GE
Industrial Solutions

AF-650 GP™
General Purpose Drive

Design and Installation Guide

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Safety

Safety Symbols

The following symbols are used in this manual:

⚠WARNING

Indicates a potentially hazardous situation that could result in death or serious injury.

⚠CAUTION

Indicates a potentially hazardous situation that could result in minor or moderate injury. It can also be used to alert against unsafe practices.

NOTICE

Indicates important information, including situations that can result in damage to equipment or property.

Qualified Personnel

Correct and reliable transport, storage, installation, operation, and maintenance are required for the trouble-free and safe operation of the drive. Only qualified personnel are allowed to install and operate this equipment.

Qualified personnel are defined as trained staff, who are authorized to install, commission, and maintain equipment, systems, and circuits in accordance with pertinent laws and regulations. Also, the qualified personnel must be familiar with the instructions and safety measures described in these operating instructions.

Safety Precautions

⚠WARNING

HIGH VOLTAGE

Drives contain high voltage when connected to AC mains input, DC supply, or load sharing. Failure to perform installation, start-up, and maintenance by qualified personnel can result in death or serious injury.

- **Only qualified personnel must perform installation, start-up, and maintenance.**

⚠WARNING

UNINTENDED START

When the frequency converter is connected to AC mains, DC supply, or load sharing, the motor may start at any time. Unintended start during programming, service, or repair work can result in death, serious injury, or property damage. The motor can start via an external switch, a fieldbus command, an input reference signal from the keypad, or after a cleared fault condition.
To prevent unintended motor start:

- **Disconnect the frequency converter from the mains.**
- **Press [Off/Reset] on the keypad before programming parameters.**
- **Completely wire and assemble the frequency converter, motor, and any driven equipment before connecting the frequency converter to AC mains, DC supply, or load sharing.**

⚠WARNING

DISCHARGE TIME

The frequency converter contains DC-link capacitors, which can remain charged even when the frequency converter is not powered. Failure to wait the specified time after power has been removed before performing service or repair work, could result in death or serious injury.

1. **Stop motor.**
2. **Disconnect AC mains, permanent magnet type motors, and remote DC-link power supplies, including battery back-ups, UPS, and DC-link connections to other frequency converters.**
3. **Wait for the capacitors to discharge fully, before performing any service or repair work. The duration of waiting time is specified in *Table 1.1*.**

Voltage [V]	Power size [kW (hp)]	Minimum waiting time (minutes)
200–240	0.25–3.7 (1/3–5)	4
	5.5–37 (7.5–50)	15
380–500	0.37–7.5 (1/2–10)	4
	11–75 (15–100)	15
	90–250 (125–350)	20
	315–800 (450–1200)	40
525–600	0.75–7.5 (1–10)	4
	11–75 (15–100)	15
525–690	11–75 (15–100)	15
	90–315 (125–400)	20
	355–1200 (500–1350)	30

Discharge Time

WARNING

LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the drive properly can result in death or serious injury.

- **Ensure the correct grounding of the equipment by a certified electrical installer.**

WARNING

EQUIPMENT HAZARD

Contact with rotating shafts and electrical equipment can result in death or serious injury.

- **Ensure that only trained and qualified personnel perform installation, start-up, and maintenance.**
- **Ensure that electrical work conforms to national and local electrical codes.**
- **Follow the procedures in this guide.**

WARNING

UNINTENDED MOTOR ROTATION WINDMILLING

Unintended rotation of permanent magnet motors creates voltage and can charge the unit, resulting in death, serious injury, or equipment damage.

- **Ensure that permanent magnet motors are blocked to prevent unintended rotation.**

CAUTION

INTERNAL FAILURE HAZARD

An internal failure in the drive can result in serious injury when the drive is not properly closed.

- **Ensure that all safety covers are in place and securely fastened before applying power.**

Approvals

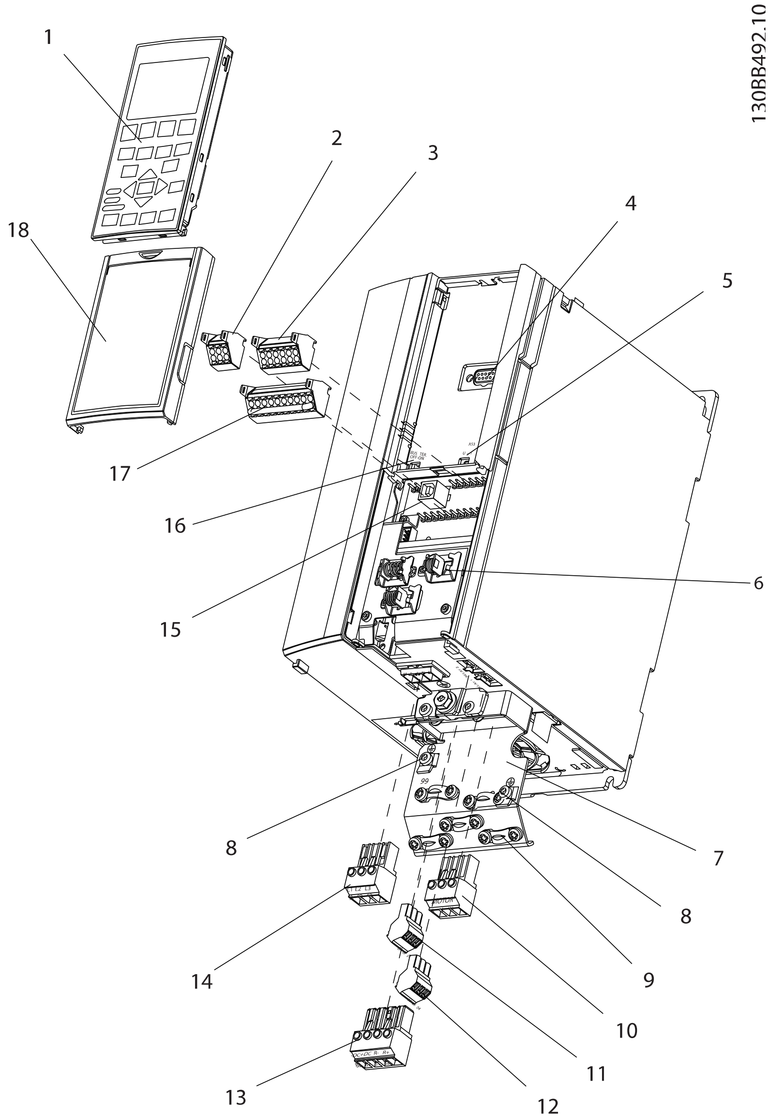
Approvals

Contents

1 Introduction

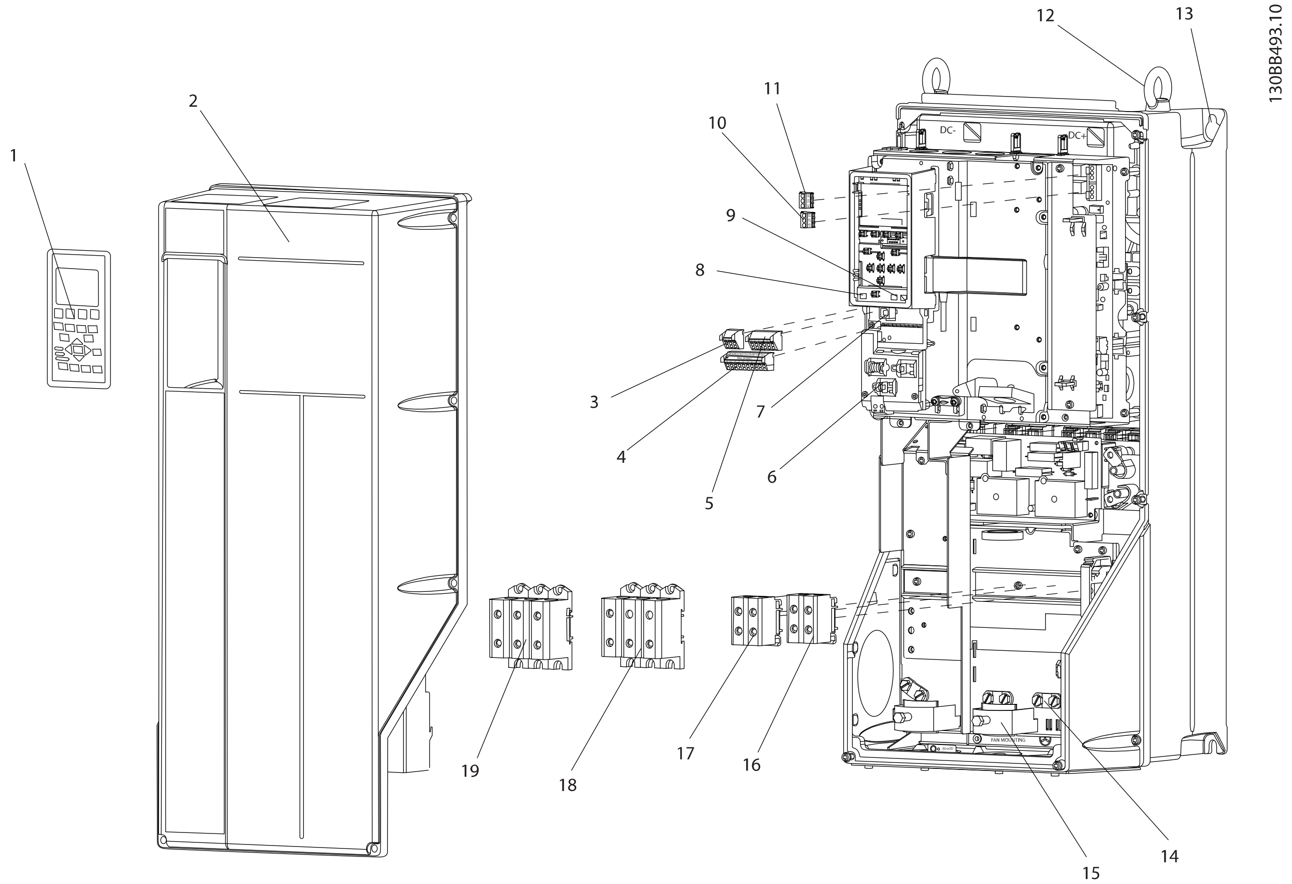
1

1.1 Exploded Views



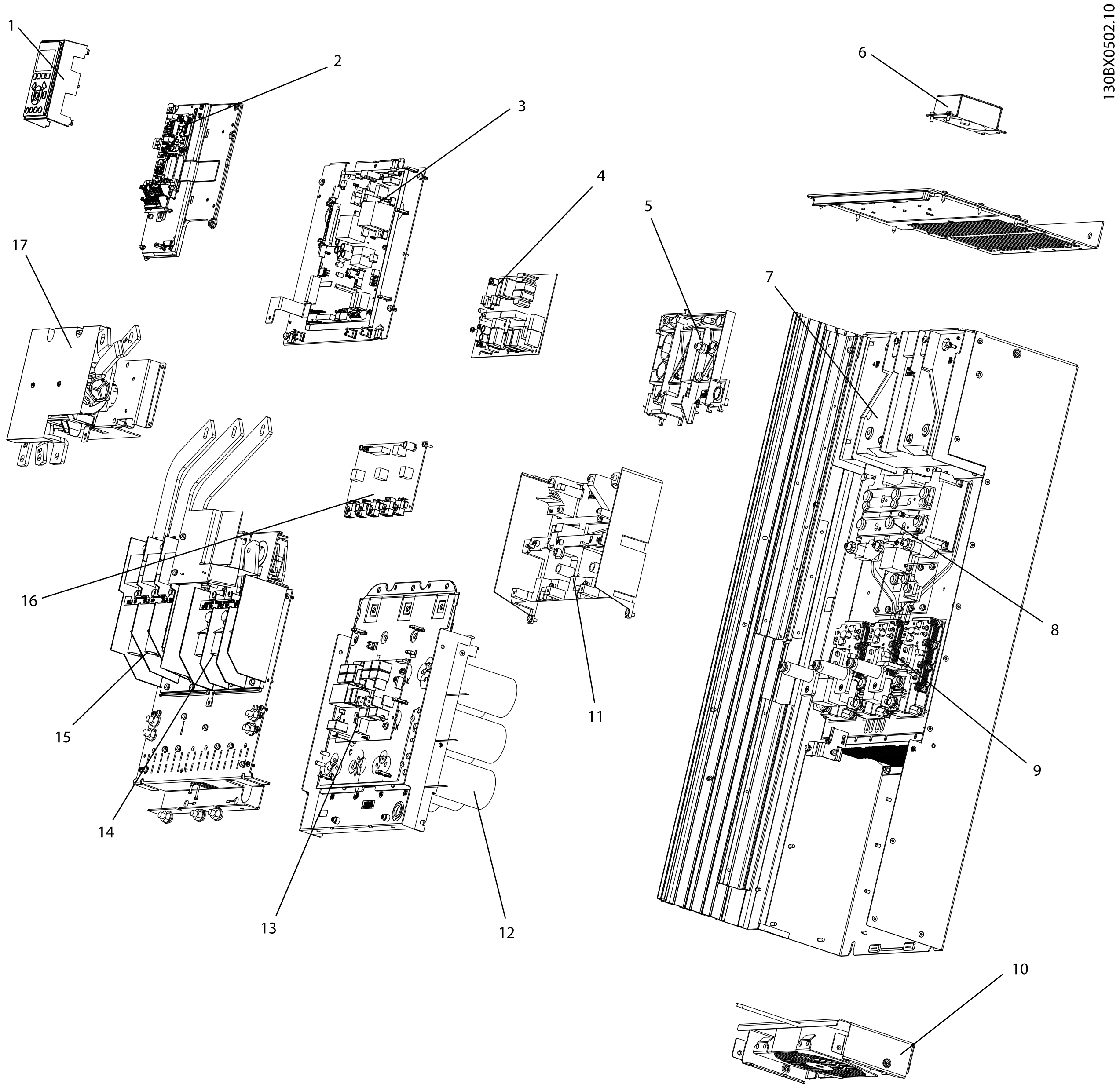
1	Keypad	10	Motor output terminals 96 (U), 97 (V), 98 (W)
2	RS485 serial bus connector (+68, -69)	11	Relay 1 (01, 02, 03)
3	Analog I/O connector	12	Relay 2 (04, 05, 06)
4	Keypad input plug	13	Brake (-81, +82) and load sharing (-88, +89) terminals
5	Analog switches (A53), (A54)	14	Mains input terminals 91 (L1), 92 (L2), 93 (L3)
6	Cable strain relief/PE ground	15	USB connector
7	Ground termination plate	16	Serial bus terminal switch
8	Grounding clamp (PE)	17	Digital I/O and 24 V supply
9	Shielded cable grounding clamp and strain relief	18	Control cable cover plate

