	340 (40)
1030 – 1300 920 – 1030	380 – 500V 525 – 690V	FI13	340 (40)
1600 – 2300 1300 – 1900	380 – 500V 525 – 690V	FI14	340 (40)

[1] Tightening torque of terminal connection to the isolative base.

Note: Apply counter torque to the nut on the other side of the terminal when tightening/ loosening the terminal screw in order to avoid damage to the terminal.

Cable and Motor Insulation Checks

1. Motor cable insulation checks

   Disconnect the motor cable from terminals U, V and W of the inverter and from the motor. Measure the insulation resistance of the motor cable between each phase conductor as well as between each phase conductor and the protective ground conductor.

   The insulation resistance must be >1MΩ.

2. DC supply cable insulation checks

   Disconnect the DC supply cable from terminals B- and B+ of the inverter and from DC supply. Measure the insulation resistance between each conductor and ground.

   The insulation resistance must be >1MΩ.

3. Motor insulation checks

   Disconnect the motor cable from the motor and open the bridging connections in the motor connection box. Measure the insulation resistance of each motor winding. The measurement voltage must equal at least the motor nominal voltage but not exceed 1,000V.
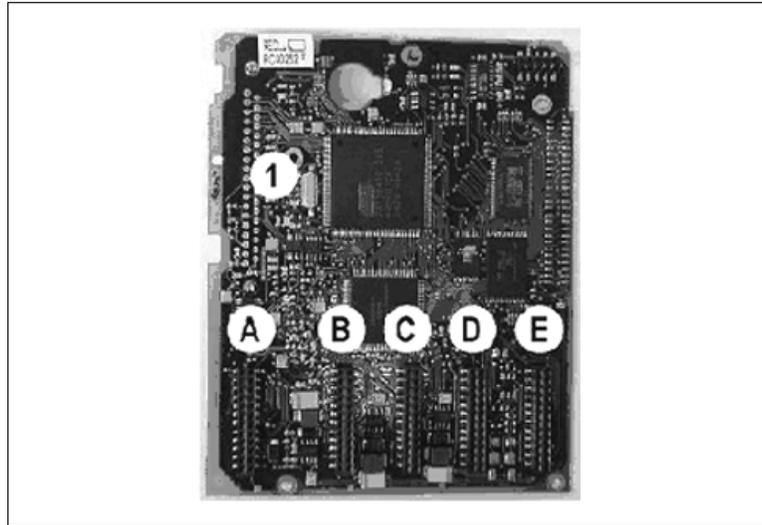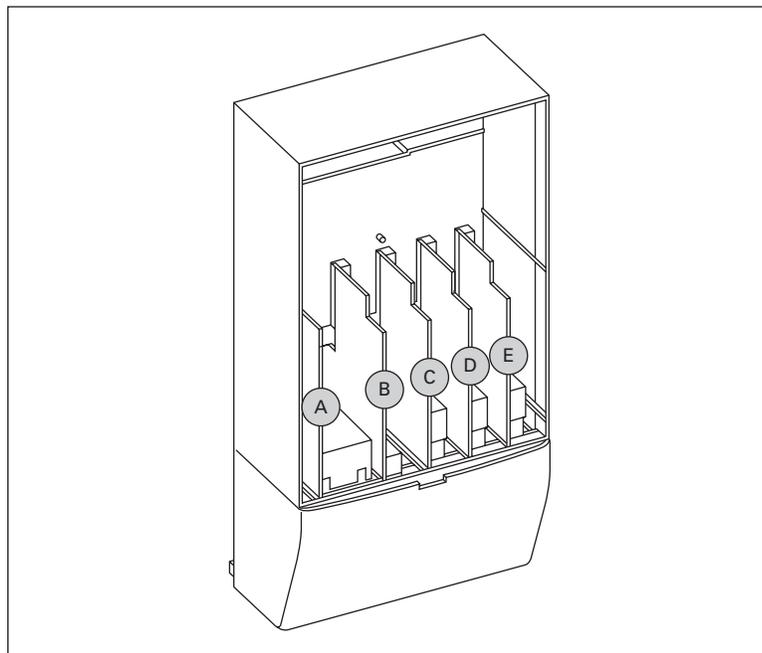
   The insulation resistance must be >1MΩ.

Chapter 4 — Control Wiring

The control unit of the inverter consists of the control board and option boards (see **Figures 4-1** and **4-2**) connected to the five slot connectors (A to E) on the control board. The control board is connected to the power unit through a D connector (1).


Figure 4-1: Control Board

Figure 4-2: Basic and Option Board Connections of the Control Board

When the inverter is delivered from the factory, the control unit usually includes two basic boards (I/O board and relay board), which are normally installed in slots A and B. On the next pages you will find the arrangement of the control I/O and the relay terminals of the two basic boards, the general wiring diagram and the control signal descriptions. The I/O boards mounted at the factory are indicated in the type code. For more information on the option boards, see the option board user manual.

The control board can be powered externally (+24V) by connecting the external power source to bidirectional terminal #6 (see **Figure 4-5)**. This voltage is sufficient for parameter setting and for keeping the fieldbus active.

Note: If the +24V input of several inverters are connected in parallel, we recommend to use a diode in terminal #6 to avoid the current flowing in opposite direction, which might damage the control board.
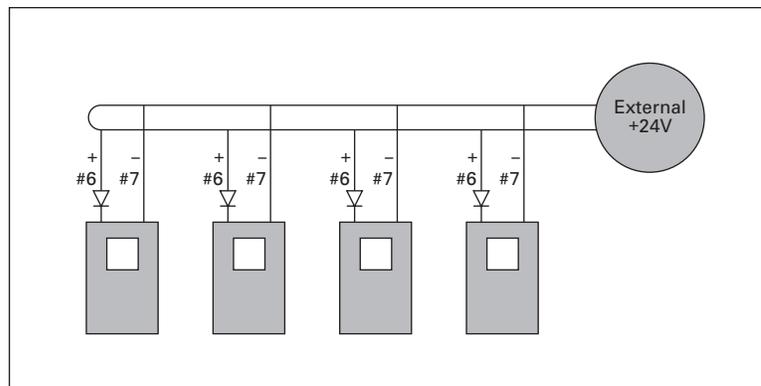
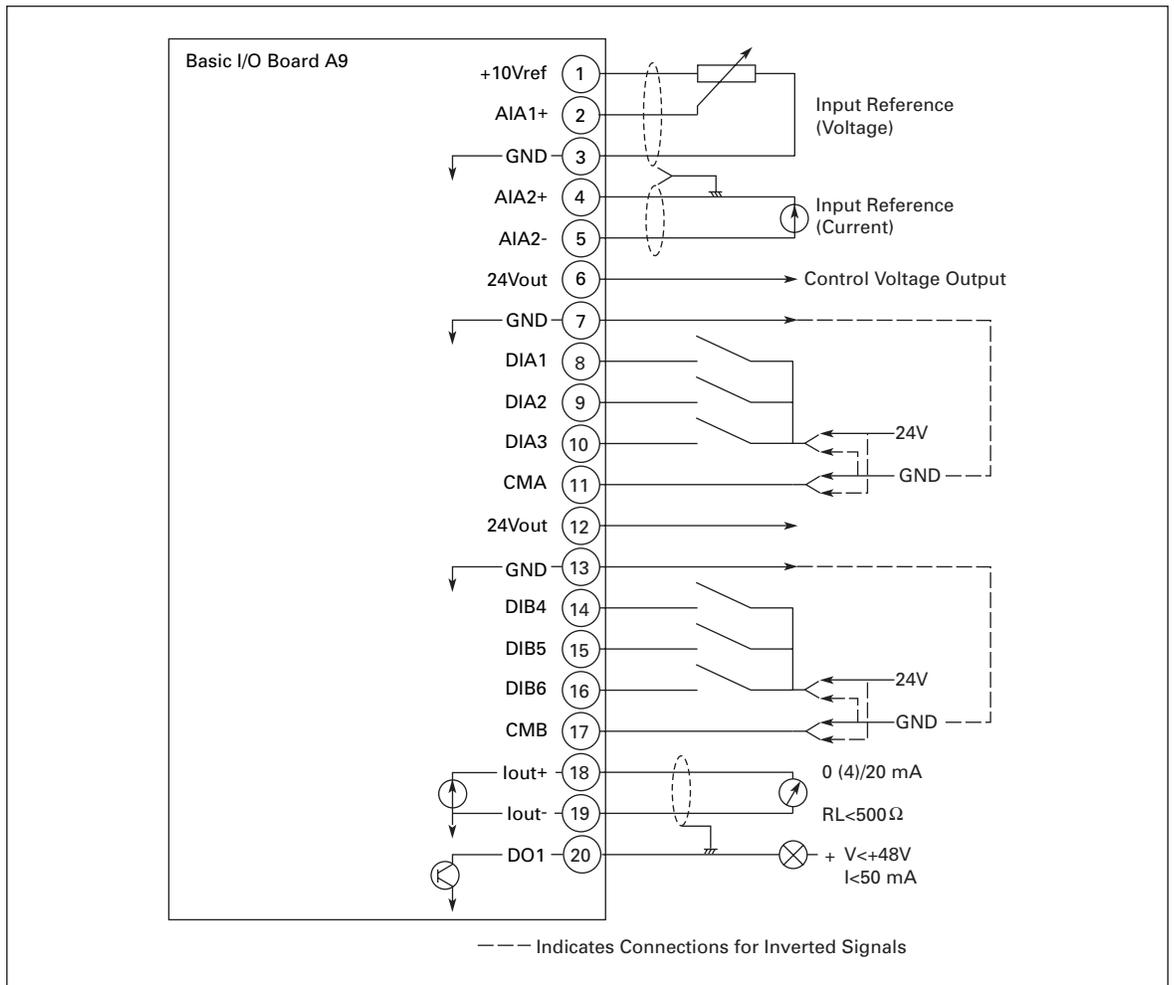**Figure 4-3: Inverters Connected in Parallel**

Control Wiring Details

The basic control connections for boards A2 and A3 are shown in **Figures 4-6** and **4-7**.

You can find the signal descriptions for applications in the application manual.
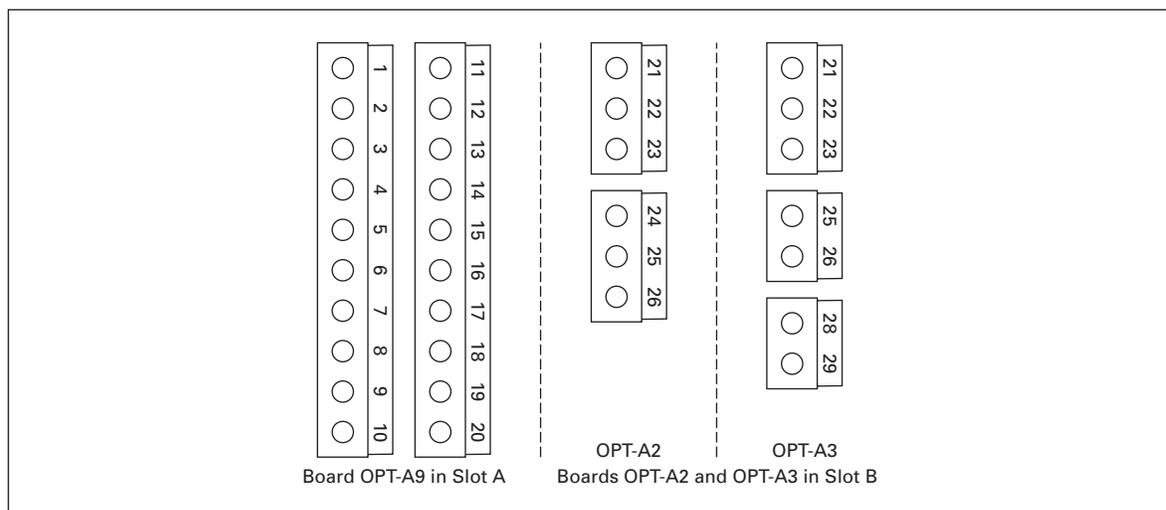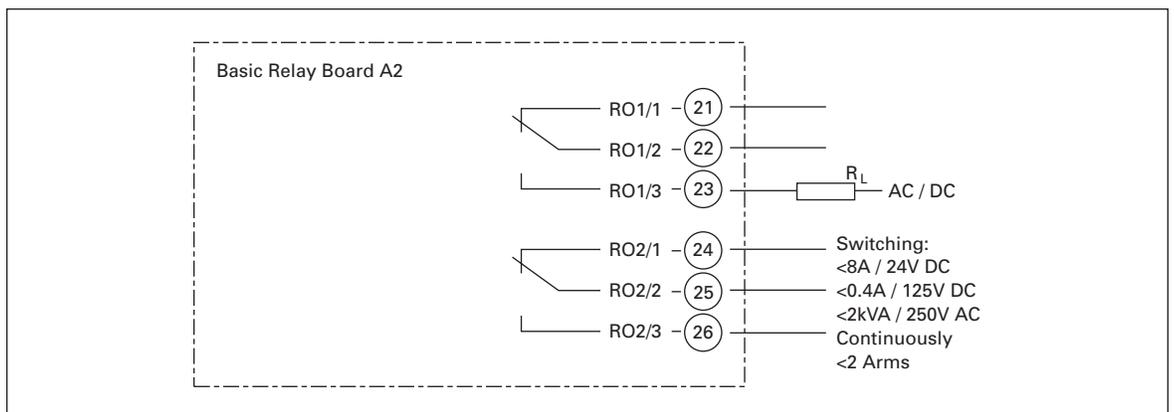

Figure 4-4: I/O Terminals of the Two Basic Boards

Figure 4-5: Option Board A9 Wiring Diagram

Figure 4-6: Option Board A2 Wiring Diagram
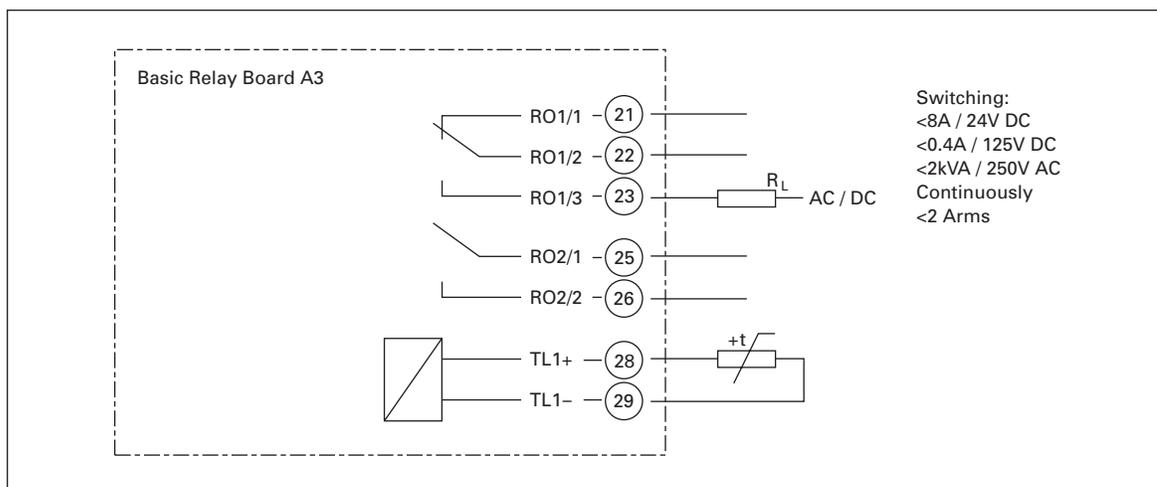
Figure 4-7: Option Board A3 Wiring Diagram

Control Cables

The control cables shall be at least 20 AWG screened multicore cables, see **Table 4-1**. The maximum terminal wire size is 14 AWG for the relay terminals and 16 AWG for other terminals.