Illustration 1.1 Exploded View Unit Size 12 and 13



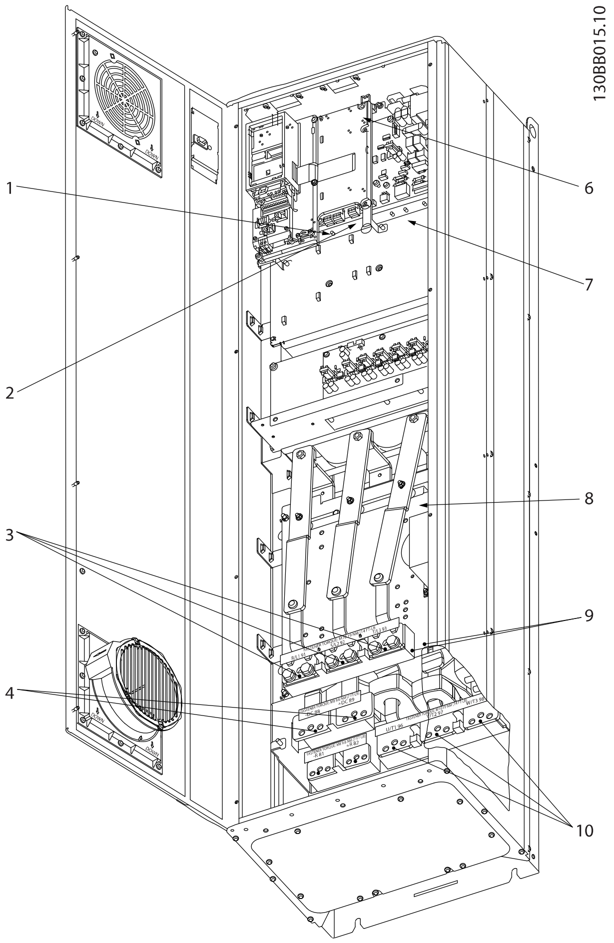
1	Keypad	11	Relay 2 (04, 05, 06)
2	Cover	12	Lifting ring
3	RS485 serial bus connector	13	Mounting slot
4	Digital I/O and 24 V supply	14	Grounding clamp (PE)
5	Analog I/O connector	15	Cable strain relief/PE ground
6	Cable strain relief/PE ground	16	Brake terminal (-81, +82)
7	USB connector	17	Load sharing terminal (DC bus) (-88, +89)
8	Serial bus terminal switch	18	Motor output terminals 96 (U), 97 (V), 98 (W)
9	Analog switches (A53), (A54)	19	Mains input terminals 91 (L1), 92 (L2), 93 (L3)
10	Relay 1 (01, 02, 03)		

Illustration 1.2 Exploded View Unit Sizes 15, 21, 22, 31, and 32



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

Illustration 1.3 Exploded View Unit Sizes 4xh



1)	AUX Relay		
	01 02 03		
	04 05 06		
2)	Temp Switch	6)	SMPS Fuse (see *chapter 13.3 Fuse Specifications* for part number)
	106 104 105	7)	AUX Fan
3)	Line		100 101 102 103
	R S T		L1 L2 L1 L2
	91 92 93	8)	Fan Fuse (see *chapter 13.3 Fuse Specifications* for part number)
	L1 L2 L3	9)	Mains ground
4)	Load sharing	10)	Motor
	-DC +DC		U V W
	88 89		96 97 98
			T1 T2 T3

Illustration 1.4 Compact IP21 (NEMA 1) and IP54 (NEMA 12), Unit Sizes 41, 42, 43, 44, 51, 52

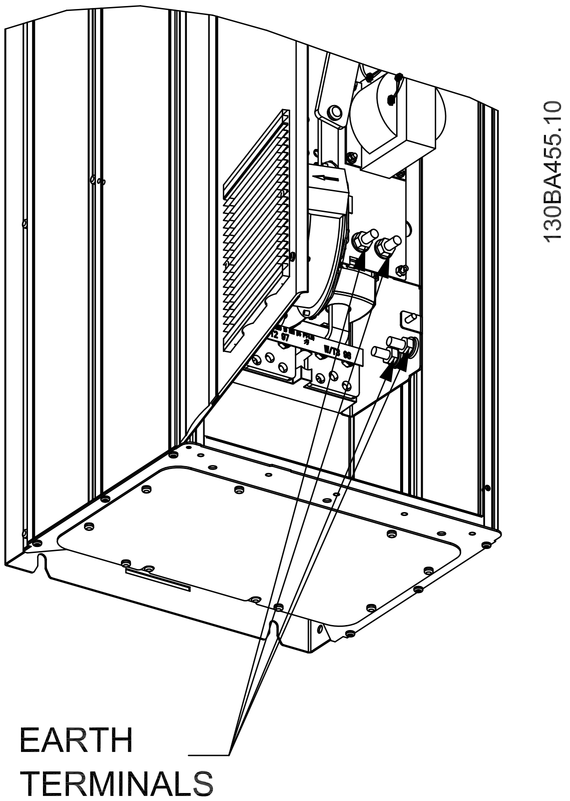
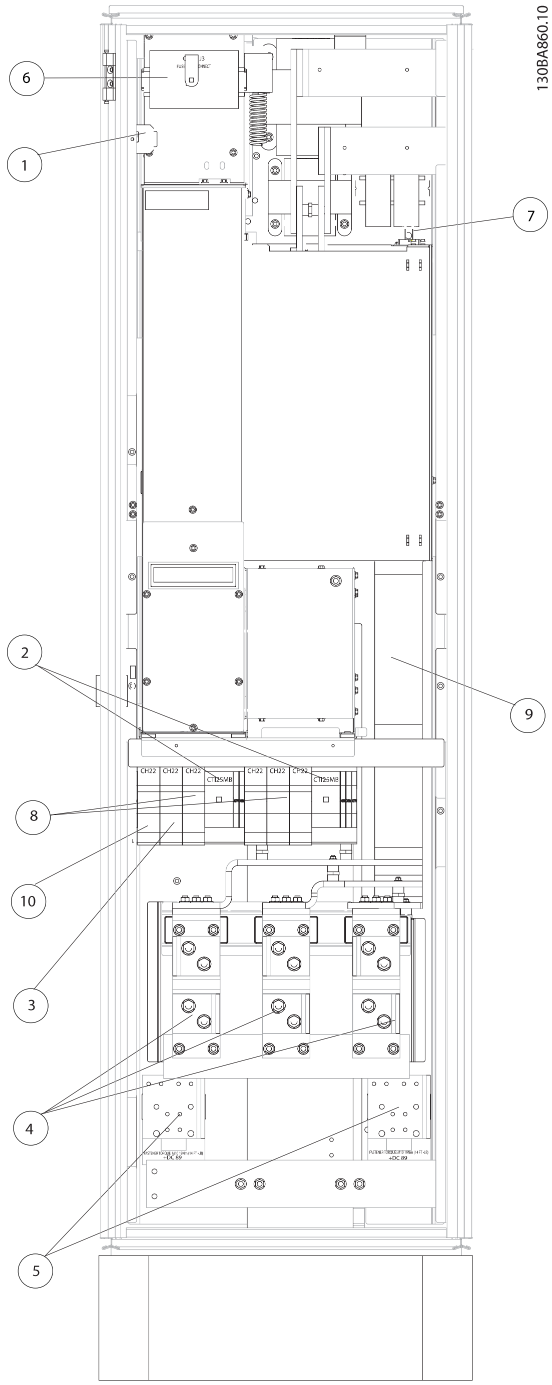
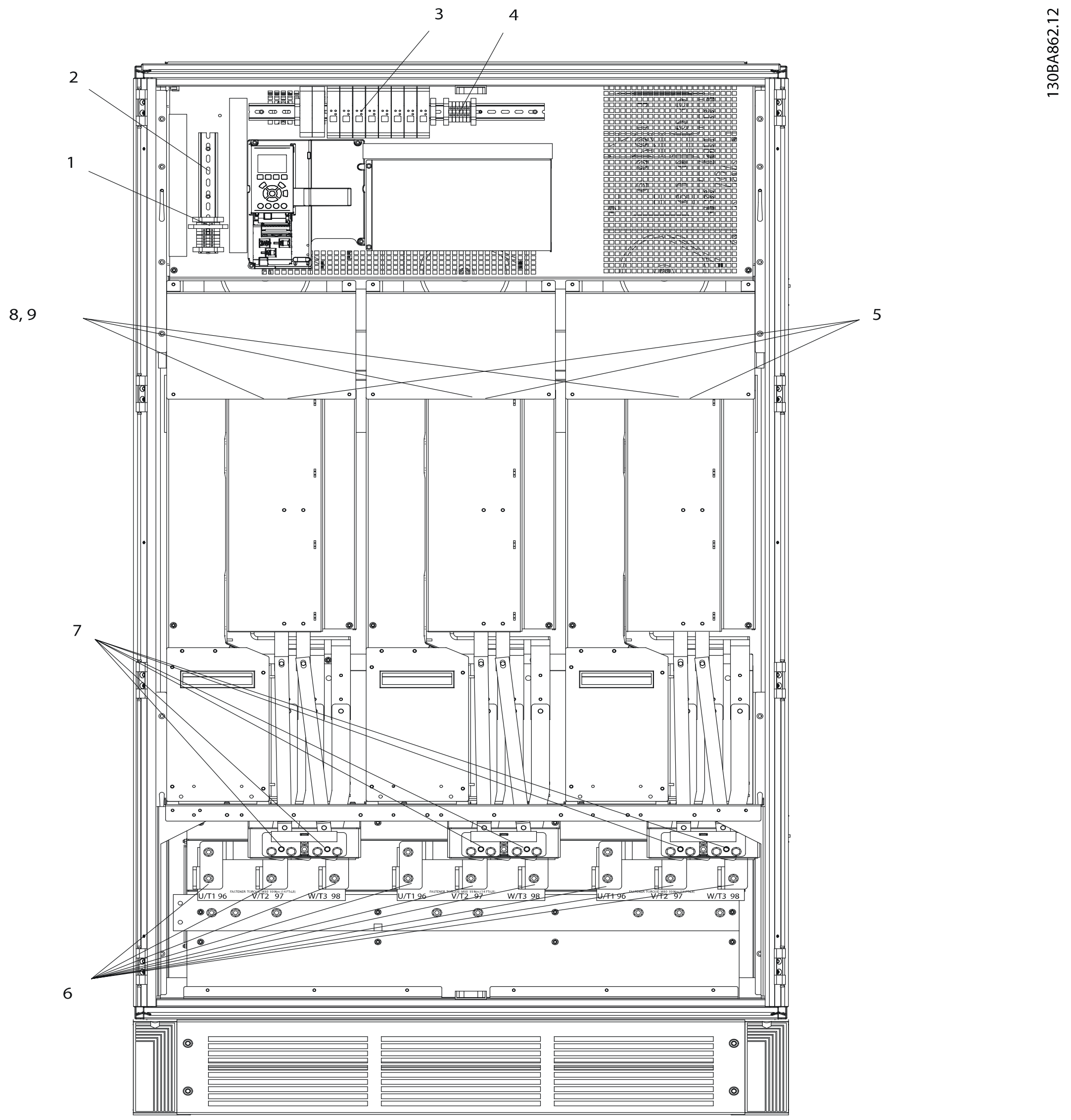


Illustration 1.5 Position of Ground Terminals IP21 (NEMA Type 1) and IP54 (NEMA Type 12)



1)	24 V DC, 5 A	5)	Load sharing
	T1 Output Taps		-DC +DC
	Temp Switch		88 89
	106 104 105	6)	Control Transformer Fuses (2 or 4 pieces). See *chapter 13.3 Fuse Specifications* for part numbers.
2)	Manual Motor Starters	7)	SMPS Fuse. See *chapter 13.3 Fuse Specifications* for part numbers.
3)	30 A Fuse Protected Power Terminals	8)	Manual Motor Controller fuses (3 or 6 pieces). See *chapter 13.3 Fuse Specifications* for part numbers.
4)	Line	9)	Mains fuses, unit sizes 61 and 62 (3 pieces). See *chapter 13.3 Fuse Specifications* for part numbers.
	R S T	10)	30 A Fuse Protected Power fuses
	L1 L2 L3		

Illustration 1.6 Rectifier Cabinet, unit sizes 61, 62, 63, and 64



1)	External Temperature Monitoring	6)	Motor
2)	AUX Relay		U V W
	01 02 03		96 97 98
	04 05 06		T1 T2 T3
4)	AUX Fan	8)	Fan Fuses. See *chapter 13.3 Fuse Specifications* for part numbers.
	100 101 102 103	9)	SMPS Fuses. See *chapter 13.3 Fuse Specifications* for part numbers.
	L1 L2 L1 L2		

Illustration 1.7 Inverter Cabinet, Unit Sizes 62 and 64
(Unit Sizes 61 and 63 are similar with two inverter modules)

1.1.1 Extended Options Cabinets

If a frequency converter is ordered with brake chopper, it is supplied with an options cabinet that makes it taller.

Options unit designations	Extension cabinets	Possible options
45h	41h enclosure with short extension	Brake
47h	42h enclosure with short extension	Brake

Table 1.1 Overview of Extended Options

The 47h include a 200 mm pedestal for floor mounting.

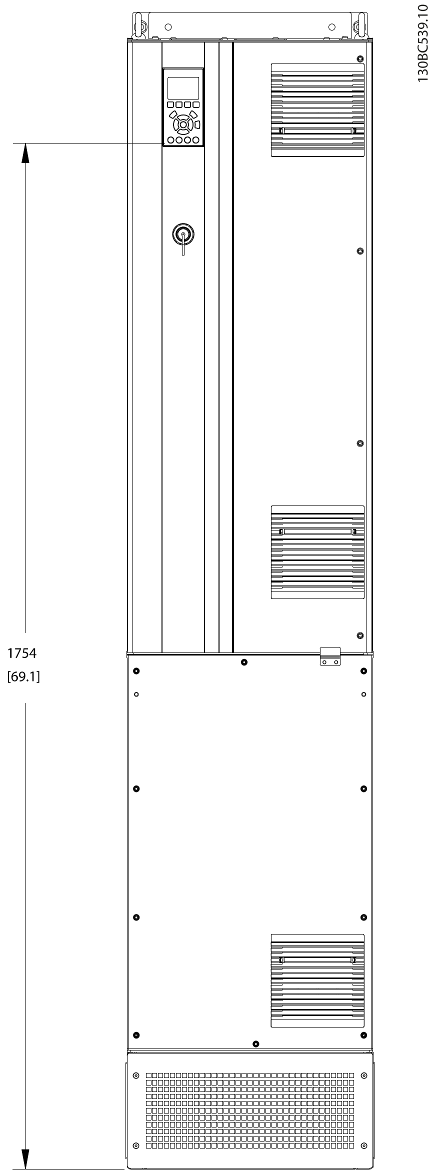


Illustration 1.8 47h Enclosure

1.2 Purpose of the Manual

This manual provides detailed information for the installation and start-up of the frequency converter.
Chapter 2 Installation provides requirements for mechanical and electrical installation, including:

- Input
- Motor
- Control wiring
- Serial communication wiring
- Control terminal functions

Chapter 3 Start-up and Functional Testing provides detailed procedures for:

- Start-up
- Basic operational programming
- Functional testing

The remaining chapters provide supplementary details. These details include:

- User interface
- Detailed programming
- Application examples
- Start-up
- Troubleshooting
- Specifications

1.3 Additional Resources

Other resources are available to understand advanced frequency converter functions and programming.

- The *Programming Guide, DET-618* provides greater detail on working with parameters and many application examples.
- Optional equipment is available that may change some of the procedures described. Reference the instructions supplied with those options for specific requirements.

1.4 Product Overview

A frequency converter is an electronic motor controller that converts DC into a variable AC waveform output. The frequency and voltage of the output are regulated to control the motor speed or torque. The frequency converter can vary the speed of the motor in response to system feedback, such as position sensors on a conveyor belt. The frequency converter can also regulate the motor by responding to remote commands from external controllers.

The frequency converter offers many control, monitoring, and efficiency functions such as:

- Monitoring the system and motor status
- Issuing warnings or alarms for fault conditions
- Starting and stopping the motor
- Optimizing energy efficiency

Operation and monitoring functions are available as status indications to an outside control system or serial communication network.

1.5 Internal Frequency Converter Controller Functions

Illustration 1.9 is a block diagram of the frequency converter's internal components.

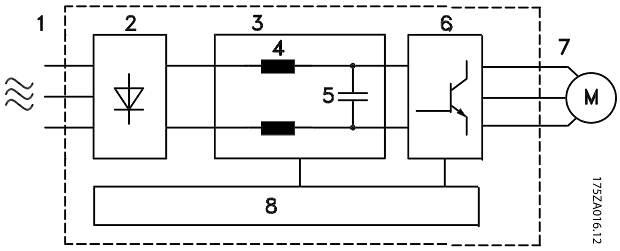


Illustration 1.9 Frequency Converter Block Diagram

Area	Title	Functions
1	Mains input	• 3-phase AC mains supply to the frequency converter.
2	Rectifier	• The rectifier bridge converts the AC input to DC current to supply inverter power.
3	DC-bus	• Intermediate DC-bus circuit handles the DC current.
4	DC reactors	• Filter the intermediate DC circuit voltage. • Prove mains transient protection. • Reduce RMS current. • Raise the power factor reflected back to the line. • Reduce harmonics on the AC input.
5	Capacitor bank	• Stores the DC power. • Provides ride-through protection for short power losses.
6	Inverter	• Converts the DC into a controlled PWM AC waveform for a controlled variable output to the motor.
7	Output to motor	• Regulated 3-phase output power to the motor.
8	Control circuitry	• Input power, internal processing, output, and motor current are monitored to provide efficient operation and control. • User interface and external commands are monitored and performed. • Status output and control can be provided.

Table 1.2 Legend to *Illustration 1.9*

2 Installation

2.1 Installation Site Check List

- The frequency converter relies on the ambient air for cooling. Observe the limitations on ambient air temperature for optimal operation.
- Ensure that the installation location has sufficient support strength to mount the frequency converter.
- Keep the manual, drawings, and diagrams accessible for detailed installation and operation instructions. It is important that the manual is available for equipment operators.
- Locate equipment as near to the motor as possible. Keep motor cables as short as possible. Check the motor characteristics for actual tolerances.

  Do not exceed:
  - 300 m (1000 ft) for unshielded motor cables.
  - 150 m (500 ft) for shielded cable.
- Ensure that the ingress protection rating of the frequency converter is suitable for the installation environment. IP55 (NEMA 12) or IP66 (NEMA 4) enclosures may be necessary.

⚠CAUTION

INGRESS PROTECTION

IP54, IP55, and IP66 ratings can only be guaranteed if the unit is properly closed.

- **Ensure that all cable glands and unused holes for glands are properly sealed.**
- **Ensure that the unit cover is properly closed.**

⚠CAUTION

DEVICE DAMAGE THROUGH CONTAMINATION

Do not leave the frequency converter uncovered.

2.2 Frequency Converter and Motor Pre-installation Check List

- Compare the model number of unit on the nameplate to what was ordered to verify the proper equipment.
- Ensure each of the following are rated for same voltage:
  - Mains (power)
  - Frequency converter
  - Motor
- Ensure that the frequency converter output current rating is equal to or greater than motor full load current for peak motor performance:
  - Motor size and frequency converter power must match for proper overload protection.
  - If frequency converter rating is less than motor, full motor output cannot be achieved.

2.3 Mechanical Installation

2.3.1 Cooling

- To provide cooling airflow, mount the unit to a solid flat surface or to the optional backplate (see *chapter 2.3.4 Mounting*).
- Top and bottom clearance for air cooling must be provided. Generally, 100–225 mm (4–10 in) is required. See *Illustration 2.1* for clearance requirements.
- Improper mounting can result in over heating and reduced performance.
- Derating for temperatures starting between 40 °C (104 °F) and 50 °C (122 °F) and elevation 1000 m (3300 ft) above sea level must be considered.

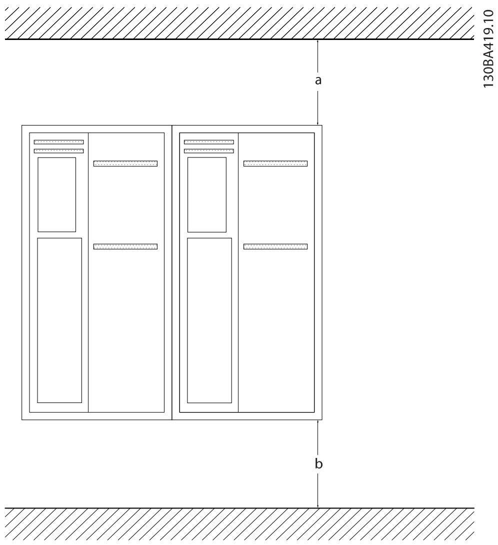


Illustration 2.1 Top and Bottom Cooling Clearance

Size	12–15	21–24	31, 33	32, 34, 41h, 42h, 43h, 44h, 51, and 52
a/b [mm]	100	200	200	225

Table 2.1 Minimum Airflow Clearance Requirements

2

2.3.2 Cooling and Airflow (125 hp and above)

Cooling

Cooling can be obtained in different ways, by using the cooling ducts in the bottom and the top of the unit, by taking air in and out the back of the unit or by combining the cooling possibilities.

Duct cooling

A back-channel cooling kit is available to direct the heat sink cooling air out of the panel when an IP20/chassis frequency converter is installed in a Rittal enclosure. Use of this kit reduces the heat in the panel and smaller door fans can be specified on the enclosure.

Back cooling

The back channel cooling air can be ventilated out of the room so that the heat from the back channel is not dissipated into the control room. A door fan(s) is required on the enclosure to remove the heat not contained in the backchannel of the frequency converters and any additional losses generated by other components inside the enclosure. The total required air flow must be calculated so that the appropriate fans can be selected.

Airflow

The necessary airflow over the heat sink must be secured. The flow rate is in *Table 2.2*.

Protection	Unit size	Door fan(s)/Top fan	Heat sink fan(s)
IP20/Chassis	43h	102 m^3/hr (60 CFM)	420 m^3/hr (250 CFM)
	44h	204 m^3/hr (120 CFM)	840 m^3/hr (500 CFM)
IP00/Chassis	51	340 m^3/h (200 cfm)	1445 m^3/h (850 cfm)
IP21/Nema 1	41h	102 m^3/hr (60 CFM)	420 m^3/hr (250 CFM)
	42h	204 m^3/hr (120 CFM)	840 m^3/hr (500 CFM)
	52	255 m^3/h (150 cfm)	1445 m^3/h (650 cfm)
	61, 62, 63, 64	700 m^3/h (412 cfm)[1)]	985 m^3/h (580 cfm)[1)]
IP54/Nema 12	41h	102 m^3/hr (60 CFM)	420 m^3/hr (250 CFM)
	42h	204 m^3/hr (120 CFM)	840 m^3/hr (500 CFM)
	52	255 $m^3$3/h (150 cfm)	1445 m^3/h (650 cfm)
	61, 62, 63, 64	525 m^3/h (309 cfm)[1)]	985 m^3/h (580 cfm)[1)]

Table 2.2 Heat sink Airflow

1) Airflow per fan. Unit Sizes 6X contain multiple fans.