You can find the tightening torques of the option board terminals in **Table 4-1**.

Table 4-1: Tightening Torques of Option Board Terminals

Terminal Screw	Tightening Torque lb-in.
Relay and thermistor terminals (screw M3)	4.5
Other terminals (screw M2.6)	1.8

Galvanic Isolation Barriers

The control connections are isolated from the mains potential and the GND terminals are permanently connected to ground. See **Figure 4-8**.

The digital inputs are galvanically isolated from the I/O ground. the relay outputs are also double-isolated from each other at 300V AC (EN-50178).
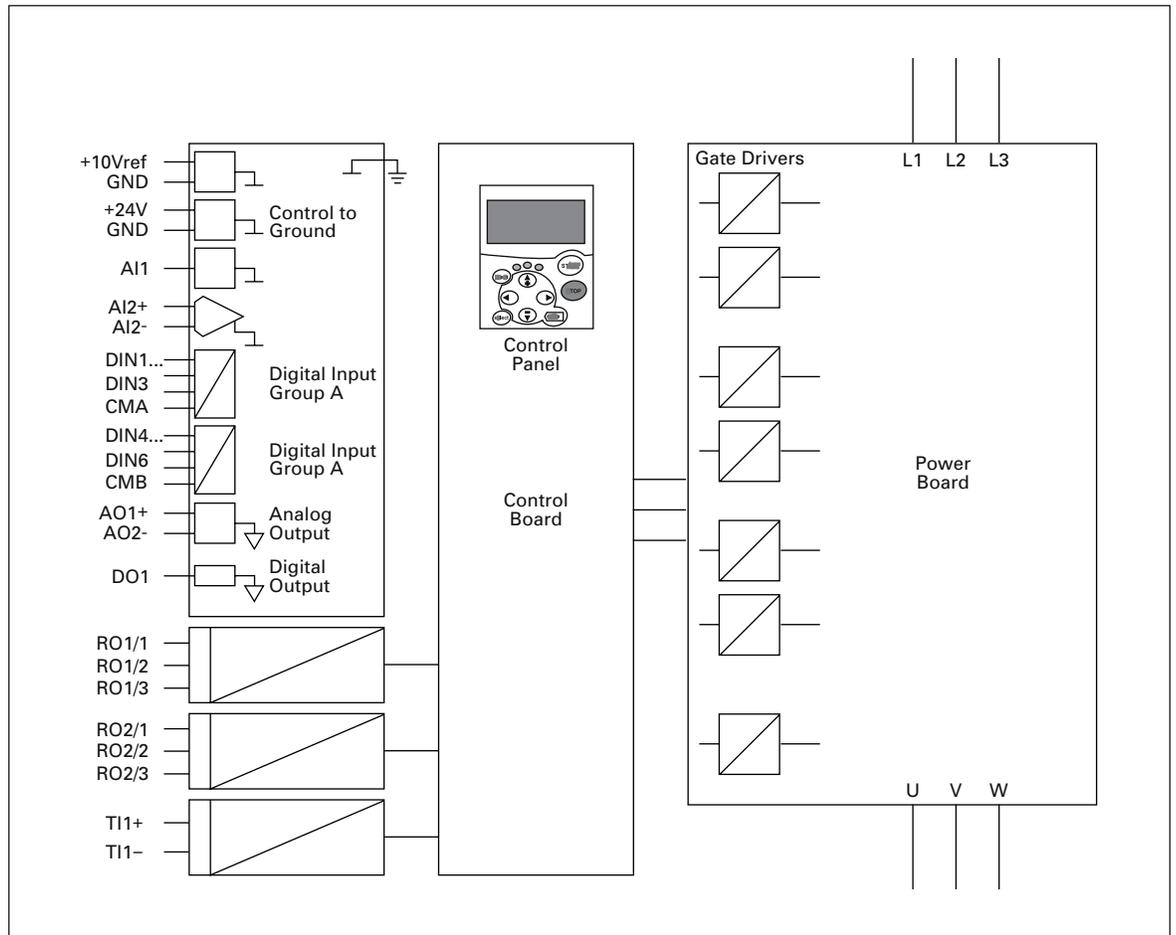
Figure 4-8: Galvanic Isolation Barriers

Table 4-2: Control I/O Terminal Signals on Option Board A9

Terminal		Signal	Technical Information
1	+10 Vref	Reference voltage	Maximum current 10 mA
2	AI1+	Analog input, voltage or current	Selection V or mA with jumper block X1 (see **Page 4-8**) Default: 0 to +10V (Ri = 200 kΩ) (-10V to +10V Joy-stick control, selected with a jumper) 0 to 20 mA (Ri = 250 Ω) Differential input if not connected to ground; Allows ±20V differential mode voltage to GND
3	GND/AI1–	Analog input common	
4	AI2+	Analog input, voltage or current	Selection V or mA with jumper block X1 (see **Page 4-8**): Default: 0 to 20 mA (Ri = 250 Ω) 0 to +10V (Ri = 200 kΩ) (10V to +10V Joy-stick control, selected with a jumper) Differential input if not connected to ground; Allows ±20V differential mode voltage to GND
5	GND/AI2–	Analog input common	
6	24 Vout (bidirectional)	24V auxiliary voltage	±15%; maximum current 250 mA all boards total; 150 mA from single board. Can also be used as external power backup for the control unit (and fieldbus).
7	GND	I/O ground	Ground for reference and controls
8	DIN1	Digital input 1	R_i = min. 5kΩ 18 – 30V = "1"
9	DIN2	Digital input 2	
10	DIN3	Digital input 3	
11	CMA	Digital input common A for DIN1, DIN2 and DIN3.	Must be connected to GND or 24V of I/O terminal or to external 24V or GND Selection with jumper block X3 (see **Page 4-8**)
12	24 Vout (bidirectional)	24V auxiliary voltage	Same as terminal #6
13	GND	I/O ground	Same as terminal #7
14	DIN4	Digital input 4	R_i = min. 5kΩ 18 – 30V = "1"
15	DIN5	Digital input 5	
16	DIN6	Digital input 6	
17	CMB	Digital input common B for DIN4, DIN5 and DIN6	Must be connected to GND or 24V of I/O terminal or to external 24V or GND Selection with jumper block X3 (see **Page 4-8**)
18	AO1+	Analog signal (+output)	Output signal range: Current 0(4) – 20 mA, R_L max. 500Ω or Voltage 0 – 10V, R_L >1kΩ Selection with jumper block X3 (see **Page 4-8**)
19	AO1-	Analog output common	
20	DO1	Open collector output	Maximum U_{in} = 48V DC Maximum current = 50 mA

Table 4-3: Control I/O Terminal Signals on Option Board A2

OPTA2				
21	RO1/1	Relay output 1	Switching capacity	24V DC/8A 250V AC/8A 125V DC/0.4A
22	RO1/2			
23	RO1/3		Min. switching load	5V/10 mA
24	RO2/1	Relay output 2	Switching capacity	24V DC/8A 250V AC/8A 125V DC/0.4A
25	RO2/2			
26	RO2/3		Min. switching load	5V/10 mA

Table 4-4: Control I/O Terminal Signals on Option Board A3

OPTA3				
21	RO1/1	Relay output 1	Switching capacity	24V DC/8A 250V AC/8A 125V DC/0.4A
22	RO1/2			
23	RO1/3		Min. switching load	5V/10 mA
24	RO2/1	Relay output 2	Switching capacity	24V DC/8A 250V AC/8A 125V DC/0.4A
25	RO2/2			
26	RO2/3		Min. switching load	5V/10 mA
28	TI1+	Thermistor input		
29	TI1-			

Digital Input Signal Inversions

The active signal level depends on which potential the common inputs CMA and CMB (terminals 11 and 17) are connected to. The alternatives are either +24V or ground (0V). See **Figure 4-9**.

We recommend the use of positive logic in all control connections of the inverter. If negative logic is used, additional appropriate measures are needed to meet the safety regulation requirements.

The 24 volt control voltage and the ground for the digital inputs and the common inputs (CMA, CMB) can be either internal or external.
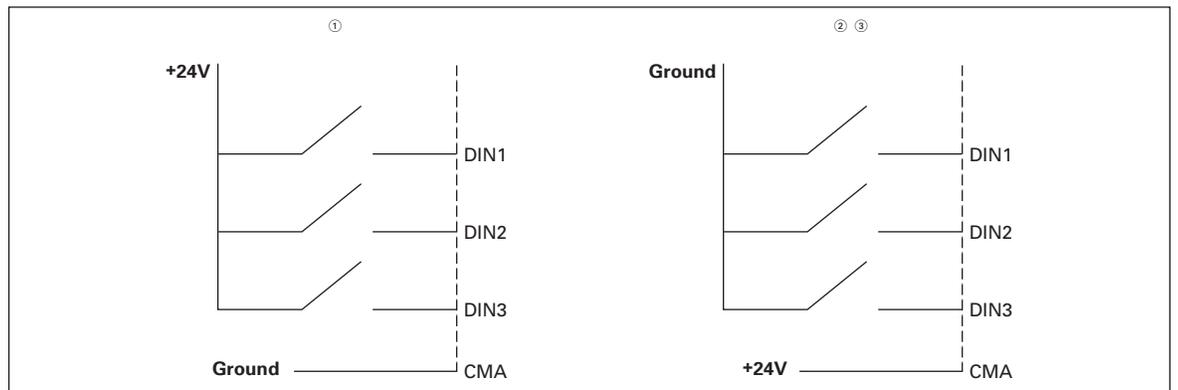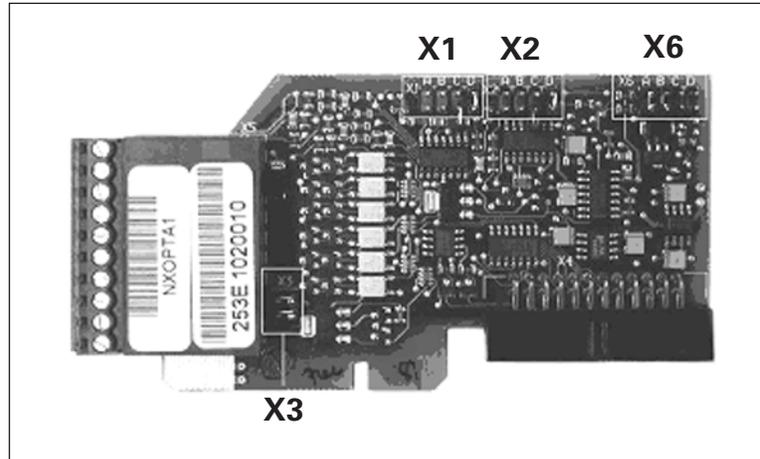

Figure 4-9: Positive/Negative Logic

① Positive logic (+24V is the active signal) = Input is active when the switch is closed.
② Negative logic (0V is the active signal) = Input is active when the switch is closed.
③ Requires setting of jumper X3 to position "CMA/CMB isolated from ground."

Jumper Selections on Option Board A9

The user can customize the functions of the inverter to better suit his needs by selecting certain positions for the jumpers on the OPTA9 board. The positions of the jumpers determine the signal type of analogue and digital inputs.

On the A9 basic board, there are four jumper blocks (X1, X2, X3 and X6), each containing eight pins and two jumpers. The selection possibilities of the jumpers are shown in **Figure 4-11**.

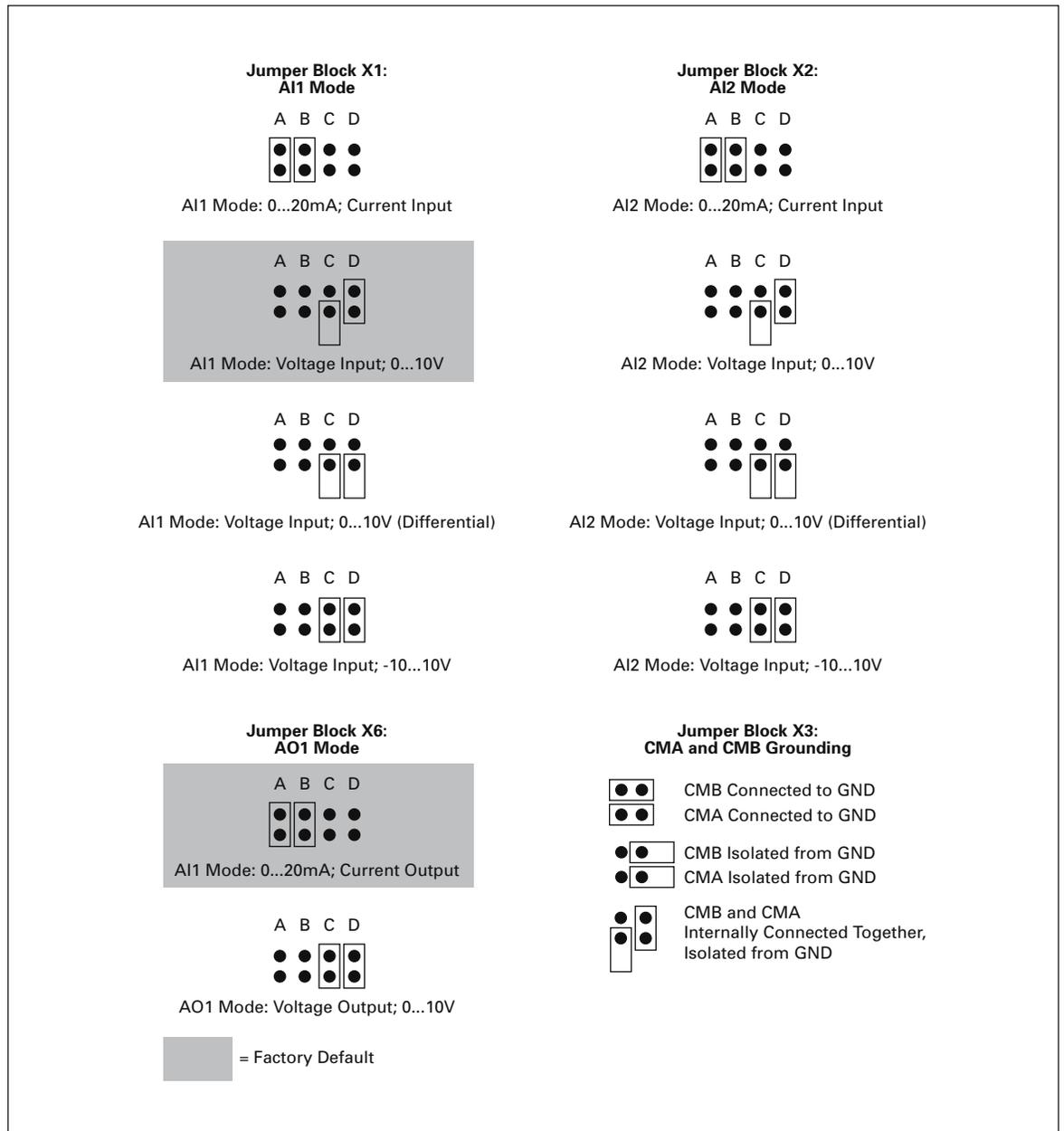**Figure 4-10: Jumper Blocks on Option Board A9**

**Jumper Block X1:
AI1 Mode**

A B C D

AI1 Mode: 0...20mA; Current Input

A B C D

AI1 Mode: Voltage Input; 0...10V

A B C D

AI1 Mode: Voltage Input; 0...10V (Differential)

A B C D

AI1 Mode: Voltage Input; -10...10V

**Jumper Block X6:
AO1 Mode**

A B C D

AI1 Mode: 0...20mA; Current Output

A B C D

AO1 Mode: Voltage Output; 0...10V

= Factory Default

**Jumper Block X2:
AI2 Mode**

A B C D

AI2 Mode: 0...20mA; Current Input

A B C D

AI2 Mode: Voltage Input; 0...10V

A B C D

AI2 Mode: Voltage Input; 0...10V (Differential)

A B C D

AI2 Mode: Voltage Input; -10...10V

**Jumper Block X3:
CMA and CMB Grounding**

CMB Connected to GND
CMA Connected to GND

CMB Isolated from GND
CMA Isolated from GND

CMB and CMA
Internally Connected Together,
Isolated from GND

Figure 4-11: Jumper Selection for Option Board A9

⚠ **CAUTION**

Ensure that the jumper positions are correct. Running the motor with signal settings that differ from the jumper positions will not harm the inverter, but may harm the motor.