2.3.3 Lifting

- Check the weight of the unit to determine a safe lifting method
- Ensure that the lifting device is suitable for the task
- If necessary, plan for a hoist, crane, or forklift with the appropriate rating to move the unit
- For lifting, use hoist rings on the unit, when provided

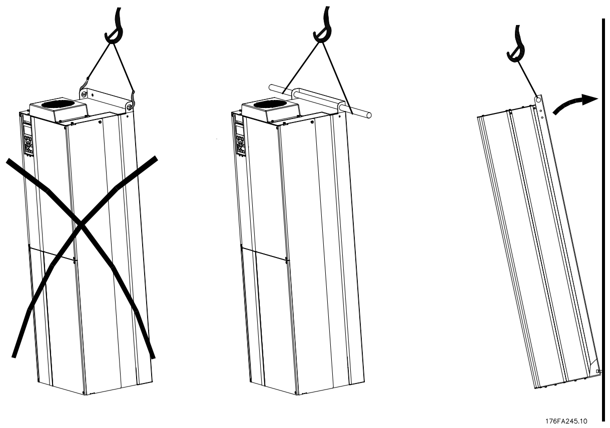


Illustration 2.2 Recommended Lifting Method, 4X and 5X Unit Sizes

⚠WARNING

Maximum diameter for bar is 2.5 cm (1 in). The angle from the top of the frequency converter to the lifting cable should be 60° or greater.

2.3.4 Mounting

- Mount the unit vertically.
- The frequency converter allows side-by-side installation.
- Ensure that the strength of the mounting location supports the unit weight.
- Mount the unit to a solid flat surface or to the optional backplate to provide cooling airflow (see *Illustration 2.3* and *Illustration 2.4*).
- Improper mounting can result in over heating and reduced performance.
- Use the slotted mounting holes on the unit for wall mount, when provided.
- For outdoor installations of Nema 4X/IP66 drives: The drive must be installed under a suitable cover to protect from direct exposure to sun, snow, and ice.

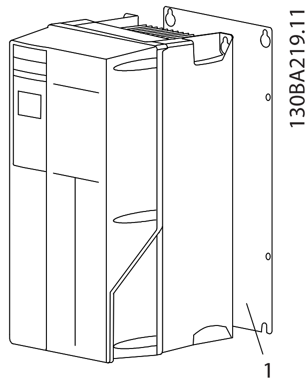


Illustration 2.3 Proper Mounting with Backplate

Item A in *Illustration 2.3* and *Illustration 2.4* is a backplate properly installed for required airflow to cool the unit.

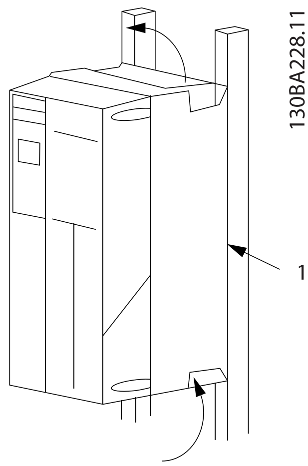


Illustration 2.4 Proper Mounting with Railings

NOTICE

Back plate is needed when mounted on railings.

2

2.4 Acoustic Noise

The typical values measured at a distance of 1 m from the unit:

Unit size	At reduced fan speed (50%) [dBA]	Full fan speed [dBA]
12	51	60
13	51	60
14	50	55
15	54	63
21	61	67
22	58	70
23	59.4	70.5
24	53	62.8
31	52	62
32	55	65
33	56.4	67.3
34	–	–
41h/43h/45h	–	72
42h/44h/47h	–	75
61/62/63/64	78	80

Table 2.3 Measured Values

2.5 Electrical Installation

This section contains detailed instructions for wiring the frequency converter.

The following tasks are described:

- Wiring the motor to the frequency converter output terminals.
- Wiring the AC mains to the frequency converter input terminals.
- Connecting control and serial communication wiring.
- After power has been applied, checking input and motor power; programming control terminals for their intended functions.

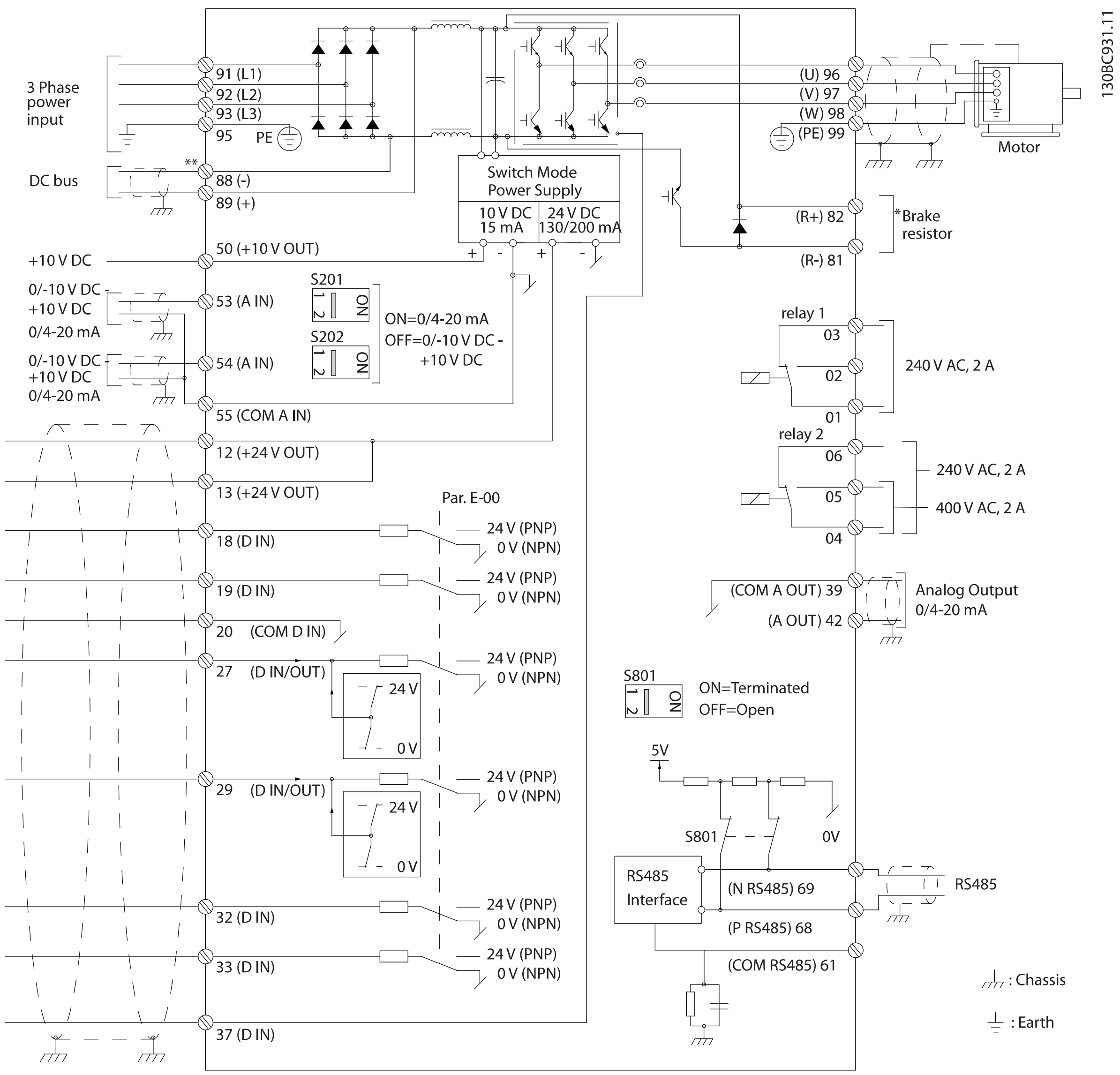


Illustration 2.5 Basic Wiring Schematic Drawing

A=Analog, D=Digital

Terminal 37 is used for Safe Torque Off. Refer to *Safe Torque Off Operating Instructions* for further information.

*The brake chopper factory option must be ordered to use dynamic brake resistors

**The DC bus option must be ordered from factory.

2.5.1 Requirements

WARNING

EQUIPMENT HAZARD!

Rotating shafts and electrical equipment can be hazardous. All electrical work must conform to national and local electrical codes. It is recommended that installation, start up, and maintenance is performed only by trained and qualified personnel. Failure to follow these guidelines could result in death or serious injury.

CAUTION

WIRING ISOLATION!

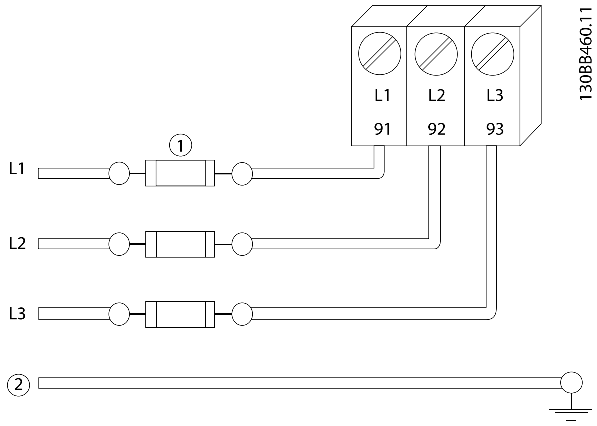
Run input power, motor wiring, and control wiring in three separate metallic conduits or use separated shielded cable for high frequency noise isolation. Failure to isolate power, motor, and control wiring could result in less than optimum frequency converter and associated equipment performance.

For your safety, comply with the following requirements:

- Electronic controls equipment is connected to hazardous mains voltage. Extreme care should be taken to protect against electrical hazards when applying power to the unit.
- Run motor cables from multiple frequency converters separately. Induced voltage from output motor cables run together can charge equipment capacitors even with the equipment turned off and locked out.

Overload and equipment protection

- An electronically activated function within the frequency converter provides overload protection for the motor. The overload calculates the level of increase to activate timing for the trip (controller output stop) function. The higher the current draw, the quicker the trip response. The overload provides Class 20 motor overload protection. See *chapter 10 Warnings and Alarms* for details on the trip function.
- Because the motor wiring carries high frequency current, it is important that wiring for mains, motor power, and control are run separately. Use metallic conduit or separated shielded wire. Failure to isolate power, motor, and control wiring could result in less than optimum equipment performance.
- All frequency converters must be provided with short circuit and overcurrent protection. Input fusing is required to provide this protection, see *Illustration 2.6*. Fuses must be provided by the installer as part of installation. See maximum fuse ratings in *chapter 13.3 Fuse Specifications*.



1	Fuses
2	Ground

Illustration 2.6 Frequency Converter Fuses

Wire type and ratings

- All wiring must comply with local and national regulations regarding cross-section and ambient temperature requirements.
- GE recommends that all power connections be made with a minimum 75 °C rated copper wire.
- See for recommended wire sizes.

2.5.2 Grounding Requirements

WARNING

GROUNDING HAZARD!

For operator safety, it is important to ground the frequency converter properly in accordance with national and local electrical codes and instructions contained within these instructions. Ground currents are higher than 3.5 mA. Failure to ground the frequency converter properly could result in death or serious injury.

NOTICE

It is the responsibility of the user or certified electrical installer to ensure correct grounding of the equipment in accordance with national and local electrical codes and standards.

- Follow all local and national electrical codes to ground electrical equipment properly.
- Proper protective grounding for equipment with ground currents higher than 3.5 mA must be established, see *chapter 2.5.2.1 Leakage Current (>3.5 mA)*.
- A dedicated ground wire is required for input power, motor power, and control wiring.

- Use the clamps provided with on the equipment for proper ground connections.
- Do not ground one frequency converter to another in a “daisy chain” fashion.
- Keep the ground wire connections as short as possible.
- Use of high-strand wire to reduce electrical noise is recommended.
- Follow motor manufacturer wiring requirements.

2.5.2.1 Leakage Current (>3.5 mA)

Follow national and local codes regarding protective earthing of equipment with a leakage current > 3.5 mA. Frequency converter technology implies high frequency switching at high power. This generates a leakage current in the ground connection. A fault current in the frequency converter at the output power terminals might contain a DC component which can charge the filter capacitors and cause a transient ground current. The ground leakage current depends on various system configurations including RFI filtering, shielded motor cables, and frequency converter power.

EN/IEC61800-5-1 (Power Drive System Product Standard) requires special care if the leakage current exceeds 3.5 mA.

Grounding must be reinforced in one of the following ways:

- Ground wire of at least 10 mm^2 (8 AWG).
- Two separate ground wires both complying with the dimensioning rules.

See EN 60364-5-54 § 543.7 for further information.