Note: If you change the AI/AO signal content, remember to change the corresponding board parameter in Menu M7.

Chapter 5 — Menu Information

Keypad Operation

The control keypad is the link between the SPI9000 inverter and the user. The control keypad features an alphanumeric display with seven indicators for the Run status (RUN, counter-clockwise, clockwise, READY, STOP, ALARM, FAULT) and three indicators for the control place (I/O term/Keypad/BusComm). There are also three Status Indicator LEDs (green – green – red), see **Page 5-3**.

The control information, i.e. the menu number, description of the menu or the displayed value and the numeric information are presented on three text lines.

The inverter is operable through the nine pushbuttons of the control keypad. Furthermore, the buttons can be used in setting parameters and monitoring values.

The keypad is detachable and isolated from the input line potential.

Indicators on the Keypad Display
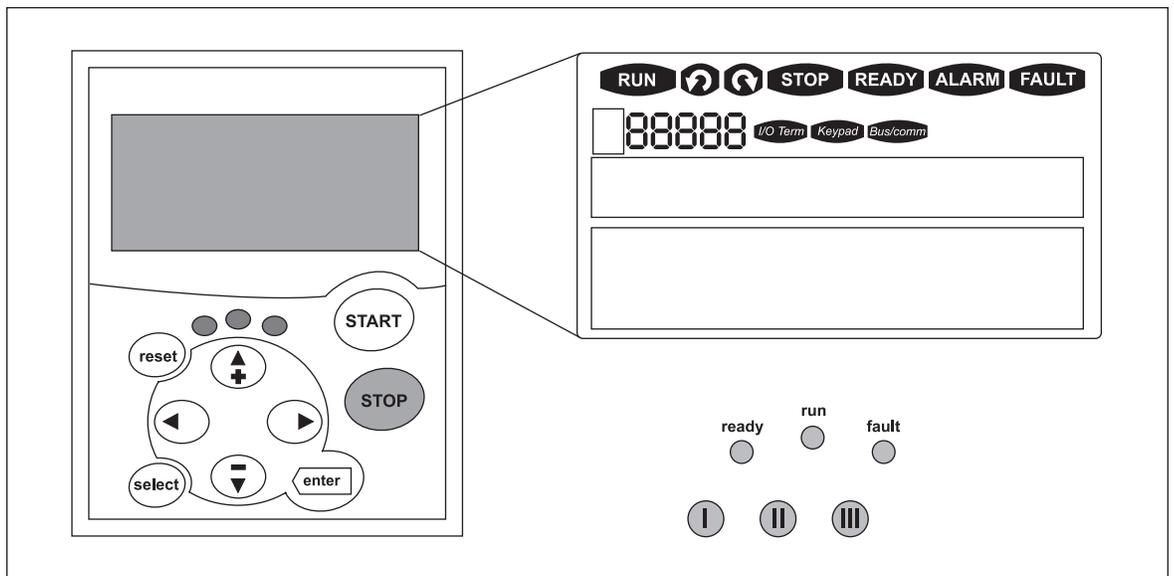
Figure 5-1: Control Keypad and Drive Status Indications

Drive Status Indicators

The drive status symbols tell the user the status of the motor and the inverter. In addition, they tell about possible irregularities detected by the motor control software in motor or inverter functions.

Table 5-1: Drive Status Indicators

Indicator	Description
RUN	Motor is running. Blinks when the stop command is given, but the frequency is still ramping down.
	Indicates the direction of motor rotation.
STOP	Indicates that the drive is not running.
READY	Lights up when AC power is on. In case of a trip, the symbol will not light up.
ALARM	Indicates that the drive is running outside a certain limit and a warning is given.
FAULT	Indicates that unsafe operating conditions are encountered and the drive was stopped.

Control Place Indicators

The symbols I/O Term, Keypad and Bus/Comm (see **Table 5-2**) indicate the choice of control place made in the Keypad control menu (M3) (see **Page 5-9**).

Table 5-2: Control Place Indicators

Indicator	Description
I/O Term	I/O terminals are selected as the control place, i.e., START/STOP commands or reference values, etc. are given through the I/O terminals.
Keypad	Control keypad is selected as the control place, i.e., the motor can be started or stopped or its reference values, etc. altered from the keypad.
Bus/comm	The inverter is controlled through a fieldbus.

Status LEDs (Green – Green – Red)

The status LEDs light up in connection with the READY, RUN and FAULT drive status indicators.

Table 5-3: Status LEDs (Green – Green – Red)

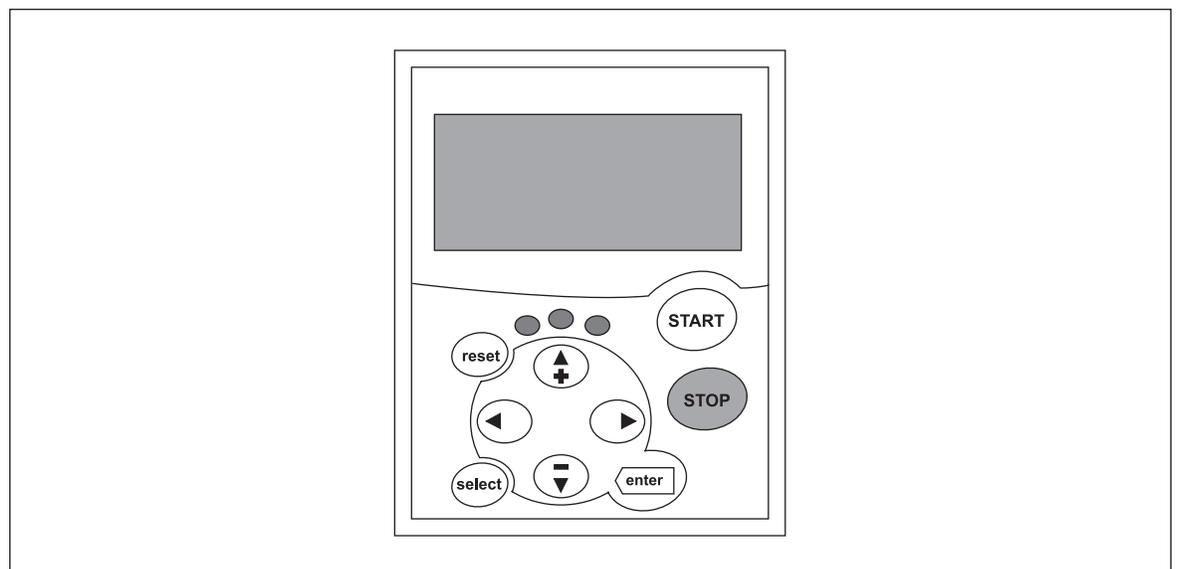| Indicator	Description
I ○	Lights up when the AC power is connected to the drive. Simultaneously, the drive status indicator READY is lit up.
II ○	Lights up when the drive is running. Blinks when the STOP button is pushed and the drive is ramping down.
III ○	Lights up when unsafe operating conditions are encountered and the drive was stopped (Fault Trip). Simultaneously, the drive status indicator FAULT blinks on the display and a fault description appears (see **Page 5-11**, Active Faults Menu).

Text Lines

The three text lines provide the users with information on their present location in the keypad menu structure as well as with information related to the operation of the drive.

Table 5-4: Text Lines

Indicator	Description
●	Location indicator: Displays the symbol and number of the menu, parameter, etc. Example: M2 = Menu 2 (Parameters); P2.1.3 = Acceleration time.
●●	Description line: Displays the description of the menu, value or fault.
●●●	Value line: Displays the numerical and textual values of references, parameters, etc. and the number of submenus available in each menu.

Keypad Pushbuttons

The alphanumeric control keypad has nine pushbuttons that are used for controlling the inverter (and motor), setting parameters and monitoring values.
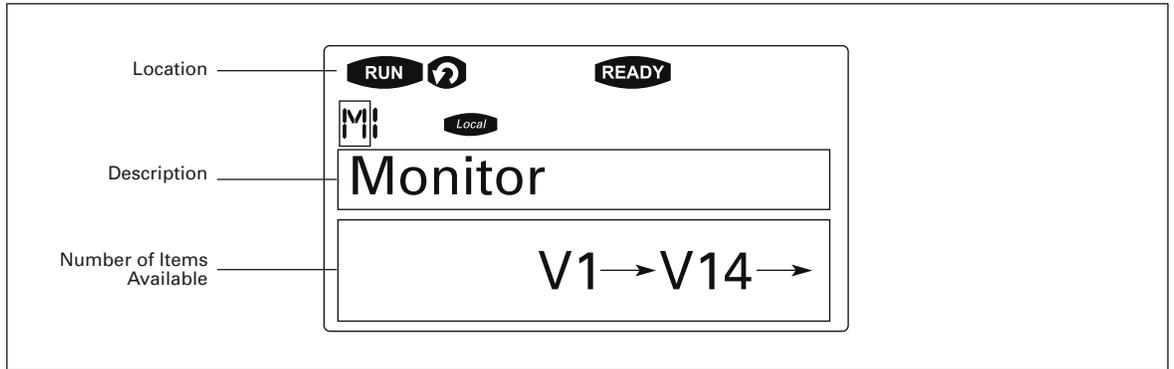

Figure 5-2: Keypad Pushbuttons

Table 5-5: Button Descriptions

Indicator	Description
reset	This button is used to reset active faults (see **Page 5-11**, Active Faults Menu).
select	This button is used to switch between the two latest displays. This may be useful when you want to see how the changed (new) value influences some other value.
enter ↵	The ENTER button is used for: • Confirmation of selections • Fault history reset (2 – 3 seconds)
▲ +	This button is used to browse up through the main menu and pages of different submenus. Edit values.
▬ ▼	This button is used to browse down through the main menu and pages of different submenus. Edit values.
◄	This button is used to: • Move backward in the menu • Move cursor left (in parameter menu) • Exit edit mode • Press and hold for 2 to 3 seconds to return to main menu
►	This button is used to: • Move forward in the menu • Move cursor right (in parameter menu) • Enter edit mode
START	Pressing this button starts the motor if the keypad is in the active control place. See **Page 5-10**, Selection of Control Place.
STOP	Pressing this button stops the motor (unless disabled by parameter R3.4/R3.6). See **Page 5-10**, Selection of Control Place.

Menu Navigation

The data on the control keypad is arranged in menus and submenus. The menus are used for the display and editing of measurement and control signals, parameter settings and reference value and fault displays. Through the menus, you can also adjust the contrast of the display.

Location ——————— RUN ⟳   READY

M|
          Local

Description ——————— Monitor

Number of Items
Available ——————— V1→V14→

Figure 5-3: Keypad Display Data

The first menu level consists of menus M1 to M7 and is called the Main menu. The user can navigate in the main menu with the Browser buttons up and down. The desired submenu can be entered from the main menu with the menu buttons. When there still are pages to enter under the currently displayed menu or page, you can see an arrow in the lower right corner of the display and can reach the next menu level by pressing Menu Button Right.

The control keypad navigation chart is shown in **Figure 5-4**. Please note that menu M1 is located in the lower left corner. From there you will be able to navigate your way up to the desired menu using the menu and browser buttons.

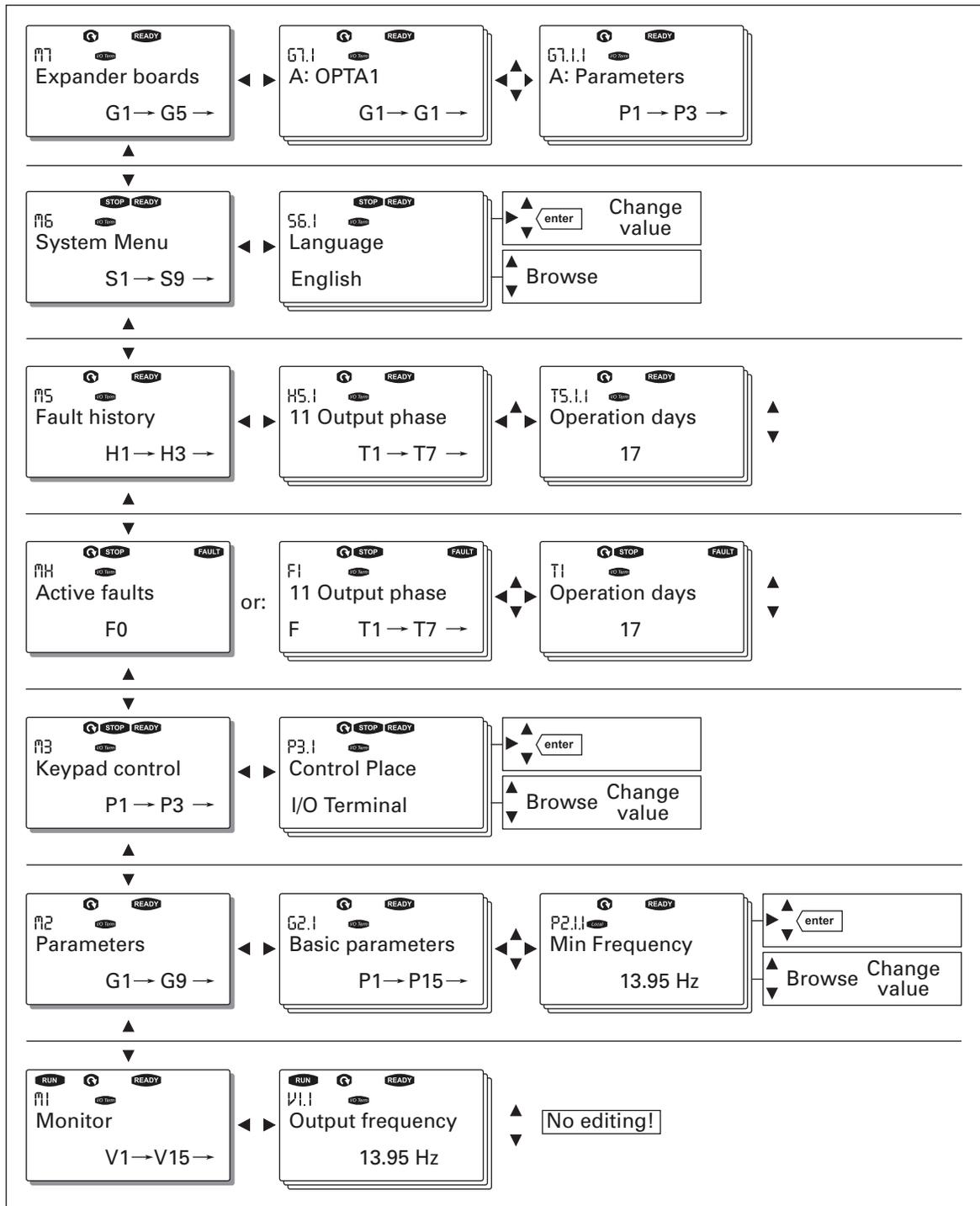You will find more detailed descriptions of the menus later in this chapter.

**Figure 5-4: Keypad Navigation Chart**

Monitoring Menu (M1)

You can enter the Monitoring menu from the Main menu by pressing Menu Button Right when the location indication M1 is visible on the first line of the display. **Figure 5-5** shows how to browse through the monitored values.

The monitored signals carry the indication V#.# and they are listed in **Table 5-6**. The values are updated once every 0.3 seconds.

This menu is meant only for signal checking. The values cannot be altered here. For changing values of parameters, see **Page 5-8**.
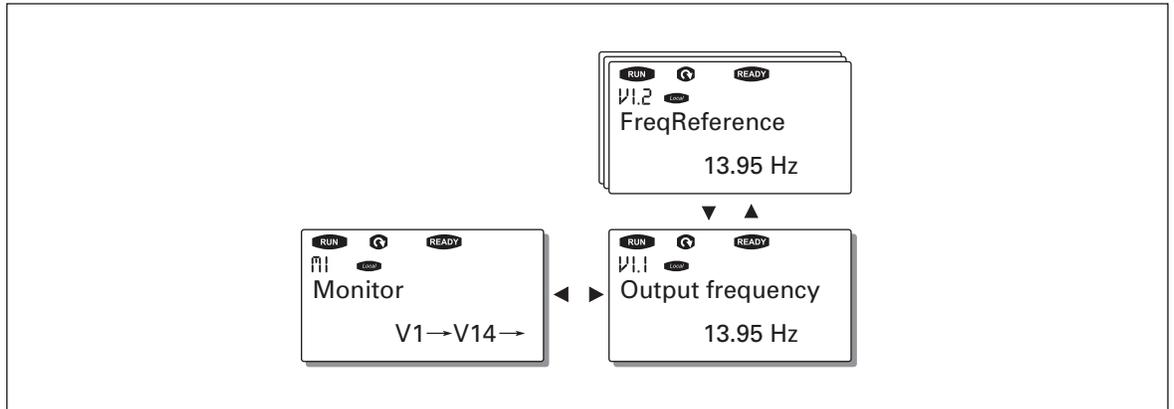
Figure 5-5: Monitoring Menu

Table 5-6: Monitored Signals

Code	Signal Name	Unit	Description
V7.1	Output frequency	Hz	Frequency to the motor
V7.2	Frequency reference	Hz	
V7.3	Motor speed	rpm	Calculated motor speed
V7.4	Motor current	A	Measured motor current
V7.5	Motor torque	%	Calculated torque based/nominal torque of the unit
V7.6	Motor power	%	Calculated actual power/nominal power of the unit
V7.7	Motor voltage	V	Calculated motor voltage
V7.8	DC-link voltage	V	Measured DC-link voltage
V7.9	Unit temperature	°C	Heatsink temperature
V7.10	Motor temperature	%	Calculated motor temperature
V7.11	Voltage input	V	AI1
V7.12	Current input	mA	AI2
V7.13	DIN1, DIN2, DIN3	—	Digital input statuses
V7.14	DIN4, DIN5,DIN6	—	Digital input statuses
V7.15	DO1, RO2, RO3	—	Digital and relay output statuses
V7.16	Analog output current	mA	AO1
M1.17	Multimonitoring items		Displays three selectable monitoring values. See **Page 5-23**.

Note: Applications may embody more monitoring values.

Parameter Menu (M2)

Parameters are the way of conveying the commands of the user to the inverter. Parameter values can be edited by entering the Parameter Menu from the Main Menu when the location indication M2 is visible on the first line of the display. The value editing procedure is presented in **Figure 5-6**.

Pressing Menu Button Right once takes you to the Parameter Group Menu (G#). Locate the desired parameter group by using the Browser buttons and press Menu Button Right again to see the group and its parameters. Use the Browser buttons to find the parameter (P#) you want to edit. Pressing Menu Button right takes you to the edit mode. As a sign of this, the parameter value starts to blink. You can now change the value in two different ways:

- Set the desired value with the Browser buttons and confirm the change with the ENTER button. Consequently, the blinking stops and the new value is visible in the value field.

- Press Menu Button Right once more. Now you will be able to edit the value digit by digit. This may come in handy, when a relatively greater or smaller value than that on the display is desired. Confirm the change with the ENTER button.

The value will not change unless the ENTER button is pressed. Pressing Menu Button Left takes you back to the previous menu.

Several parameters are locked, i.e. cannot be edited, when the drive is in RUN status. If you try to change the value of such a parameter the text *Locked* will appear on the display. The inverter must be stopped to edit these parameters.

The parameter values can also be locked using the function in menu M6 (see **Page 5-22**).

You can return to the Main menu any time by pressing Menu Button Left for 1 to 2 seconds.

The basic application package includes seven applications with different sets of parameters. You will find the parameter lists in the application manual.

Once in the last parameter of a parameter group, you can move directly to the first parameter of that group by pressing Browser button up.

See the diagram for parameter value change procedure in **Figure 5-6**.

Note: You can connect power to the control board by connecting the external power source to the bidirectional terminal #6 on the OPTA9 board (see **Chapter 4**). The external power source can also be connected to the corresponding +24V terminal on any option board. This voltage is sufficient for parameter setting and for keeping the fieldbus active.
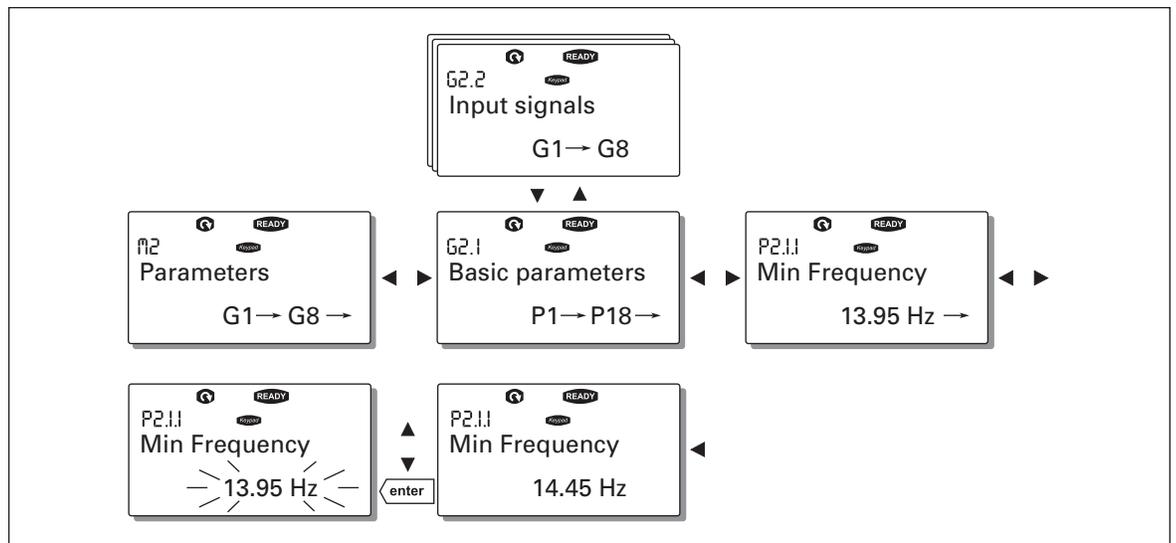
Figure 5-6: Parameter Value Change Procedure

Keypad Control Menu (M3)

In the Keypad Control Menu, you can choose the control place, edit the frequency reference and change the direction of the motor. You can enter the submenu level by pressing Menu Button Right.

Note: There are some special functions that can be performed in menu M3:

Select the keypad as the active control place by pressing start for 3 seconds when the motor is running. The keypad will become the active control place and the current frequency reference and direction will be copied to the keypad.

Select the keypad as the active control place by pressing stop for 3 seconds when the motor is stopped. The keypad will become the active control place and the current frequency reference and direction will be copied to the keypad.

Copy the frequency reference set elsewhere (I/O, fieldbus) to the panel by pressing enter for 3 seconds.

Note: If you are in any other menu than menu M3, these functions will not work.

If you are in some other menu than menu M3 and try to start the motor by pressing the START button when the keypad is not selected as the active control place, you will get an error message: Keypad Control NOT ACTIVE.

Selection of Control Place

There are three different places (sources) where the inverter can be controlled. For each control place, a different symbol will appear on the alphanumeric display:

- I/O terminals
- Keypad (panel)
- Fieldbus

You can change the control place by entering the edit mode with Menu Button Right. The options can then be browsed with the Browser buttons. Select the desired control place with the ENTER button. See **Figure 5-7**.
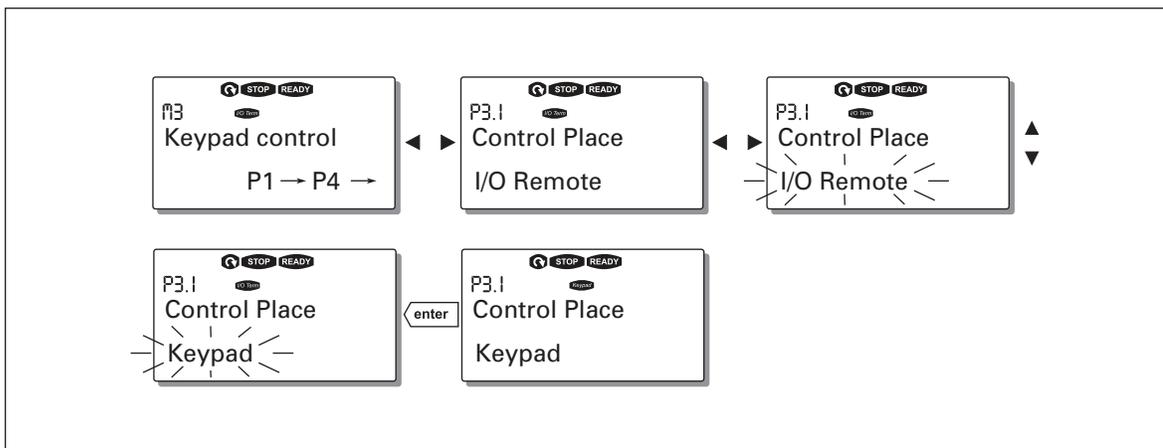
Figure 5-7: Selection of Control Place

Keypad Reference

The keypad reference submenu (P3.2) displays and allows the operator to edit the frequency reference. The changes will take place immediately. This reference value will not, however, influence the rotation speed of the motor unless the keypad has been selected as the active control place.

Note: The maximum difference in RUN mode between the output frequency and the keypad reference is 6 Hz. The program automatically monitors the keypad reference value.

You may edit the reference value (pressing the ENTER button is not necessary).

Keypad Direction

The keypad direction submenu (P3.3) displays and allows the operator to change the rotating direction of the motor. This setting will not, however, influence the rotation direction of the motor unless the keypad has been selected as the active control place.

Note: For additional information on controlling the motor with the keypad, see **Pages 5-3** and **6-2**.

STOP Button Activated

By default, pushing the STOP button will always stop the motor regardless of the selected control place. You can disable this function by giving parameter 3.4 the value 0. If the value of this parameter is 0, the STOP button will stop the motor only when the keypad has been selected as the active control place.

Active Faults Menu (M4)

You can enter the Active Faults menu from the Main menu by pressing Menu Button Right when the location indication M4 is visible on the first line of the keypad display.

When a fault brings the inverter to a stop, the location indication F1, the fault code, a short description of the fault, and the fault type symbol (see below) will appear on the display. In addition, the indication FAULT or ALARM (see **Table 5-1**) is displayed and, in case of a FAULT, the red LED on the keypad starts to blink. If several faults occur simultaneously, the list of active faults can be browsed with the Browser buttons.

The memory of active faults can store a maximum of 10 faults in the order of appearance. The display can be cleared with the RESET button and the read-out will return to the same state it was in before the fault trip. The fault remains active until it is cleared with the RESET button or with a reset signal from the I/O terminal.

Note: Remove external Start signal before resetting the fault to prevent unintentional restart of the drive.
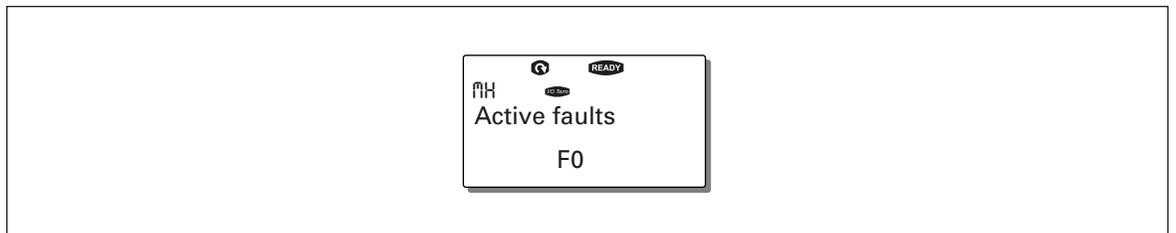
Figure 5-8: Normal State, No Faults

Fault Types

The inverter has four types of faults. These types differ from each other on the basis of the subsequent behavior of the drive. See **Table 5-7**.
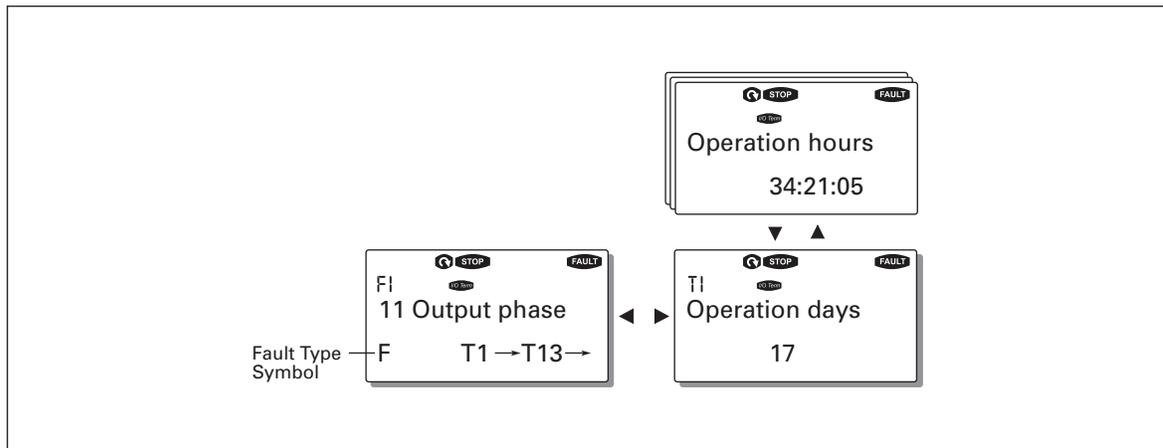
Figure 5-9: Fault Display

Table 5-7: Fault Types

Fault Type Symbol	Meaning
A (Alarm)	This type of fault is a sign of an unusual operating condition. It does not cause the drive to stop, nor does it require any special actions. The "A fault" remains in the display for about 30 seconds.
F (Fault)	An "F fault" makes the drive stop. Actions need to be taken to restart the drive.
AR (Fault Autoreset)	If an "AR fault" occurs the drive will stop immediately. The fault is reset automatically and the drive tries to restart the motor. Finally, if the restart is not successful, a fault trip (FT, see below) occurs.
FT (Fault Trip)	If the drive is unable to restart the motor after an AR fault an FT fault occurs. The "FT fault" has basically the same effect as the F fault: the drive is stopped.