Using RCDs

Where residual current devices (RCDs), also known as earth leakage circuit breakers (ELCBs), are used, comply with the following:

- Use RCDs of type B only which are capable of detecting AC and DC currents.
- Use RCDs with an inrush delay to prevent faults due to transient ground currents.
- Dimension RCDs according to the system configuration and environmental considerations.

2.5.2.2 Grounding Using Shielded Cable

Grounding clamps are provided for motor wiring (see *Illustration 2.7*).

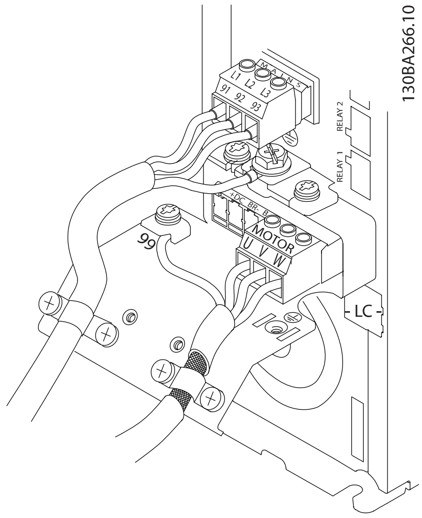


Illustration 2.7 Grounding with Shielded Cable

2.5.3 Motor Connection

⚠WARNING

INDUCED VOLTAGE!

Run output motor cables from multiple frequency converters separately. Induced voltage from output motor cables run together can charge equipment capacitors even with the equipment turned off and locked out. Failure to run output motor cables separately could result in death or serious injury.

- For maximum wire sizes, see *Table 12.1*.
- Comply with local and national electrical codes for cable sizes.
- Motor wiring knockouts or access panels are provided at the base of IP21 and higher (Nema 1, 12, and 4/4X Indoor) units.
- Do not install power factor correction capacitors between the frequency converter and the motor.
- Do not wire a starting or pole-changing device between the frequency converter and the motor.
- Connect the 3-phase motor wiring to terminals 96 (U), 97 (V), and 98 (W).
- Ground the cable in accordance with grounding instructions provided.
- Torque terminals in accordance with the information provided in *chapter 12 Terminal and Applicable Wire*.
- Follow motor manufacturer wiring requirements.

Illustration 2.8 shows mains input, motor, and grounding for basic frequency converters. Actual configurations vary with unit types and optional equipment.

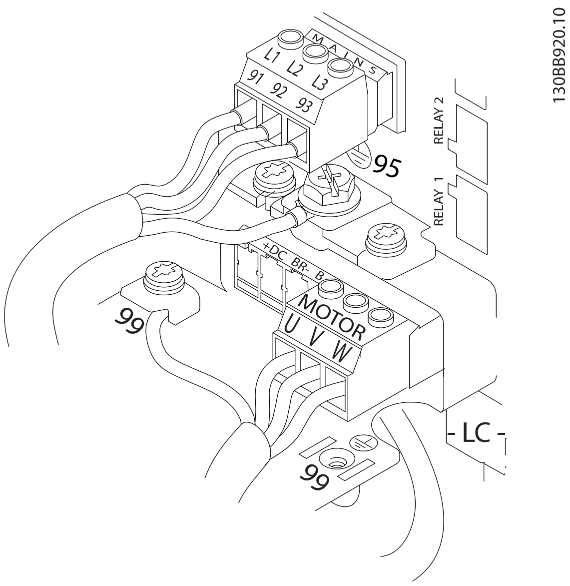


Illustration 2.8 Example of Motor, Mains, and Ground Wiring

2.5.4 AC Mains Connection

- Size wiring based on the input current of the frequency converter. For maximum wire sizes, see *Table 12.1*.
- Comply with local and national electrical codes for cable sizes.
- Connect 3-phase AC input power wiring to terminals L1, L2, and L3 (see *Illustration 2.8*).
- Depending on the configuration of the equipment, input power is connected to the mains input power or the input disconnect.
- Ground the cable in accordance with grounding instructions provided in *chapter 2.5.2 Grounding Requirements*.
- All frequency converters may be used with an isolated input source and with ground reference power lines. When supplied from an isolated mains source (IT mains or floating delta) or TT/TN-S mains with a grounded leg (grounded delta), set *parameter SP-50 RFI Filter* to *[0] Off*. When off, the internal RFI filter capacitors between the chassis and the intermediate circuit are isolated to avoid damage to the DC link and to reduce ground capacity currents in accordance with IEC 61800-3.

2.5.5 Control Wiring

- Isolate control wiring from high-power components in the frequency converter.
- If the frequency converter is connected to a thermistor, for PELV isolation, optional thermistor control wiring must be reinforced/double insulated. A 24 V DC supply voltage is recommended.

2.5.5.1 Access

- Remove access cover plate with a screwdriver. See *Illustration 2.9*.
- Or remove front cover by loosening attaching screws. See *Illustration 2.10*.
  Tightening torque for front cover is 2.0 Nm for unit size 15 Nm and 2.2 Nm for unit sizes 2X and 3X.

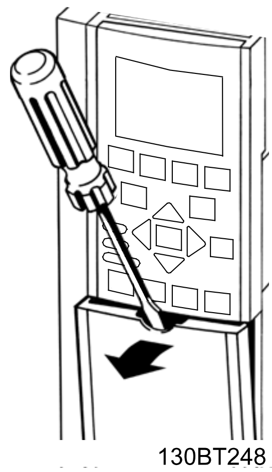


Illustration 2.9 Control Wiring Access for IP20/Open Chassis Enclosures

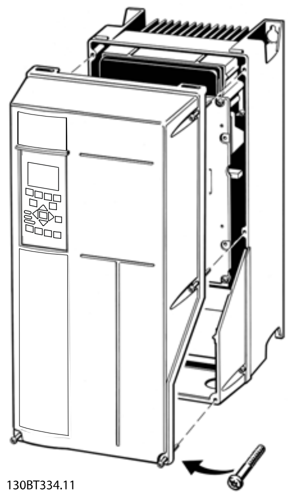


Illustration 2.10 Control Wiring Access for IP55/ Nema 12 and IP66/Nema 4/4X Indoor

2.5.5.2 Control Terminal Types

Illustration 2.11 shows the removable frequency converter connectors. Terminal functions and default settings are summarized in *Table 2.5*.

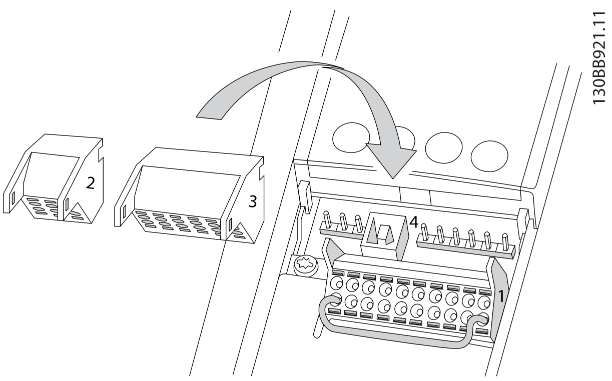


Illustration 2.11 Control Terminal Locations

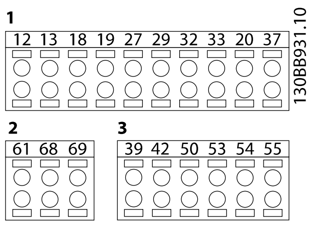


Illustration 2.12 Terminal Numbers

- **Connector 1** provides four programmable digital inputs terminals, two extra digital terminals programmable as either input or output, a 24 V DC terminal supply voltage, and a common for optional customer supplied 24 V DC voltage. A digital input for STO (Safe Torque Off) function.
- **Connector 2** terminals (+)68 and (-)69 are for an RS485 serial communications connection.
- **Connector 3** provides two analog inputs, one analog output, 10 V DC supply voltage, and commons for the inputs and output.
- **Connector 4** is a USB port available for use with the DCT-10.
- Also provided are two Form C relay outputs that are in various locations depending after the frequency converter configuration and size.
- Some options available for ordering with the unit may provide extra terminals. See the manual provided with the equipment option.

See *chapter 13.2 General Technical Data* for terminal ratings details.

Terminal description			
Terminal	**Parameter**	**Default setting**	**Description**
Digital inputs/outputs			
12, 13	–	+24 V DC	24 V DC supply voltage. Maximum output current is 200 mA total for all 24 V loads. Useable for digital inputs and external transducers.
18	E-01	[8] Start	Digital inputs.
19	E-02	[10] Reversing	
32	E-05	[0] No operation	
33	E-06	[0] No operation	
27	E-03	[0] No operation	Selectable for either digital input or output. Default setting is input.
29	E-04	[14] Jog	
20	–		Common for digital inputs and 0 V potential for 24 V supply.
37	–	Safe Torque Off (STO)	Safe input. Used for STO.
Analog inputs/outputs			
39	–	–	Common for analog output.
42	AN-50	[0] No operation	Programmable analog output. The analog signal is 0–20 mA or 4–20 mA at a maximum of 500 Ω

Terminal description			
Terminal	Parameter	Default setting	Description
Digital inputs/outputs			
50	–	+10 V DC	10 V DC analog supply voltage. 15 mA maximum commonly used for potentiometer or thermistor.
53	AN-1#	Reference	Analog input. Selectable for voltage or current. Switches A53 and A54 select mA or V.
54	AN-2#	Feedback	
55	–	–	Common for analog input.

Table 2.4 Terminal Description Digital Inputs/Outputs, Analog Inputs/Outputs

Terminal description			
Terminal	Parameter	Default setting	Description
Serial communication			
61	–	–	Integrated RC-Filter for cable screen. ONLY for connecting the shield when experiencing EMC problems.
68 (+)	O-3#	–	RS485 Interface. A control card switch is provided for termination resistance.
69 (-)	O-3#	–	
Relays			
01, 02, 03	E-24	[0] No operation	Form C relay output. Usable for AC or DC voltage and resistive or inductive loads.
04, 05, 06	E-24	[0] No operation	

Table 2.5 Terminal Description Serial Communication

2.5.5.3 Wiring to Control Terminals

Control terminal connectors can be unplugged from the frequency converter for ease of installation, as shown in *Illustration 2.11*.

1. Open the contact by inserting a small screwdriver into the slot above or below the contact, as shown in *Illustration 2.13*.
2. Insert the bared control wire into the contact.
3. Remove the screwdriver to fasten the control wire into the contact.
4. Ensure that the contact is firmly established and not loose. Loose control wiring can be the source of equipment faults or less than optimal operation.

See *chapter 12 Terminal and Applicable Wire* for control terminal wiring sizes.

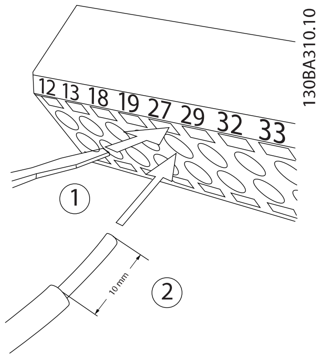
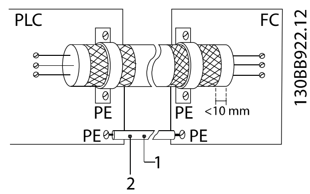


Illustration 2.13 Connecting Control Wiring

2.5.5.4 Using Shielded Control Cables

Correct screening
The preferred method usually is to secure control and serial communication cables with screening clamps provided at both ends to ensure best possible high frequency cable contact.
If the ground potential between the frequency converter and the PLC is different, electric noise may occur that disturbs the entire system. Solve this problem by fitting an equalizing cable next to the control cable. Minimum cable cross-section: 16 mm^2 (6 AWG).



1	Minimum 16 mm^2 (6 AWG)
2	Equalizing cable

Illustration 2.14 Correct Screening

50/60 Hz ground loops
With long control cables, ground loops may occur. To eliminate ground loops, connect one end of the screen-to-ground with a 100 nF capacitor (keeping leads short).

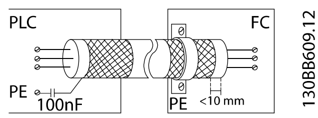
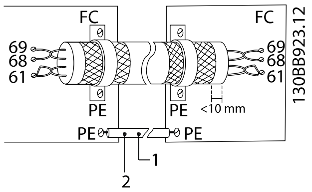


Illustration 2.15 50/60 Hz Ground Loops

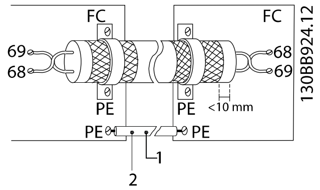
Avoid EMC noise on serial communication
This terminal is connected to ground via an internal RC link. Use twisted-pair cables to reduce interference between conductors. The recommended method is in *Illustration 2.16*:



1	Minimum 16 mm^2 (6 AWG)
2	Equalizing cable

Illustration 2.16 Twisted-pair Cables

Alternatively, the connection to terminal 61 can be omitted:



1	Minimum 16 mm^2 (6 AWG)
2	Equalizing cable

Illustration 2.17 Twisted-pair Cables without Terminal 61

2.5.5.5 Control Terminal Functions

Frequency converter functions are commanded by receiving control input signals.