Note: Fault Codes are listed in **Appendix A**.

Fault Time Data Record

When a fault occurs, the information described in **Figure 5-8** is displayed. By pressing Menu Button Right, you will enter the Fault time data record menu indicated by T.1→T.#. In this menu, some selected important data valid at the time of the fault are recorded. This feature will help the user or the service person in determining the cause of the fault.

The data available are:

Table 5-8: Fault Time Recorded Data

Data	Units	Description
T.1	D	Counted operation days (Fault 43: Additional code)
T.2	hh:mm:ss (d)	Counted operation hours (Fault 43: Counted operation days)
T.3	Hz hh:mm:ss	Output frequency (Fault 43: Counted operation hours)
T.4	A	Motor current
T.5	V	Motor voltage
T.6	%	Motor power
T.7	%	Motor torque
T.8	V	DC bus voltage
T.9	°C	Unit temperature
T.10	—	Run status
T.11	—	Direction
T.12	—	Warnings
T.13	—	Zero speed [1]

[1] Tells the user if the drive was at zero speed (< 0.01 Hz) when the fault occurred

Real Time Record

If real time is set to run on the inverter, the data items T1 and T2 will appear as follows:

Table 5-9: Real Time Record

| Data	Units	Description
T.1	yyyy-mm-dd	Counted operation days
T.2	hh:mm:SS,sss	Counted operation hours

Fault History Menu (M5)

You can enter the Fault History menu from the Main menu by pressing Menu Button Right when the location indication M5 is visible on the first line of the keypad display.

All faults are stored in the Fault History menu where you can browse them with the Browser buttons. Additionally, the Fault Time Data Record pages (see **Page 5-12**) are accessible for each fault. You can return to the previous menu any time by pressing Menu Button Left.

The memory of the inverter can store a maximum of 30 faults in order of appearance. The number of faults currently in the fault history is shown on the value line of the main page (H1→H#). The order of the faults is indicated by the location indication in the upper left corner of the display. The latest fault is indicated by F5.1, the one before that by F5.2 and so on. If there are 30 uncleared faults in the memory, the next fault will erase the oldest fault from the memory.

Pressing the ENTER button for about 2 to 3 seconds resets the whole fault history. The symbol H# will change to 0.
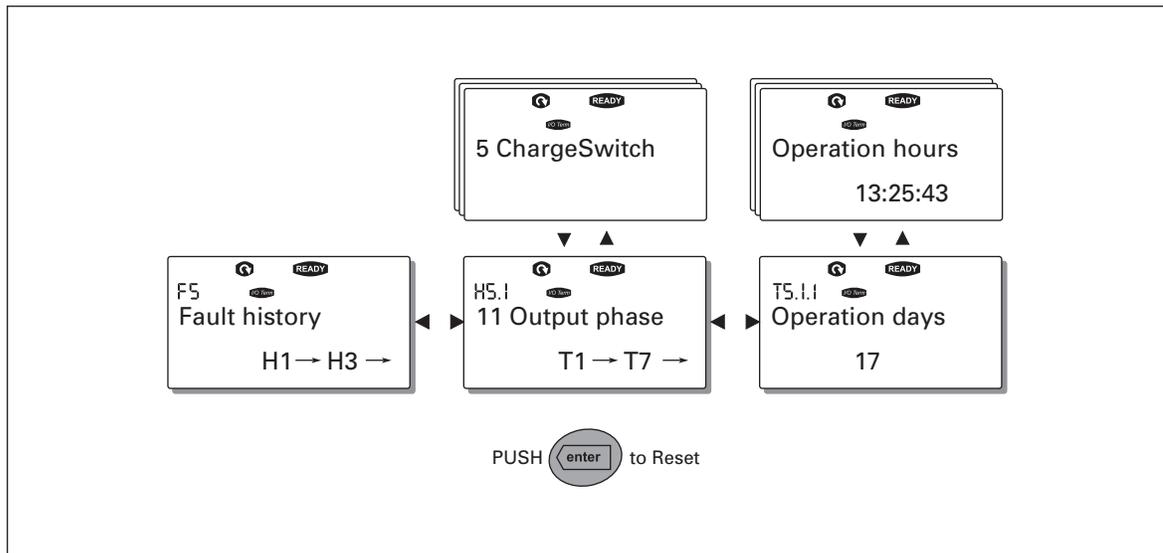
Figure 5-10: Fault History Menu

System Menu (M6)

You can enter the System menu from the Main menu by pressing Menu Button Right when the location indication M6 is visible on the first line of the keypad display.

The controls associated with the general use of the inverter, such as application selection, customized parameter sets or information about the hardware and software are located under the System menu. The number of submenus and subpages is shown with the symbol S (or P) on the value line.

Table 5-10 has a list of the functions available in the System menu.

Table 5-10: System Menu Functions

Code	Function	Min	Max	Unit	Default	Cust	Selections
S6.1	Selection of language				English		English Deutsch Suomi Svenska Italiano
S6.2	Application selection				Basic Application		Basic Application Standard Application Local/Remote control Appl. Multi-Step Application PID Control Application Multi-Purpose Control Appl. Pump and Fan Control Appl.
S6.3	Copy parameters						
S6.3.1	Parameter sets						Load factory defaults Store set 1 Load set 1 Store set 2 Load set 2
S6.3.2	Load to keypad						All parameters
S6.3.3	Load from keypad						All parameters All but motor parameters Application parameters
P6.3.4	Parameter backup				Yes		No Yes
S6.4	Parameter comparison						
S6.5	Safety						
S6.5.1	Password				Not used		**0**=Not used
P6.5.2	Parameter locking				Change Enabled		Change Enabled Change Disabled
S6.5.3	Start-Up Wizard						No Yes
S6.5.4	Multimonitoring items				Change Enabled		Change Enabled Change Disabled
S6.6	Keypad settings						
P6.6.1	Default page						
P6.6.2	Default page/OM						
P6.6.3	Timeout time	0	65535	s	30		
P6.6.4	Contrast	0	31		18		
P6.6.5	Backlight time	Always	65535	min	10		
S6.7	Hardware settings						
P6.7.1	Internal brake resistor				Connected		Not connected Connected
P6.7.2	Fan control function				Continuous		Continuous Temperature
P6.7.3	HMI acknowledge.	200	5000	ms	200		
P6.7.4	HMI: no. of retries	1	10		5		

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Table 5-10: System Menu Functions, continued

Code	Function	Min	Max	Unit	Default	Cust	Selections
S6.8	System information						
S6.8.1	Total counters						
C6.8.10.1.	MWh counter			kWh			
C6.8.10.2.	Operation day counter						
C6.8.1.3.	Operation hour counter						
S6.8.2	Trip counters						
T6.8.2.1	MWh counter			kWh			
T6.8.2.2	Clear MWh counter						
T6.8.2.3	Operation day counter						
T6.8.2.4	Operation hour counter						
T6.8.2.5	Clear operation hour counter						
S6.8.3	Software information						
S6.8.3.1	Software package						
S6.8.3.2	System software version						
S6.8.3.3	Firmware interface						
S6.8.3.4	System load						
S6.8.4	Applications						
S6.8.4.#	Name of application						
D6.8.4.#.1	Application ID						
D6.8.4.#.2	Applications: version						
D6.8.4.#.3	Applications: firmware interface						
S6.8.5	Hardware						
I6.8.5.1	Unit power						
I6.8.5.2	Unit voltage						
I6.8.5.3	Info: Brake chopper						
I6.8.5.4	Info: Brake resistor						
S6.8.6	Expander boards						

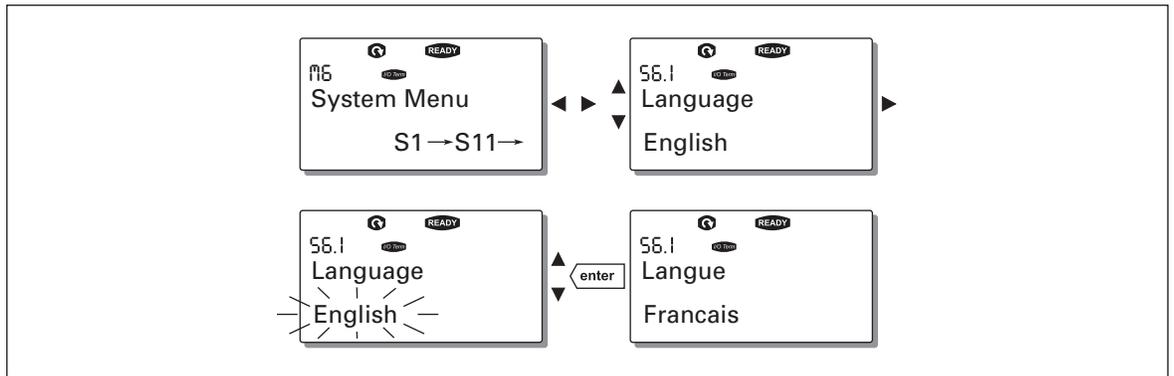### Selection of Language

The control keypad offers you the possibility to control the inverter through the keypad in the language of your choice.

Locate the language selection page under the System menu. Its location indication is S6.1. Press Menu Button Right once to enter the edit mode. As the name of the language starts to blink you can select another language for the keypad texts. Confirm with the ENTER button. The blinking stops and all text information on the keypad is presented in the selected language.

You can return to the previous menu any time by pressing Menu Button Left.

Figure 5-11: Selection of Language

Application Selection

The user can select the desired application on the Application selection page (S6.2). To enter the page, press Menu Button Right on the first page of the System menu. To change the application, press Menu Button Right once more. The name of the application starts to blink. Now you can browse the applications with the Browser buttons and select the desired application with the ENTER button.

After application change, you will be asked if you want the parameters of the new application to be uploaded to the keypad. If you want to do this, press the ENTER button. Pressing any other button leaves the parameters of the previously used application saved in the keypad.

For more information about the application, see the application manual.
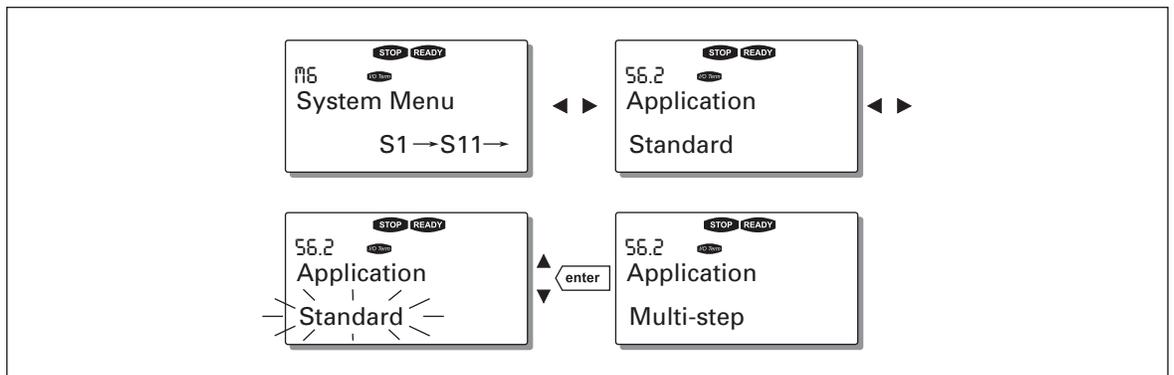
Figure 5-12: Change of Application

Copy Parameters

The parameter copy function is used when the operator wants to copy one or all parameter groups from one drive to another. All the parameter groups are first uploaded to the keypad, then the keypad is connected to another drive and then the parameter groups are downloaded to it (or possibly back to the same drive).

Before any parameters can be successfully copied from one drive to another, the drive has to be stopped when the parameters are downloaded to it:

The parameter copy menu (S6.3) contains four functions:

Parameter Sets (S6.3.1)

The user can reload the factory default parameter values and store and load two customized parameter sets (all parameters included in the application).

On the Parameter Sets page (S6.3.1), press Menu Button Right to enter the edit mode. The text LoadFactDef begins to blink and you can confirm the loading of factory defaults by pressing the ENTER button. The drive resets automatically.

Alternatively, you can choose any other storing or loading functions with the Browser buttons. Confirm with the ENTER button. Wait until "OK" appears on the display.
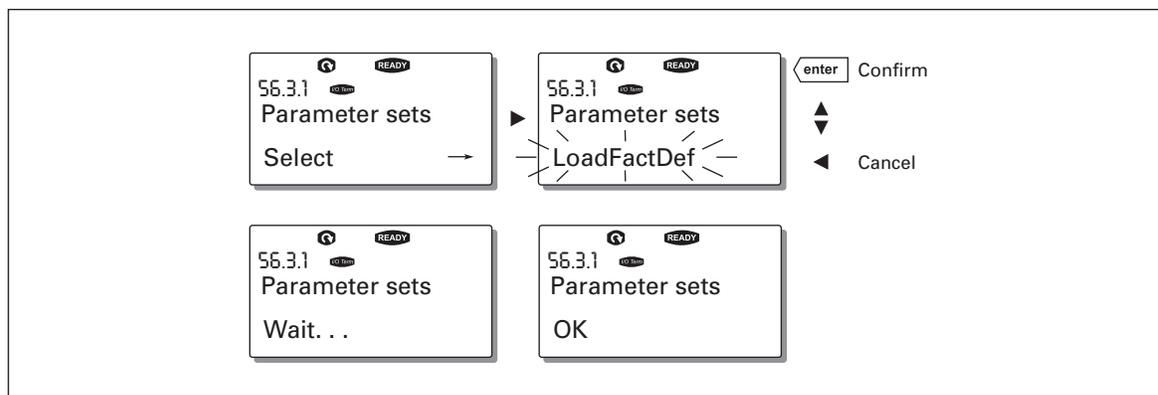

Figure 5-13: Storing and Loading of Parameter Sets

Upload parameters to keypad (To keypad, S6.3.2)

This function uploads all existing parameter groups to the keypad provided that the drive is stopped.