- Each terminal must be programmed for the function it is supporting in the parameters associated with that terminal. See *Table 2.5* for terminals and associated parameters.
- It is important to confirm that the control terminal is programmed for the correct function. See *chapter 4 User Interface* for details on accessing parameters and *chapter 5 About Programming* for details on programming.
- The default terminal programming is intended to initiate frequency converter functioning in a typical operational mode.

2.5.5.6 Terminal 53 and 54 Switches

- Analog input terminals 53 and 54 can select either voltage (-10 V to 10 V) or current (0/4–20 mA) input signals.
- Remove power to the frequency converter before changing switch positions.
- Set switches A53 and A54 to select the signal type. U selects voltage, I selects current.
- The switches are accessible when the keypad has been removed (see *Illustration 2.18*).

NOTICE

Some option cards available for the unit may cover these switches and must be removed to change switch settings. Always remove power to the unit before removing option cards.

- Terminal 53 default is for a speed reference signal in open loop set in *parameter DR-61 Terminal 53 Switch Setting*.
- Terminal 54 default is for a feedback signal in closed loop set in *parameter DR-63 Terminal 54 Switch Setting*.

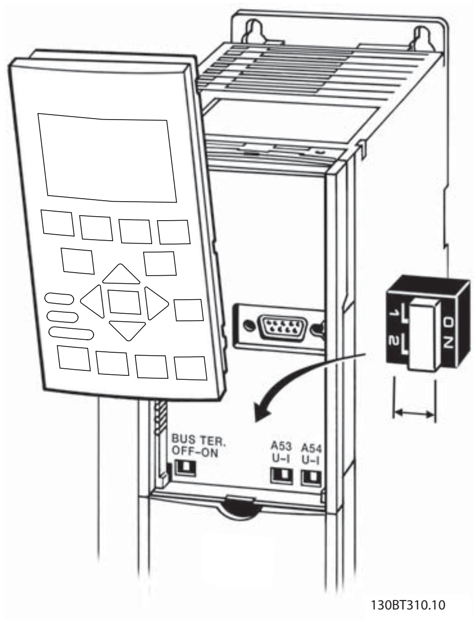


Illustration 2.18 Location of Terminals 53 and 54 Switches and Bus Termination Switch

2.5.5.7 Terminal 37

Terminal 37 Safe Torque Off function
The AF-650 GP is available with Safe Torque Off functionality via control terminal 37. Safe torque off (STO) disables the control voltage of the power semiconductors of the frequency converter output stage which in turn

prevents generating the voltage required to rotate the motor. To run STO, additional wiring for the frequency converter is required. Refer to *Safe Torque Off Operating Instructions* for further information.

2

2.5.6 Serial Communication

Connect RS485 serial communication wiring to terminals (+)68 and (-)69.

- Shielded serial communication cable is recommended.
- See *chapter 2.5.2 Grounding Requirements* for proper grounding.

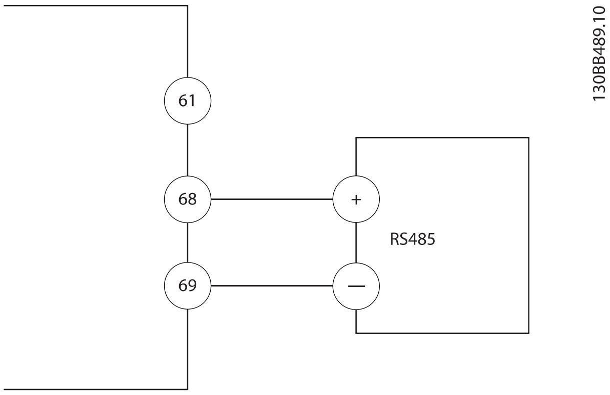


Illustration 2.19 Serial Communication Wiring Diagram

For basic serial communication set-up, select the following:

1. Protocol type in *parameter O-30 Protocol*.
2. Frequency converter address in *parameter O-31 Address*.
3. Baud rate in *parameter O-32 Drive Port Baud Rate*.

- Two communication protocols are internal to the frequency converter.
  - Drive profile
  - Modbus RTU
- Functions can be programmed remotely using the protocol software and RS485 connection or in parameter group *O-## Options/Comms*.
- Selecting a specific communication protocol changes various default parameter settings to match that protocol's specifications along with making extra protocol-specific parameters available.
- Option cards which install into the frequency converter are available to provide extra communication protocols. See the option-card documentation for installation and operation instructions.

2.5.7 Electrical Installation - EMC Precautions

The following is a guideline to good engineering practice when installing frequency converters. Follow these guidelines to comply with EN 61800-3 *First environment*. If the installation is in EN 61800-3 *Second environment*, that is, industrial networks, or in an installation with its own transformer, deviation from these guidelines is allowed but not recommended. See also *chapter 7.1.1 General Aspects of EMC Emissions*, and *chapter 7.1.3 EMC Test Results (Emission)*.

Good engineering practice to ensure EMC-correct electrical installation:

- Use only braided screened/armoured motor cables and braided screened/armoured control cables. The shield should provide a minimum coverage of 80%. The shield material must be metal, not limited to but typically copper, aluminum, steel, or lead. There are no special requirements for the mains cable.
- Installations using rigid metal conduits are not required to use shielded cable, but the motor cable must be installed in conduit separate from the control and mains cables. Full connection of the conduit from the frequency converter to the motor is required. The EMC performance of flexible conduits varies a lot and information from the manufacturer must be obtained.
- Connect the screen/armour/conduit to ground at both ends for motor cables and for control cables. Sometimes, it is not possible to connect the shield in both ends. If so, connect the shield at the frequency converter.
- Avoid terminating the screen/armour with twisted ends (pigtails). It increases the high frequency impedance of the shield, which reduces its effectiveness at high frequencies. Use low impedance cable clamps or EMC cable glands instead.
- Avoid using unscreened/unarmoured motor or control cables inside cabinets housing the drive(s), whenever this can be avoided.

Leave the shield as close to the connectors as possible.

Illustration 2.20 shows an example of an EMC-correct electrical installation of an IP20 frequency converter. The frequency converter is fitted in an installation cabinet with an output contactor and connected to a PLC, which is installed in a separate cabinet. Other ways of doing the installation may have just as good an EMC performance, provided the above guide lines to engineering practice are followed.

If the installation is not carried out according to the guideline and if unshielded cables and control wires are used, some emission requirements are not complied with, although the immunity requirements are fulfilled. See *chapter 7.1.3 EMC Test Results (Emission)*.

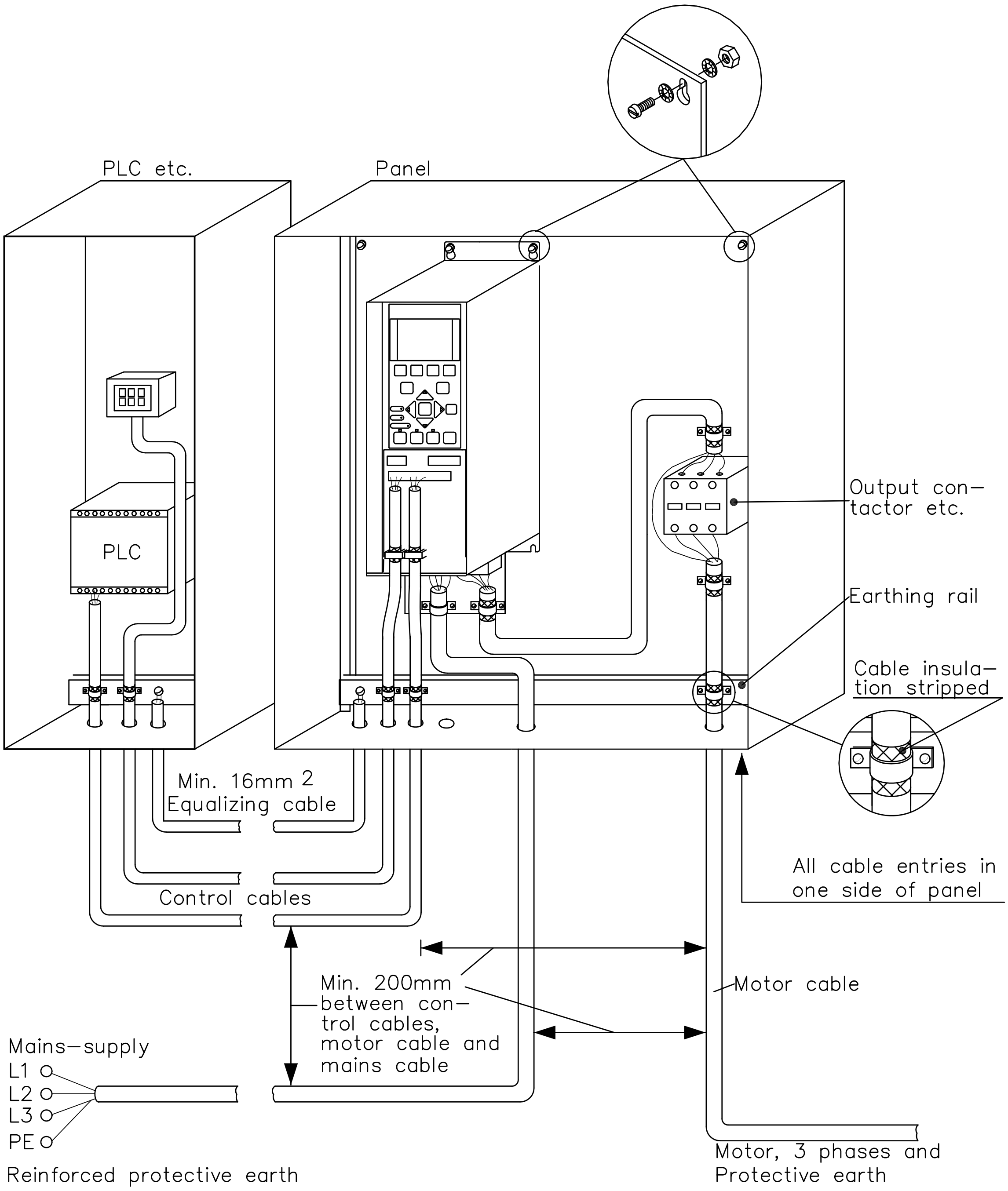


Illustration 2.20 EMC-correct Electrical Installation of a Frequency Converter in Cabinet

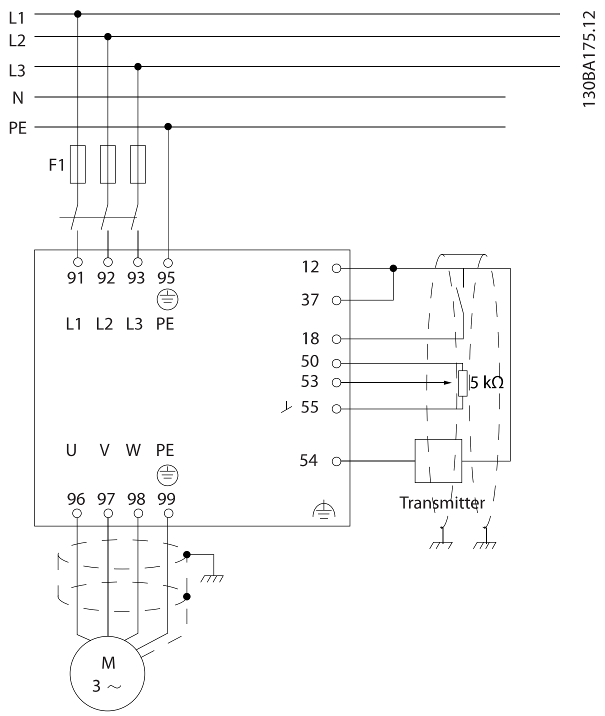


Illustration 2.21 Electrical Connection Diagram

3 Start-up and Functional Testing

3.1 Pre-start

3.1.1 Safety Inspection

WARNING

HIGH VOLTAGE

If input and output connections have been connected improperly, there is potential for high voltage on these terminals. If power leads for multiple motors are improperly run in same conduit, there is potential for leakage current to charge capacitors within the frequency converter, even when disconnected from mains input.

- **For initial start-up, make no assumptions about power components.**
- **Follow pre-start procedures.**

Failure to follow pre-start procedures could result in personal injury or damage to equipment.