Enter the To Keypad page (S6.3.2) from the Parameter Copy menu. Pressing Menu Button Right takes you to the edit mode. Use the Browser buttons to select the option All Parameters and press the ENTER button. Wait until "OK" appears on the display.
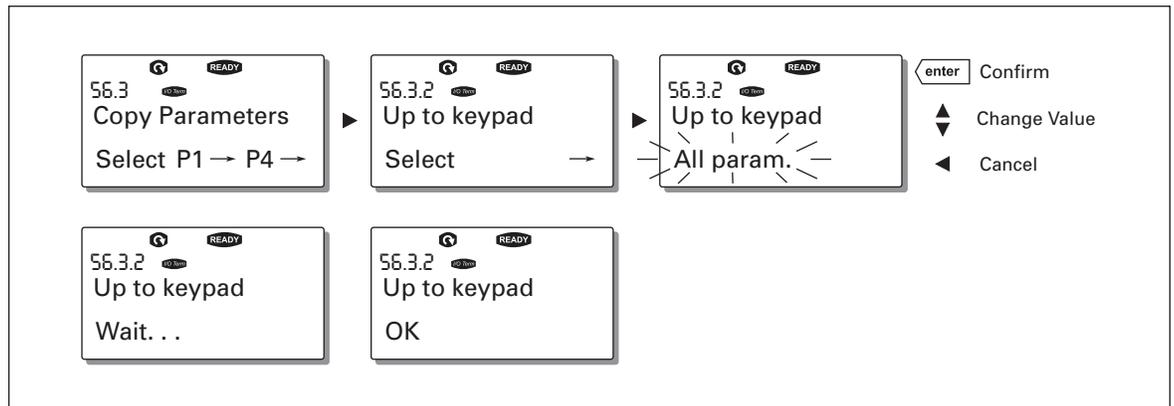
Figure 5-14: Parameter Copy to Keypad

Download parameters to drive (From keypad, S6.3.3)

This function downloads one or all parameter groups uploaded to the keypad to a drive provided that the drive is in STOP status.

Enter the To Keypad page (S6.3.2) from the Parameter Copy menu. Pressing the Menu Button Right takes you to the edit mode. Use the Browser buttons to select either All Parameters, All but Motor Parameters or Application Parameters and press the ENTER button. Wait until "OK" appears on the display.

The procedure to download the parameters from keypad to drive is similar to that of from drive to keypad. See **Figure 5-14**.

Automatic Parameter Backup (P6.3.4)

On this page you can activate or inactivate the parameter backup function. Enter the edit mode by pressing Menu Button Right. Select Yes or No with the Browser buttons.

When the Parameter backup function is activated control keypad makes a copy of the parameters of the presently used application. When applications are changed, you will be asked if you wish the parameters of the new application to be uploaded to the keypad. If you want to do this, press the ENTER button. If you wish to keep the copy of the parameters of the previously used application saved in the keypad, press any other button. Now you will be able to download these parameters to the drive following the instructions given in Chapter Copy Parameters on **Page 5-18**.

If you want the parameters of the new application to be automatically uploaded to the keypad, you have to do this for the parameters of the new application once on page 6.3.2 as instructed. Otherwise the panel will always ask for the permission to upload the parameters.

Note: Parameters saved in the parameter settings on page S6.3.1 will be deleted when applications are changed. If you want to transfer the parameters from one application to another, you have to upload them first to the keypad.

Parameter Comparison

In the Parameter Comparison submenu (S6.4), you can compare the actual parameter values to the values of your customized parameter sets and those loaded to the control keypad.

You can compare the parameter by pressing Menu Button Right in the Compare Parameters submenu. The actual parameter values are first compared to those of the customized parameter Set1. If no differences are detected, "0" is displayed on the lowermost line. If any of the parameter values differ from those of Set1, the number of the deviations is displayed together with symbol P (for example, P1→P5 = five deviating values). By pressing Menu Button Right once more, you can enter pages where you can see both the actual value and the value it was compared to. In this display, the value on the description line (in the middle) is the default value and the one on the value line (lowermost) is the edited value. Furthermore, you can also edit the actual value with the Browser buttons in the edit mode which you can enter by pressing Menu Button Right once.
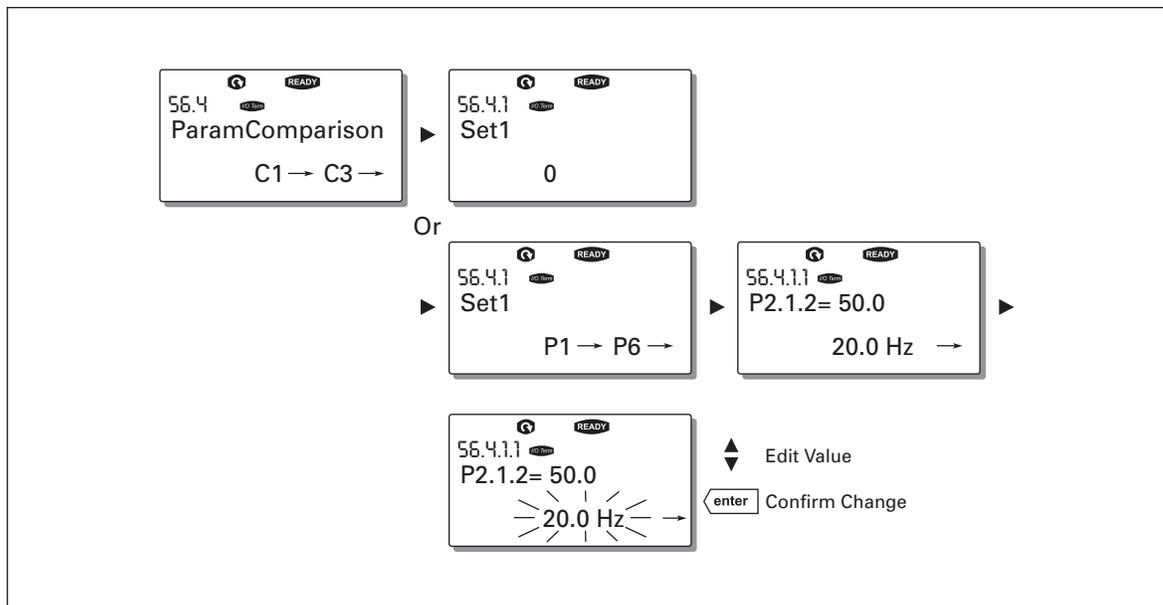

Figure 5-15: Parameter Comparison

For more information visit: **www.EatonElectrical.com**

Safety

Note: The Security submenu is protected with a password. Store the password in a safe place!
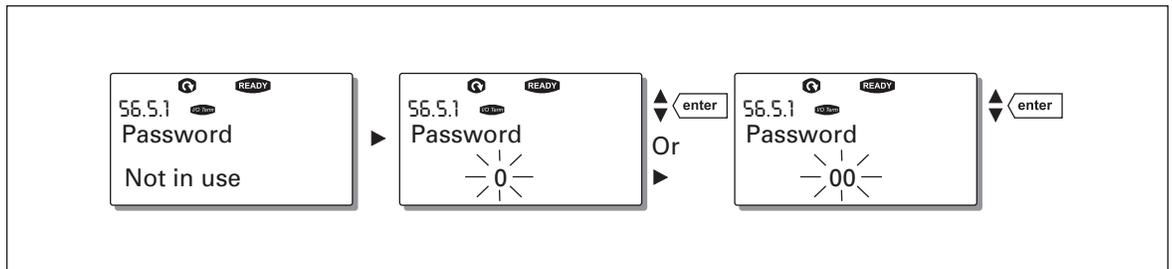
Password (S6.5.1)

The application selection can be protected against unauthorized changes with the Password function (S6.5.1).

By default, the Password function is not in use. If you want to activate the function, enter the edit mode by pressing Menu Button Right. A blinking zero appears in the display and you can set a password with the Browser buttons. The password can be any number between 1 and 65535.

Note: You can also set the password by digits. In the edit mode, push Menu Button Right again and another zero appears on the display. Set ones first. To set the tens, press Menu Button Right, and so on. Confirm the password with the ENTER button. After this, you have to wait until the Timeout time (P6.6.3) (see **Page 5-24**) has expired before the password function is activated.

If you try to change applications or the password itself, you will be prompted for the current password. Enter the password with the Browser buttons.

You can deactivate the password function by entering the value 0.

Figure 5-16: Password Setting

Note: Store the password in a safe place! No changes can be made unless a valid password is entered.
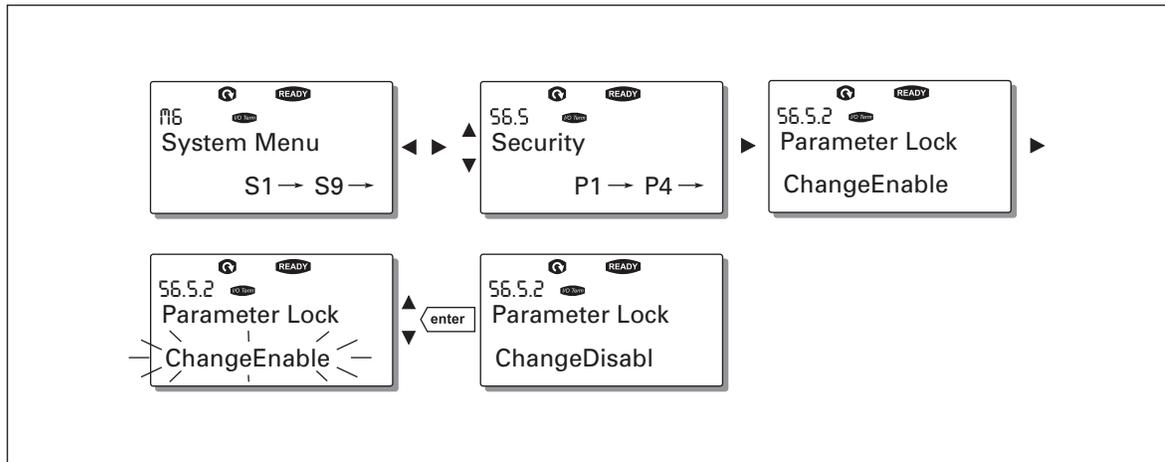
Parameter Lock (P6.5.2)

This function allows the user to prohibit changes to the parameters.

If the parameter lock is activated, the text *locked* will appear on the display if you try to edit a parameter value.

Note: This function does not prevent unauthorized editing of parameter values.

Enter the edit mode by pressing Menu Button Right. Use the Browser buttons to change the parameter lock status. Confirm the change with the ENTER button or go back to the previous level by pressing Menu Button Left.


Figure 5-17: Parameter Locking

Start-Up Wizard (P6.5.3)

The Start-Up Wizard facilitates the commissioning of the inverter. If active, the Start-Up Wizard prompts the operator for the language and application of his/her choice and then displays the first menu or page.

Activating the Start-Up Wizard: In the System Menu, find page P6.5.3. Press Menu Button Right once to enter the edit mode. Use the Browser buttons to select Yes and confirm the selection with the ENTER button. If you want to deactivate the function, follow the same procedure and give the parameter value "NO".
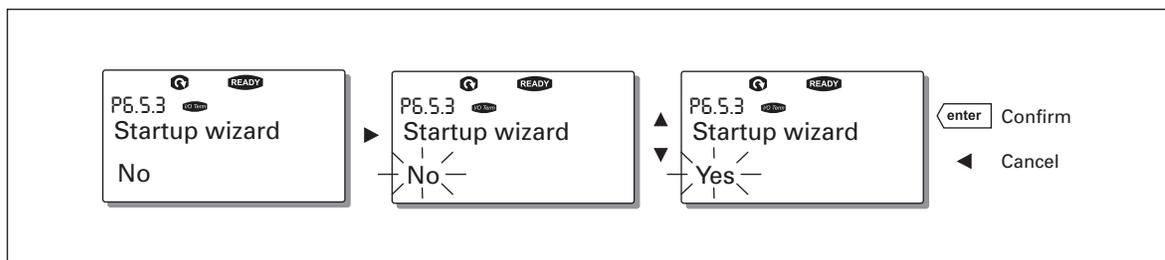

Figure 5-18: Activation of Start-Up Wizard

Multimonitoring Items (P6.5.4)

The alphanumeric keypad features a display where you can monitor up to three actual values at the same time — see Monitoring Menu (M1) on **Page 5-7** and the manual of the application you are using. On page P6.5.4 of the System Menu, you can define whether the operator can replace the values monitored with other values. See below.
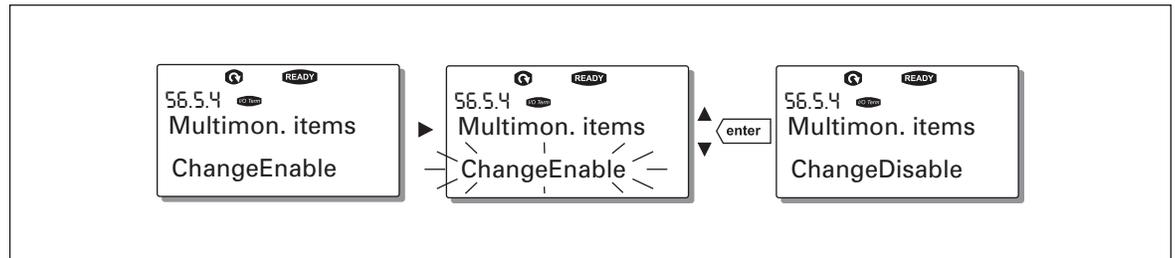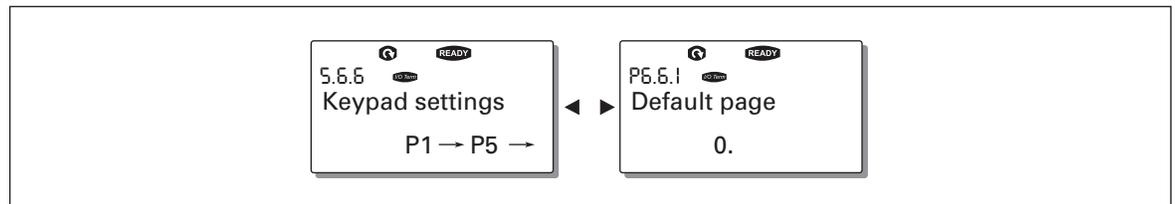

Figure 5-19: Disabling the Change of Multimonitoring Items

Keypad Settings

In the Keypad Settings submenu under the System menu, you can further customize your inverter operator interface.

Locate the Keypad Setting submenu (S6.6). Under the submenu, there are four pages (P#) associated with the keypad operation:
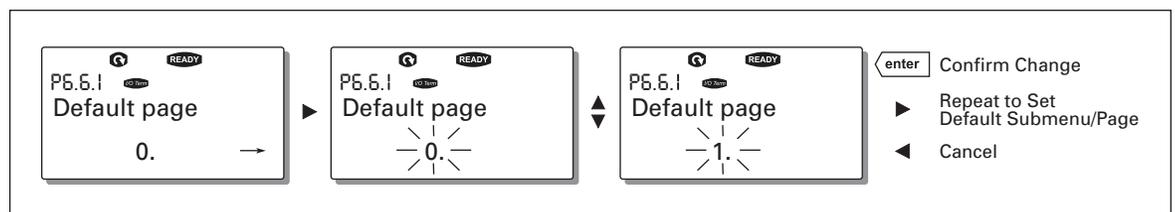

Figure 5-20: Keypad Settings Submenu

Default Page (P6.6.1)

Here you can set the location (page) to which the display automatically moves when the Timeout Time (see below) has expired or the power is switched on to the keypad.

If the default page is 0, the function is not activated, i.e. the latest displayed page remains on the keypad display. Pressing Menu Button Right takes you to the edit mode. Change the number of the Main menu with the Browser buttons. To edit the number of the submenu/page, press Menu Button Right. If the page you want to move to by default is at the third level, repeat the procedure. Confirm the new default page with the ENTER button. You can return to the previous menu at any time by pressing Menu Button Left.

Figure 5-21: Default Page Function

Default page in the operating menu (P6.6.2)

Here you can set the location (page) in the Operating menu (in special applications only) to which the display automatically moves to when the set Timeout Time (see below) has expired or the power is switched on to the keypad.

See how to set the Default page in **Figure 5-21**.

Timeout Time (P6.6.3)

The Timeout Time setting defines the time after which the keypad display returns to the Default page (P6.6.1).

Enter the edit mode by pressing Menu Button Right. Set the desired timeout time and confirm it with the ENTER button. You can return to the previous menu at any time by pressing Menu Button Left.
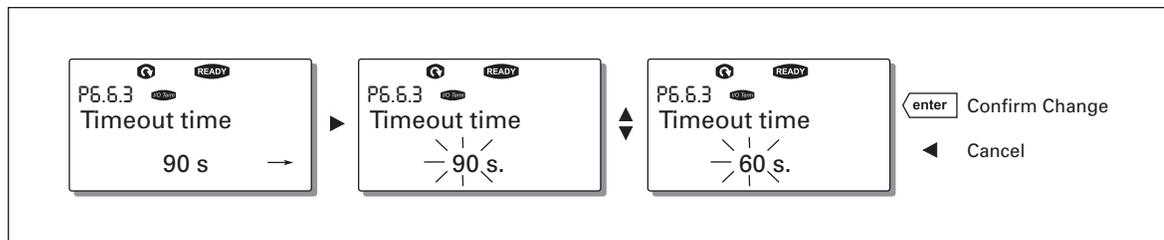
Figure 5-22: Timeout Time Setting

Note: If the Default page value is 0, the Timeout Time setting has no effect.

Contrast Adjustment (P6.6.4)

In case the display is unclear, you can adjust its contrast through the same procedure as for the timeout time setting (see above).

Backlight Time (P6.6.5)

By giving a value for the Backlight time, you can determine how long the backlight stays on before going out. You can select any time between 1 and 65535 minutes or "Forever." For the value setting procedure, see Timeout Time above.

Hardware Settings

Note: The Hardware settings submenu is protected with a password. Store the password in a safe place!

In the Hardware Settings submenu (S6.7) under the System menu, you can further control some functions of the hardware in your inverter. The functions available in this menu are Internal brake resistor connection, Fan control, HMI acknowledge timeout and HMI retry.

Internal Brake Resistor Connection (P6.7.1)

This function tells the inverter, whether the internal brake resistor is connected or not. If you have ordered the inverter with an internal brake resistor, the default value of this parameter is Connected. However, if it is necessary to increase braking capacity by installing an external brake resistor, or if the internal brake resistor is disconnected for another reason, it is advisable to change the value of this function to Not conn. in order to avoid unnecessary fault trips.

Enter the edit mode by pressing Menu Button Right. You can change the brake resistor information with the Browser buttons. Confirm the change with the ENTER button or return to the previous level with Menu Button Left.

Note: The brake resistor is available as optional equipment for all classes. It can be installed internally in classes FR4 to FR6.
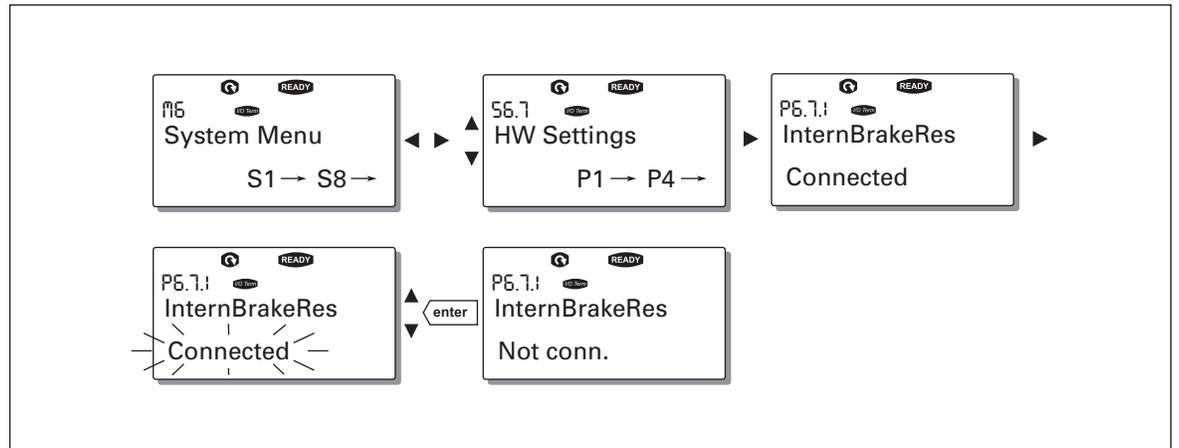

Figure 5-23: Internal Brake Resistor Connection

Fan Control (P6.7.2)

This function allows you to control the cooling fan of the inverter. You can set the fan to run continuously when the power is switched on or depending on the temperature of the unit. If the latter function has been selected, the fan is switched on automatically when the heatsink temperature reaches 60°C. The fan receives a stop command when the heatsink temperature falls to 55°C. After the command, the fan runs for approximately 1 minute before stopping. The same happens after switching on the power and after changing the value from Continuous to Temperature.

Note: The fan runs always when the drive is in RUN state.

To change the value: Enter the edit mode by pressing Menu Button Right. The value starts blinking. Use the Browser buttons to change the fan mode and confirm the change with the ENTER button. If you do not want to change the value, return to the previous level with Menu Button Left. See **Figure 5-24**.
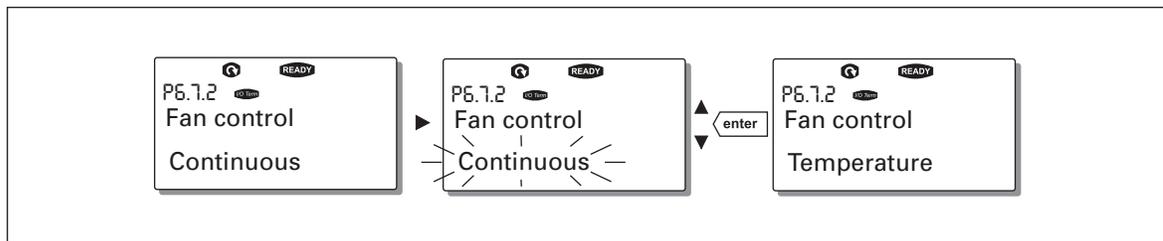
Figure 5-24: Fan Control Function

HMI Acknowledge Timeout (P6.7.3)

This function allows the user to change the timeout of the HMI acknowledgement time. The inverter waits for the HMI acknowledgment in accordance with the value of this parameter.

Note: If the inverter has been connected to the PC with a normal cable, the default values of parameters 6.7.3 and 6.7.4 (200 and 5) must not be changed.

If the inverter has been connected to the PC via a modem and there is a delay in transferring messages, the value of parameter 6.7.3 must be set according to the delay as follows:

Example:

- Transfer delay between the inverter and the PC = 600 ms

- The value of par. 6.7.3 is set to 1200 ms (2 x 600, sending delay + receiving delay)

- The corresponding setting shall be entered in the [Misc] part of the file NCDrive.ini:
  - Retries = 5
  - AckTimeOut = 1200
  - TimeOut = 6000

- It must also be considered that intervals shorter than the AckTimeOut time cannot be used in NC-Drive monitoring.

Enter the edit mode by pressing Menu Button Right. The current value starts to blink. Use the Browser buttons to change the acknowledgement time. Confirm the change with the ENTER button or return to the previous level with Menu Button Left.
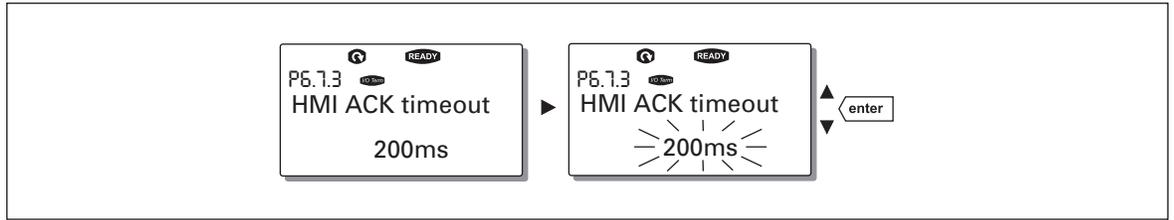
Figure 5-25: HMI Acknowledge Timeout

Number of retries to receive HMI acknowledgement (P6.7.4)

With this parameter you can set the number of times the drive will try to receive acknowledgement if it does not receive acknowledgement within the acknowledgement time (P6.7.3) or if the received acknowledgement is faulty.

You can change value through the same procedure as for P6.7.3 (see above).

Note: Changes to P6.7.3 and P6.7.4 become effective after the next start-up.

System info

In the System info submenu (S6.8) you can find inverter-related hardware and software information.

You can enter the System info submenu by pressing Menu Button Right. You can now browse the submenu pages with the Browser buttons.

Total Counters

The Total counters menu (S6.8.1) contains information on the inverter operation times i.e. the total number of MWh, operation days and operation hours. Unlike the counters in the Trip counters menu, these counters cannot be reset.

Note: The Power On time counter (days and hours) runs always when the power is on.

Table 5-11: Counter Pages

Page	Counter
C6.8.10.1	MWh counter
C6.8.10.2	Operation day counter
C6.8.1.3.	Operation hour counter

Trip Counters

Trip counters (menu S6.8.2) are counters the values of which can be reset i.e. restored to zero. You can use the following resettable counters:
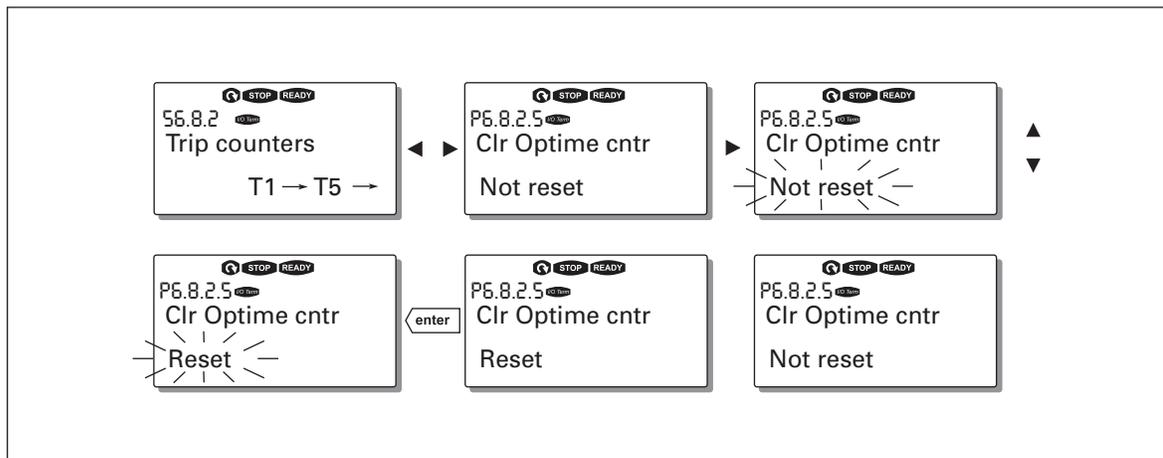
Note: The trip counters run only when the motor is running.

Table 5-12: Resettable Counters

Page	Counter
T6.8.2.1	MWh counter
T6.8.2.3	Operation day counter
T6.8.2.4	Operation hour counter

The counters can be reset on pages 6.8.2.2 (Clear MWh counter) and 6.8.2.5 (Clear Operation time counter).

Example: When you want to reset the operation counters, see **Figure 5-26**.

Figure 5-26: Counter Reset

Software (S6.8.3)

The Software information page includes information on the following inverter software related topics:

Table 5-13: Software Information Pages

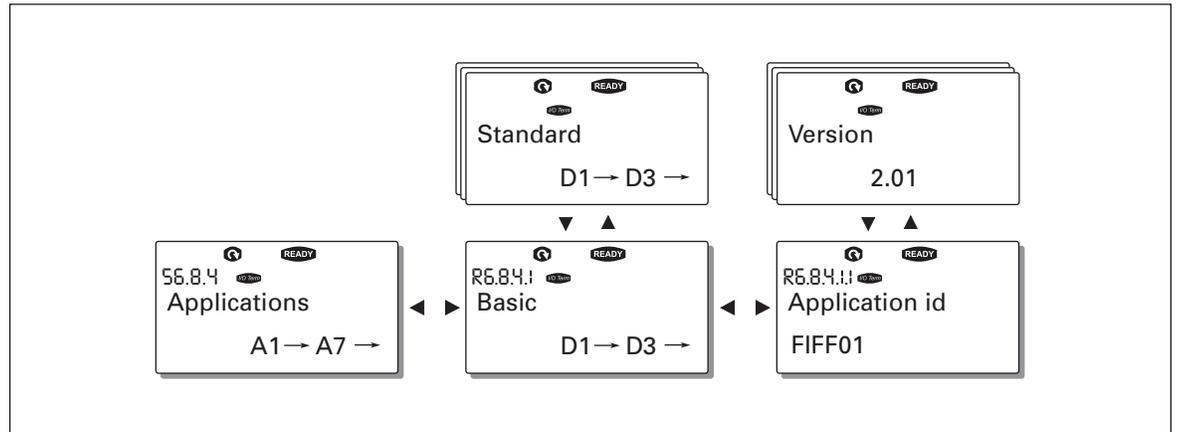| Page	Counter
6.8.3.1	Software packages
6.8.3.2	System software version
6.8.3.3	Firmware interface
6.8.3.4	System load

Applications (S6.8.4)

At location S6.8.4, you can find the Applications submenu containing information on the application currently in use and all other applications loaded into the inverter. The following information is available:

Table 5-14: Applications Information Pages

Page	Counter
6.8.4.#	Name of application
6.8.4.#.1	Application ID
6.8.4.#.2	Version
6.8.4.#.3	Firmware interface

In the Applications information page, press Menu Button Right to enter the Application pages of which there are as many as there are applications loaded into the inverter. Locate the desired application with the Browser buttons and then enter the Information pages with Menu Button Right. Use the Browser buttons to see the different pages.

Figure 5-27: Applications Info Submenu

Hardware (S6.8.5)

The Hardware information page provides information on the following hardware-related topics:

**Table 5-15: Hardware Information Pages**

Page	Counter
6.8.5.1	Nominal power of the unit
6.8.5.2	Nominal voltage of the unit
6.8.5.3	Brake chopper
6.8.5.4	Brake resistor

Expander Boards (S6.8.6)

The Expander boards submenu contains information about the basic and option boards. (See Chapter Control unit)

You can check the status of each board slot by entering the Expander Boards page with Menu Button Right. Use the Browser buttons to view the status of each board slot. The description line of the keypad will display the type of the expansion board and the text "Run" is shown below it. If no board is connected to the slot the text "no board" will be shown. If a board is connected to a slot but the connection is lost for some reason, the text "no conn." is displayed. For more information, see **Chapter 4**.