1. Switch off the Input power to the unit and ensure that it is locked out. Do not rely on the frequency converter disconnect switches for input power isolation.
2. Verify that there is no voltage on input terminals L1 (91), L2 (92), and L3 (93), phase-to-phase, and phase-to-ground.
3. Verify that there is no voltage on output terminals 96 (U), 97 (V), and 98 (W), phase-to-phase, and phase-to-ground.
4. Confirm continuity of the motor by measuring ohm values on U–V (96–97), V–W (97–98), and W–U (98–96).
5. Check for proper grounding of the frequency converter and the motor.
6. Inspect the frequency converter for loose connections on terminals.
7. Record the following motor nameplate data:
   - 7a Power
   - 7b Voltage
   - 7c Frequency
   - 7d Full load current
   - 7e Nominal speed.

   These values are needed to program the motor nameplate data later.
8. Confirm that the supply voltage matches the voltage of the frequency converter and the motor.

3.1.2 Pre-start

CAUTION

Before applying power to the unit, inspect the entire installation as detailed in *Table 3.1*. Check mark those items when completed.

Inspect for	Description	☑
Auxiliary equipment	• Look for auxiliary equipment, switches, disconnects, or input fuses/circuit breakers on the input power side of the frequency converter or output side to the motor. Ensure that they are ready for full speed operation. • Check function and installation of any sensors used for feedback to the frequency converter. • Remove power factor correction capacitors on motors, if present.	
Cable routing	• Use separate metallic conduits for each of the following: - Input power - Motor wiring - Control wiring	
Control wiring	• Check for broken or damaged wires and loose connections. • Check that control wiring is isolated from power and motor wiring for noise immunity. • Check the voltage source of the signals. • Use shielded or twisted-pair cable. Ensure that the shield is terminated correctly.	
Cooling clearance	• Measure that top and bottom clearance is adequate to ensure proper air flow for cooling.	
EMC considerations	• Check for proper installation regarding electromagnetic compatibility.	
Environmental considerations	• See equipment label for the maximum ambient operating temperature limits. • Humidity levels must be 5–95%, non-condensing.	
Fusing and circuit breakers	• Check for proper fusing or circuit breakers. • Check that all fuses are inserted firmly and in operational condition, and that all circuit breakers are in the open position.	
Grounding	• The unit requires a ground wire from its enclosure to the building ground. • Check for good ground connections that are tight and free of oxidation. • Grounding to conduit or mounting the back panel to a metal surface is not sufficient.	
Input and output power wiring	• Check for loose connections. • Check that motor and mains are in separate conduit or separated shielded cables.	
Panel interior	• Inspect that the unit interior is free of debris and corrosion.	
Switches	• Ensure that all switch and disconnect settings are in the proper positions.	
Vibration	• Check that the unit is mounted solidly or that shock mounts are used as necessary. • Check for an unusual amount of vibration.	

Table 3.1 Start-up Checklist

3.2 Applying Power

WARNING

HIGH VOLTAGE!

Frequency converters contain high voltage when connected to AC mains. Installation, start-up, and maintenance should be performed by qualified personnel only. Failure to comply could result in death or serious injury.

WARNING

UNINTENDED START!

When the frequency converter is connected to AC mains, the motor may start at any time. The frequency converter, motor, and any driven equipment must be in operational readiness. Failure to comply could result in death, serious injury, equipment, or property damage.

1. Confirm that the input voltage is balanced within 3%. If not, correct input voltage imbalance before proceeding. Repeat this procedure after the voltage correction.
2. Ensure that optional equipment wiring, if present, matches the installation application.
3. Ensure that all operator devices are in the OFF position. Panel doors should be closed or cover-mounted.
4. Apply power to the unit. DO NOT start the frequency converter at this time. For units with a disconnect switch, turn to the ON position to apply power to the frequency converter.

3.3 Basic Operational Programming

3.3.1 Required Initial Frequency Converter Programming

Frequency converters require basic operational programming before running for best performance. This requires entering motor nameplate data for the motor being operated and the minimum and maximum motor speeds. Enter data in accordance with the following procedure. Parameter settings recommended are intended for start-up and checkout purposes. Application settings may vary. See *chapter 4 User Interface* for detailed instructions on entering data via the keypad.

Enter data with power ON, but before operating the frequency converter.

1. Press [Quick Menu] on the keypad.
2. Use the navigation keys to scroll to Quick Start and press [OK].
3. Select language and press [OK]. Then enter the motor data in parameters P-02, P-03, P-06, P-07, F-04, and F-05. The information can be found on the motor nameplate.

   Parameter P-07 Motor Power [kW] or *parameter P-02 Motor Power [HP]*

   Parameter F-05 Motor Rated Voltage

   Parameter F-04 Base Frequency

   Parameter P-03 Motor Current

   Parameter P-06 Base Speed

4. Enter *parameter F-01 Frequency Setting 1* and press [OK].
5. Enter *parameter F-02 Operation Method*. Local, Remote, or Linked to Hand/Auto. In local the reference is entered on the keypad, and in remote that reference is sourced depending on *parameter F-01 Frequency Setting 1*.
6. Enter the accel/decel time in *parameter F-07 Accel Time 1* and *parameter F-08 Decel Time 1*.
7. For *parameter F-10 Electronic Overload* enter Elec OL Trip 1 for Class 20 overload protection. For further information, see *chapter 2.5.1 Requirements*.
8. For *parameter F-17 Motor Speed High Limit [RPM]* or *parameter F-15 Motor Speed High Limit [Hz]* enter the application requirements.
9. For *parameter F-18 Motor Speed Low Limit [RPM]* or *parameter F-16 Motor Speed Low Limit [Hz]* enter the application requirements.
10. Set *parameter H-08 Reverse Lock* to Clockwise, counterclockwise or Both directions.
11. In *parameter P-04 Auto Tune* select Reduced Auto Tune or Full Auto Tune and follow on-screen instructions. See *chapter 3.4 Auto Tune*.

3.4 Auto Tune

Auto tune is a test procedure, which measures the electrical characteristics of the motor to optimize compatibility between the frequency converter and the motor.

- The frequency converter builds a mathematical model of the motor for regulating output motor current. The procedure also tests the input phase balance of electrical power. It compares the motor characteristics with the data entered in P-02, P-03, P-06, P-07, F-04, and F-05.
- The motor shaft does not turn and no harm is done to the motor while running the Auto tune.

- Some motors may be unable to run the complete version of the test. In that case, select *[2] Reduced Auto Tune*.
- If an output filter is connected to the motor, select *[2] Reduced Auto Tune*.
- If warnings or alarms occur, see *chapter 10 Warnings and Alarms* for resetting the frequency converter after a trip.
- Run this procedure on a cold motor for best results.

3.5 Check Motor Rotation

Before running the frequency converter, check the motor rotation.

1. Press [Hand].
2. Press [▲] for positive speed reference.
3. Check that the speed shown is positive.
4. Verity that the wiring between the frequency converter and the motor is correct.
5. Verity that the motor running direction matches the setting in *parameter H-48 Clockwise Direction*.
    - When *parameter H-48 Clockwise Direction* is set to *[0] Normal* (default clockwise):
        a. Verify that the motor turns clockwise.
        b. Verify that the keypad direction arrow is clockwise.
    - When *parameter H-48 Clockwise Direction* is set to *[1] Inverse* (counterclockwise):
        a. Verify that the motor turns counterclockwise.
        b. Verify that the keypad direction arrow is counter-clockwise.

3.6 Local-control Test

⚠CAUTION

MOTOR START!

Ensure that the motor, system, and any attached equipment are ready for start. It is the responsibility of the user to ensure safe operation under any operational condition. Failure to ensure that the motor, system, and any attached equipment are ready for start could result in personal injury or equipment damage.

NOTICE

The Hand key on the keypad provides a local start command to the frequency converter. The [Off] key provides the stop function.
When operating in local mode, the up and down keys on the keypad increase and decrease the speed output of the drive. The left and right keys move the display cursor in the numeric display.

1. Press [Hand].
2. Accelerate the frequency converter by pressing [▲] to full speed. Moving the cursor left of the decimal point provides quicker input changes.
3. Note any acceleration problems.
4. Press [Off].
5. Note any deceleration problems.

If acceleration problems were encountered:

- If warnings or alarms occur, see *chapter 10 Warnings and Alarms*
- Check that motor data is entered correctly
- Increase the ramp time in *parameter F-07 Accel Time 1*
- Increase current limit in *parameter F-43 Current Limit*
- Increase torque limit in *parameter F-40 Torque Limiter (Driving)*

If deceleration problems were encountered:

- If warnings or alarms occur, see *chapter 10 Warnings and Alarms*.
- Check that motor data is entered correctly.
- Increase the ramp time in *parameter F-08 Decel Time 1*.
- Enable overvoltage control in *parameter B-17 Over-voltage Control*.

See *chapter 10.4 Warning and Alarm Definitions* for resetting the frequency converter after a trip.

NOTICE

Chapter 3.1 Pre-start **through** ***chapter 3.6 Local-control Test*** **in this chapter conclude the procedures for applying power to the frequency converter, basic programming, set-up, and functional testing.**

3.7 System Start-up

The procedure in this section requires user-wiring and application programming to be completed.
chapter 6 Application Set-Up Examples is intended to help with this task. Other aids to application set-up are listed in *chapter 1.3 Additional Resources*. The following procedure is recommended after application set-up by the user is completed.

⚠CAUTION

MOTOR START

Ensure that the motor, system, and any attached equipment are ready for start. It is the responsibility of the user to ensure safe operation under any condition. Failure to do so could result in personal injury or equipment damage.

1. Press [Auto].
2. Ensure that the external control functions are properly wired to the frequency converter and all programming is completed.
3. Apply an external run command.
4. Adjust the speed reference throughout the speed range.
5. Remove the external run command.
6. Note any problems.

If warnings or alarms occur, see *chapter 10 Warnings and Alarms* for resetting the frequency converter after a trip.

4 User Interface

4.1 Keypad

The keypad is the combined display and keys on the front of the unit. The keypad is the user interface to the frequency converter.

The keypad has several user functions:

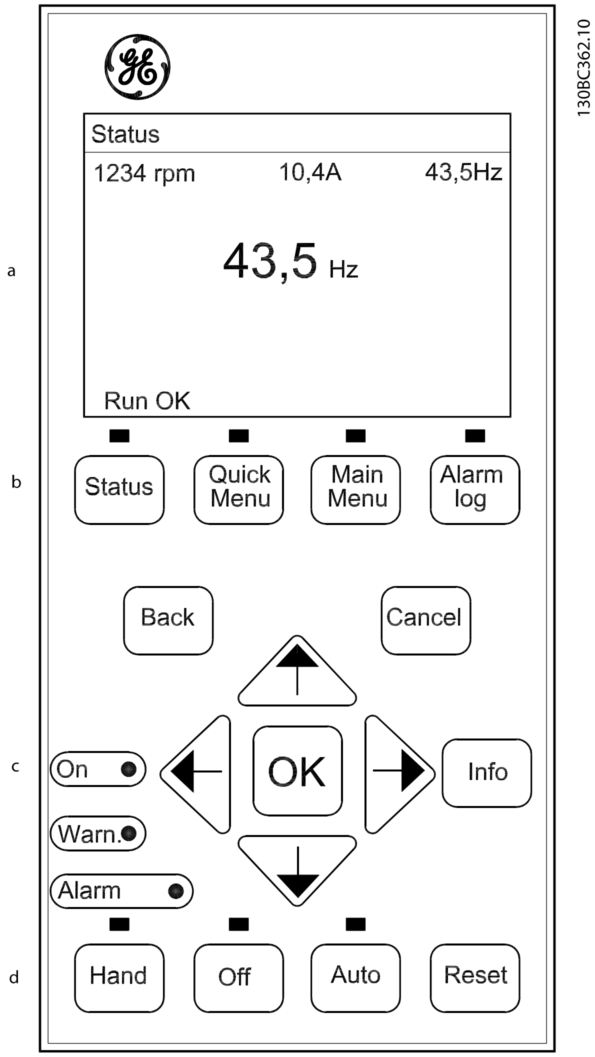
- Start, stop, and control speed when in local control
- Show operational data, status, warnings, and cautions
- Programming frequency converter functions
- Manually reset the frequency converter after a fault when auto reset is inactive

NOTICE

The display contrast can be adjusted by pressing [Status] and [▲]/[▼] keys.

4.1.1 Keypad Layout

The keypad is divided into 4 functional groups (see *Illustration 4.1*).



a	Display area.
b	Display menu keys for changing the display to show status options, programming, or error message history.
c	Navigation keys for programming functions, moving the display cursor, and speed control in local operation. The status indicator lights are also in this group.
d	Operational mode keys and reset.