For more information on expander board related parameters, see **Page 5-30**.
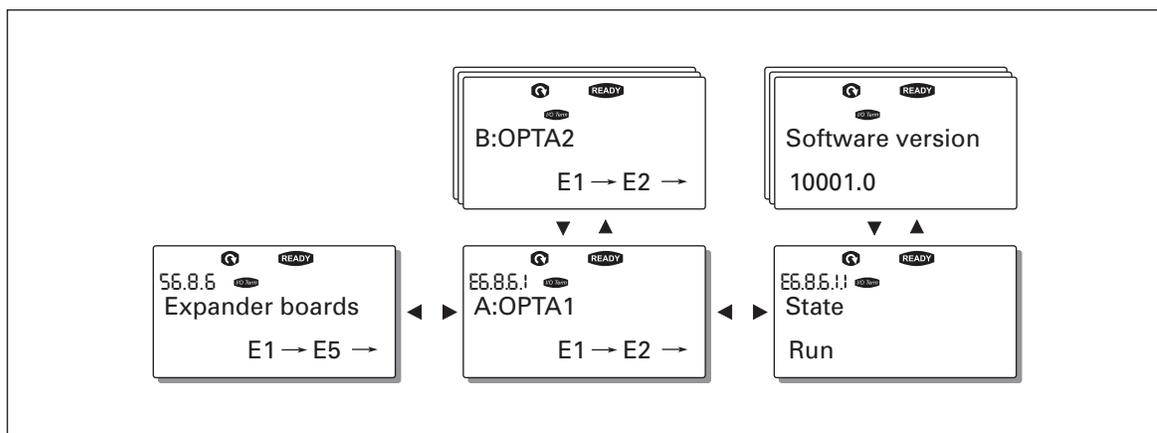
Figure 5-28: Expander Board Information Menus

Expander Board Menu (M7)

In the Expander board menu the user can 1) see the expander boards connected to the control board and 2) see and edit the parameters associated with the expander boards.

Go to the next menu level (G#) with Menu Button Right. At this level, you can browse through slots A to E with the Browser buttons to see which expander boards are connected to the control board. On the lowermost line of the display, you will also see the number of parameters associated with the board. You can view and edit the parameter values as described on **Page 5-8**. See **Table 5-16** and **Figure 5-29**.

Expander Board Parameters

Table 5-16: Expander Board Parameters (Board OPTA9)

Code	Parameter	Min	Max	Default	Cust	Selections
P7.1.1.1	AI1 mode	1	5	3		**1** = 0 to 20 mA **2** = 4 to 20 mA **3** = 0 to 10V **4** = 2 to 10V **5** = −10 to +10 V
P7.1.1.2	AI2 mode	1	5	1		See P7.1.1.1
P7.1.1.3	AO1 mode	1	4	1		**1** = 0 to 20 mA **2** = 4 to 20 mA **3** = 0 to 10V **4** = 2 to 10V
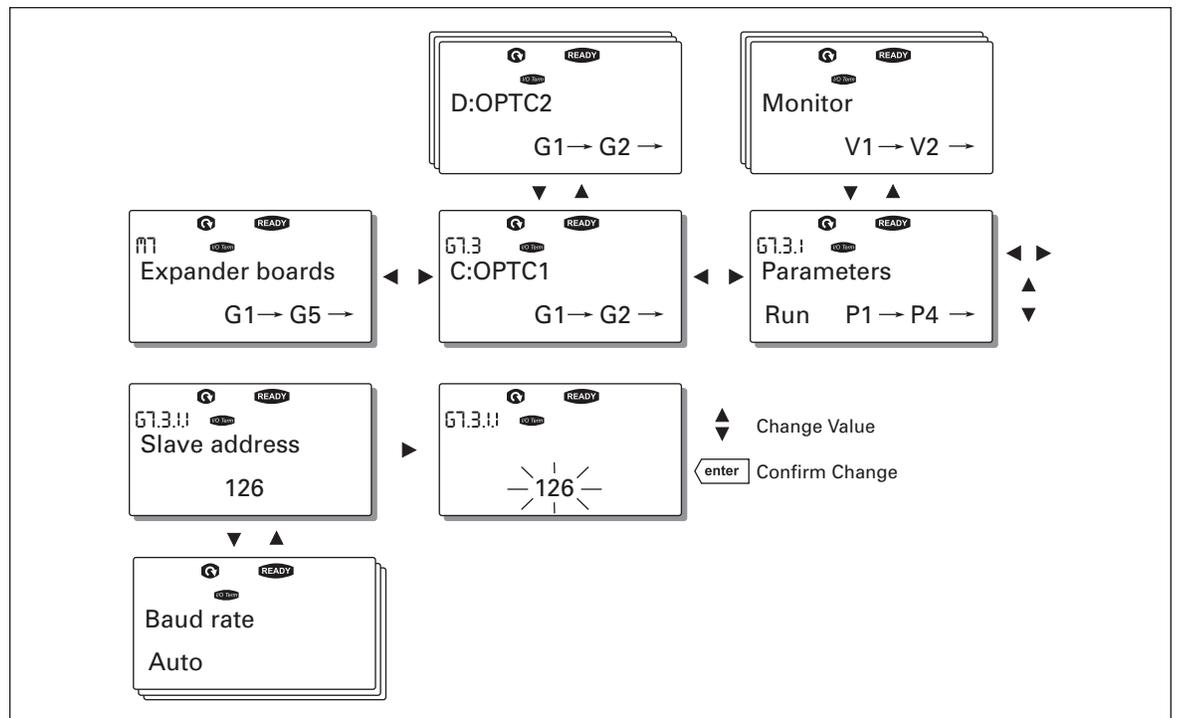
Figure 5-29: Expander Board Information Menu

Further Keypad Functions

The control keypad contains additional application-related functions. See the application manual for more information.

Chapter 6 — Start-Up

Safety Precautions

Before start-up, note the following directions and warnings:

⚠ WARNING

1   Internal components and circuit boards of the inverter (except for the galvanically isolated I/O terminals) are live when the inverter is connected to mains potential. **Coming into contact with this voltage is extremely dangerous and may cause death or severe injury.**

2   The motor terminals U, V, W and the DC-link/brake resistor terminals+/- are **live** when the inverter is connected to DC supply, **even if the motor is not running**.

3   The control I/O-terminals are isolated from the mains potential. However, the relay outputs and other I/O-terminals may have a dangerous control voltage present even when the inverter is disconnected from DC supply.

4   Do not make any connections when the inverter is connected to the DC supply.

5   After having disconnected the inverter, wait until the fan stops and the indicators on the keypad go out (if no keypad is attached see the indicator through the keypad base). Wait 5 more minutes before doing any work on inverter connections. Do not open the cover before the time has expired.

6   Before connecting the inverter to DC supply, make sure that the inverter's front cover is closed.

7   When running, the side of inverter FR8 is burning hot. Do not touch it with bare hands!

8   When running, the back of inverter FR6 is burning hot. Therefore it MUST NOT be mounted onto a surface which is not fireproof.

Sequence of Operation

1. Read the safety instructions in the front of this manual carefully and follow them.

2. After installation, make sure:

   - Both the inverter and the motor are grounded

   - DC supply and motor cables comply with the requirements given in **Chapter 3**

   - Control cables are located as far as possible from the power cables (see **Chapter 2**), and the shields of the shielded cables are connected to protective ground. The wires must not touch the electrical components of the inverter.

   - Common inputs of digital input groups are connected to +24V or the ground of the I/O terminal or the external supply.

3. Check the quality and quantity of cooling air. (See **Chapter 2**, Mounting Space Dimensions.)

4. Check the inside of the inverter for condensation.

5. Check that all Start/Stop switches connected to the I/O terminals are in the Stop position.

6. Connect the inverter to DC supply.

7. Set the parameters of group 1 according to the requirements of your application (see application manual). Set the following parameters at the least:

   - Motor nominal voltage

   - Motor nominal frequency

   - Motor nominal speed

   - Motor nominal current

   You will find the values needed for the parameters on the motor rating plate.

8. Perform either Test A or B without the motor running:

   Test A — Controls from the I/O terminals:

   - Turn the Start/Stop switch to ON position.

   - Change the frequency reference (potentiometer).

   - Check in the Monitoring Menu M1 that the value of Output Frequency changes according to the change of frequency reference.

   - Turn the Start/Stop switch to OFF position.

   Test B— Control from the Control keypad:

   - Change the control from the I/O terminals to the keypad as advised on **Page 5-10**.

   - Press the START button on the keypad.

   - Move over to the Keypad Control Menu M3 and Keypad Reference submenu (see Keypad Reference on **Page 5-10**) and change the frequency reference with the Browser buttons.

- Check in Monitoring Menu M1 that the value of Output Frequency changes according to the change of frequency reference.

- Press the STOP button on the keypad.

9. Perform the start-up tests without the motor being connected to the process. If this is not possible, make sure that each test can be done safely prior to performing it. Inform your co-workers of the tests.

  - Switch off the DC supply voltage and wait until the drive has stopped as advised on **Page 6-1**, Safety Precautions.

  - Connect the motor cable to the motor and to the motor cable terminals of the inverter.

  - Make sure that all Start/Stop switches are in Stop positions.

  - Switch the supply voltage ON.

  - Repeat Test A or B in step 8.

10. Connect the motor to the process (if the start-up test was performed without the motor being connected). Inform our co-workers of the tests.

  - Before running the tests, make sure that this can be done safely.

  - Repeat Test A or B in step 8.

Appendix A — Fault Codes

When a fault is detected by the inverter control electronics, the drive is stopped and the symbol **F** together with the ordinal number of the fault, the fault code and a short fault description appear on the display. The fault can be reset with the RESET button on the control keypad or via the I/O terminal. The faults are stored in the Fault History Menu M5, which can be browsed. **Table A-1** contains all the fault codes.

Table A-1: Fault Codes

Fault Code	Fault	Possible Cause	Solution
1	Overcurrent	Inverter detected too high a current ($>4 \times I_n$) in the motor cable: • Sudden heavy load increase • Short circuit in the motor • Unsuitable motor	Check loading. Check motor. Check cables.
2	Overvoltage	The DC link voltage exceeded the defined limits: • Deceleration time too short • High overvoltage spikes in supply	Set the deceleration time longer. Add a brake chopper or brake resistor.
3	Ground Fault ①	Current measurement has detected that the sum of motor phase currents is not zero. • Insulation failure in cables or motor	Check motor cable and motor.
5	Charging Switch	Charging switch is open, when the START command is given: • Faulty operation • Component failure	Reset the fault and restart. Should the fault re-occur, contact your Cutler-Hammer distributor.
6	Emergency Stop	Stop signal was given from the option board.	
7	Saturation Trip	Various causes: • Component failure • Brake resistor is short circuited or overloaded	Cannot be reset from the keypad. Switch off the power. DO NOT RE-CONNECT POWER. Contact Eaton. If this fault appears simultaneously with Fault 1, check motor cables and motor.
8	System Fault	• Component failure • Faulty operation **Note**: See exceptional fault data record on **Page 5-12**.	Reset the fault and restart. Should the fault re-occur, contact your Cutler-Hammer distributor.

① Programmable.

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Table A-1: Fault Codes (Continued)

Fault Code	Fault	Possible Cause	Solution
9	Undervoltage [1]	DC link voltage is below the defined voltage limits: • Supply voltage too low (most probable cause) • Inverter internal fault	In case of temporary supply voltage break, reset the fault and restart the inverter. Check the supply voltage. If it is adequate, an internal failure has occurred. Contact your Cutler-Hammer distributor.
10	Input Line Supervision [1]	Input line phase is missing.	Check supply voltage and cable.
11	Output phase supervision [1]	Current measurement has detected there is no current in one motor phase.	Check motor cable and motor.
12	Brake Chopper Supervision	• No brake resistor installed • Brake resistor is broken • Brake chopper failure	Check brake resistor. If the resistor is OK, the chopper is faulty. Contact your Cutler-Hammer distributor.
13	Inverter Undertemperature	Heatsink temperature is under -10°C	
14	Inverter Overtemperature	Heatsink temperature is over 90°C. Overtemperature warning is issued when the heatsink temperature exceeds 85°C.	Check the correct amount and flow of cooling air. Check the heatsink for dust. Check the ambient temperature. Make sure that the switching frequency is not too high in relation to ambient temperature and motor load.
15	Motor Stalled [1]	Motor stall protection has tripped.	Check motor.
16	Motor Overtemperature [1]	• Motor overheating was detected by inverter motor temperature model • Motor is overloaded	Decrease the motor load. If no motor overload exists, check the temperature model parameters.
17	Motor underload [1]	Motor underload protection tripped.	
22	EEPROM checksum fault	Parameter save fault • Faulty operation • Component failure	
24	Counter fault	Values displayed on counters are incorrect.	
25	Microprocessor watchdog fault	• Faulty operation • Component failure	Reset the fault and restart. Should the fault re-occur, contact your Cutler-Hammer distributor.
26	Startup prevented	Start-up of the drive was prevented.	Cancel prevention of start-up.
29	Thermistor fault [1]	The thermistor input of option board detected an increase in the motor temperature.	Check motor cooling and loading. Check thermistor connection. (If thermistor input of the option board is not in use, it has to be short circuited.)

[1] Programmable.

Table A-1: Fault Codes (Continued)

Fault Code	Fault	Possible Cause	Solution
31	IGBT Temperature (hardware)	IGBT inverter bridge overtemperature protection detected a short term overload current that is too high.	Check loading. Check motor size.
32	Fan Cooling	Cooling fan of the inverter does not start, when ON command is given.	Contact your Cutler-Hammer distributor.
34	CAN Bus Communication	Sent message not acknowledged.	Ensure that there is another device on the bus with the same configuration.
36	Control Unit	Control unit cannot control power unit and vice versa.	Change control unit.
37	Device Change (same type) [2]	• Option board or control unit changed • Option board of different type or drive with different power rating	Reset **Note:** No fault time data record.
38	Device Added (same type) [2]	• Option board or drive added • Drive with same power rating or same type of board added	Reset **Note:** No fault time data record.
39	Device Removed [2]	• Option board removed • Drive removed	Reset **Note:** No fault time data record.
40	Device Unknown	Unknown option board or drive.	Contact your Cutler-Hammer distributor.
41	IGBT Temperature	IGBT Inverter Bridge overtemperature protection has detected a short term overload current that is too high.	Check loading. Check motor size.
42	Brake Resistor Overtemperature [1]	Brake resistor overtemperature protection detected braking that is too heavy.	Set the deceleration time longer. Use external brake resistor.
43	Encoder Fault	**Note:** See the exceptional fault data record on **Page 5-12**. Additional codes: **1** = Encoder 1 channel A is missing **2** = Encoder 1 channel B is missing **3** = Both encoder 1 channels are missing **4** = Encoder reversed	Check encoder channel connections. Check the encoder board.
44	Device Change (different type) [2]	• Option board or control unit changed • Option board of different type or drive with different power rating	Reset. **Note:** No fault time data record is made. **Note:** Application parameter values restored to default.
45	Device Added (different type) [2]	• Option board or device added • Option board of different type or drive with different power rating added	Reset. **Note:** No fault time data record is made. **Note:** Application parameter values restored to default.

[1] Programmable.
[2] "A" faults only.

Table A-1: Fault Codes (Continued)

Fault Code	Fault	Possible Cause	Solution
50	Analog Input (signal range, 4 to 20 mA) [1]	Current for analog input is < 4 mA: • Control cable is broken or loose • Signal source failed	Check the current loop, signal source and wiring.
51	External Fault	Digital input failed.	Check source of trigger.
52	Keypad communication Fault	There is no connection between the control keypad and the inverter.	Check the keypad connection and keypad cable.
53	Fieldbus Fault	The data connection between the fieldbus master and the fieldbus board is broken.	Check installation. If installation is correct, contact your Cutler-Hammer distributor.
54	Slot Fault	Defective option board or slot.	Check that the board is properly installed and seated in slot. If the installation is correct, contact your Cutler-Hammer distributor.
56	PT100 Board Temperature Fault	Temperature limit values set for the PT100 board have been exceeded.	Determine the cause of the high temperature.

[1] Programmable.

Company Information

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