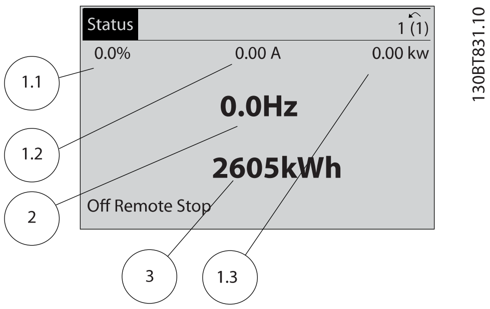
Illustration 4.1 Keypad

4.1.2 Setting Keypad Display Values

The display area is activated when the frequency converter receives power from mains voltage, a DC bus terminal, or an external 24 V DC supply.

The information displayed on the keypad can be customised for user application.

- Each display readout has a parameter associated with it.
- Options are selected in the menu Keypad Set-up.
- Display 2 has an alternate larger display option.
- The frequency converter status at the bottom line of the display is generated automatically and is not selectable.



Display	Parameter number	Default setting
1.1	K-20	Reference %
1.2	K-21	Motor current
1.3	K-22	Power [kW]
2	K-23	Frequency
3	K-24	kWh counter

Illustration 4.2 Display Readouts

4.1.3 Display Menu Keys

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

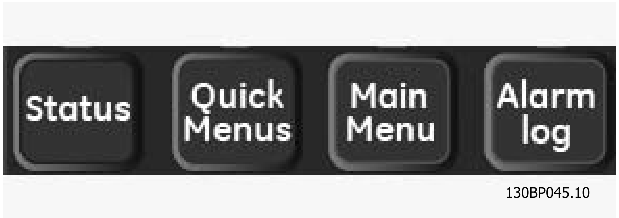


Illustration 4.3 Menu Keys

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

Table 4.1 Function Description Menu Keys

4

4.1.4 Navigation Keys

Navigation keys are used for programming functions and moving the display cursor. The navigation keys also provide speed control in local (hand) operation. There are also 3 frequency converter status indicator lights in this area.

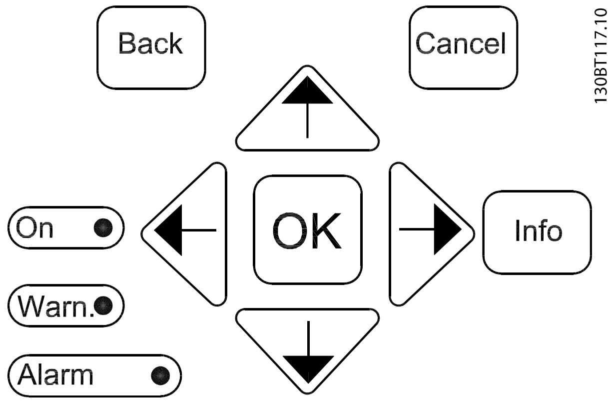


Illustration 4.4 Navigation Keys

Key	Function
Back	Reverts to the previous step or list in the menu structure.
Cancel	Cancels the last change or command as long as the display mode has not changed.
Info	Press for a definition of the function being shown.
Navigation Keys	Press the 4 navigation keys to move between items in the menu.
OK	Press to access parameter groups or to enable a choice.

Table 4.2 Navigation Keys Functions

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

Table 4.3 Indicator Lights Functions

4.1.5 Operation Keys

Operation keys are located at the bottom of the keypad.

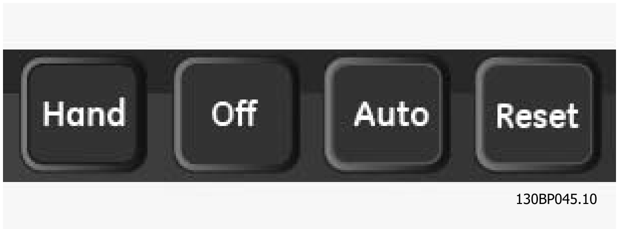


Illustration 4.5 Operation Keys

Key	Function
Hand	Starts the frequency converter in local control. • Use the navigation keys to control frequency converter speed. • An external stop signal by control input or serial communication overrides the local hand.
Off	Stops the motor, but does not remove power to the frequency converter.
Auto	Puts the system in remote operational mode. • Responds to an external start command by control terminals or serial communication. • Speed reference is from an external source.
Reset	Resets the frequency converter manually after a fault has been cleared.

Table 4.4 Operation Keys Functions

4.2 Back Up and Copying Parameter Settings

Programming data is stored internally in the frequency converter.

- The data can be uploaded into the keypad memory as storage back-up.
- Once stored in the keypad, the data can be downloaded back into the frequency converter.
- Data can also be downloaded into other frequency converters by connecting the keypad into those units and downloading the stored settings. (This is a quick way to program multiple units with the same settings).
- Restoring of the frequency converter to restore factory default settings does not change data stored in the keypad memory.

⚠WARNING

UNINTENDED START

When the frequency converter is connected to AC mains, or DC power supply, the motor may start at any time. Unintended start during programming, service, or repair work can result in death, serious injury, or property damage. The motor can start with an external switch, a serial bus command, an input reference signal from the keypad, or after a cleared fault condition.

To prevent unintended motor start:

- **Disconnect the frequency converter from mains.**
- **Press [Off/Reset] on the keypad, before programming parameters.**
- **The frequency converter, motor, and any driven equipment must be fully wired and assembled when the frequency converter is connected to AC mains, or DC power supply.**

4.2.1 Uploading data to the keypad

1. Press [Off] to stop the motor before uploading or downloading data.
2. Go to *parameter K-50 Keypad Copy*.
3. Press [OK].
4. Select *[1] All to keypad*.
5. Press [OK]. A progress bar shows the uploading process.
6. Press [Hand] or [Auto] to return to normal operation.

4.2.2 Downloading Data from the Keypad

1. Press [Off] to stop the motor before uploading or downloading data.
2. Go to *parameter K-50 Keypad Copy*.
3. Press [OK].
4. Select *[2] All from keypad*.
5. Press [OK]. A progress bar shows the downloading process.
6. Press [Hand] or [Auto] to return to normal operation.

4.3 Restoring Default Settings

NOTICE

Restore sets the unit to factory default settings. Any programming, motor data, localization, and monitoring records are lost. Uploading data to the keypad provides a back-up before restoring.

Restoring the frequency converter parameter settings back to default values is done by restoring of the frequency converter. Restoring can be carried out via *parameter H-03 Restore Factory Settings* or manually.

- Restoring using *parameter H-03 Restore Factory Settings* does not change frequency converter data such as hours run, serial communication selections, personal menu settings, fault log, alarm log, and other monitoring functions.
- Using *parameter H-03 Restore Factory Settings* is recommended.
- Manual restore erases all motor, programming, localization, and monitoring data and restores factory default settings.

4.3.1 Recommended Restoring

1. Press [Main Menu] twice to access parameters.
2. Scroll to *parameter H-03 Restore Factory Settings*.
3. Press [OK].
4. Scroll to *[2] Restore Factory Settings*.
5. Press [OK].
6. Remove power to the unit and wait for the display to turn off.
7. Apply power to the unit.

Default parameter settings are restored during start-up. This may take slightly longer than normal.

8. Alarm 80 is shown.
9. Press [Reset] to return to operation mode.

4.3.2 Manual Restoring

1. Remove power to the unit and wait for the display to turn off.
2. Press and hold [Status], [Main Menu], and [OK] at the same time and apply power to the unit.

Factory default parameter settings are restored during start-up. This may take slightly longer than normal.

Manual restoring does not reset the following frequency converter information:

- *Parameter ID-00 Operating hours*
- *Parameter ID-03 Power Up's*
- *Parameter ID-04 Over Temp's*
- *Parameter ID-05 Over Volt's*

4

5 About Programming

5.1 Introduction

The frequency converter is programmed for its application functions using parameters. Parameters are accessed by pressing either [Quick Menu] or [Main Menu] on the keypad. (See *chapter 4 User Interface* for details on using the keypad function keys.) Parameters may also be accessed through a PC using the DCT-10.

The quick menu is intended for initial start-up. Data entered in a parameter can change the options available in the parameters following that entry.

The main menu accesses all parameters and allows for advanced frequency converter applications.

5.2 Programming Example

Here is an example for programming the frequency converter for a common application in open loop using the quick menu.

- This procedure programs the frequency converter to receive a 0–10 V DC analog control signal on input terminal 53.
- The frequency converter responds by providing 20–50 Hz output to the motor proportional to the input signal (0–10 V DC =20–50 Hz).

Select the following parameters using the navigation keys to scroll to the titles and press [OK] after each action.

1. *Parameter F-01 Frequency Setting 1*

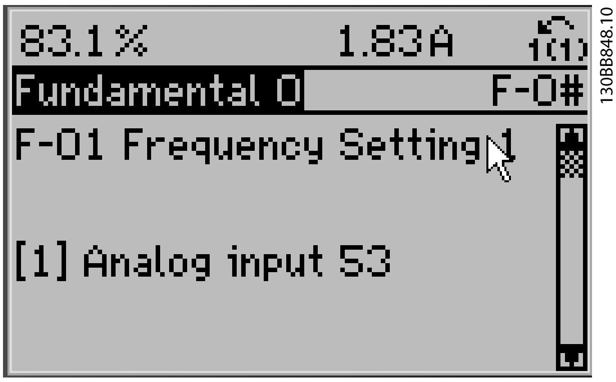


Illustration 5.1 References *parameter F-01 Frequency Setting 1*

2. *Parameter F-52 Minimum Reference*. Set minimum internal frequency converter reference to 0 Hz (this sets the minimum frequency converter speed at 0 Hz).

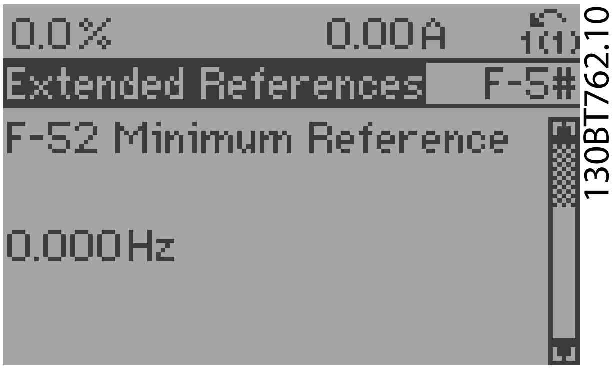


Illustration 5.2 Analog Reference *Parameter F-52 Minimum Reference*

3. *Parameter F-53 Maximum Reference*. Set maximum internal frequency converter reference to 50 Hz. (This sets the maximum frequency converter speed at 60 Hz. Note that 50 Hz is a regional variation.)

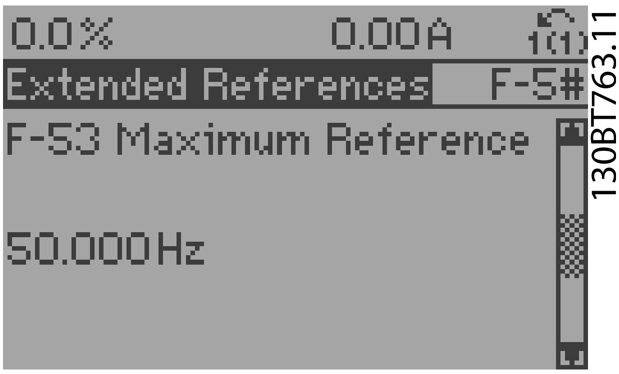


Illustration 5.3 Analog Reference *Parameter F-53 Maximum Reference*

4. *Parameter AN-10 Terminal 53 Low Voltage*. Set minimum external voltage reference on Terminal 53 at 0 V. (This sets the minimum input signal at 0 V.)

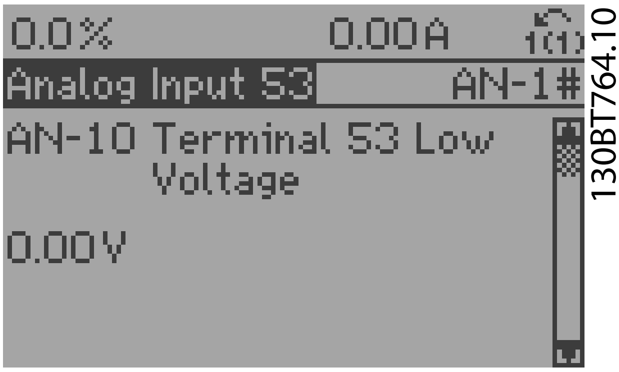


Illustration 5.4 Analog Reference *Parameter AN-10 Terminal 53 Low Voltage*

5. *Parameter AN-11 Terminal 53 High Voltage*. Set maximum external voltage reference on Terminal 53 at 10 V (this sets the maximum input signal at 10 V).

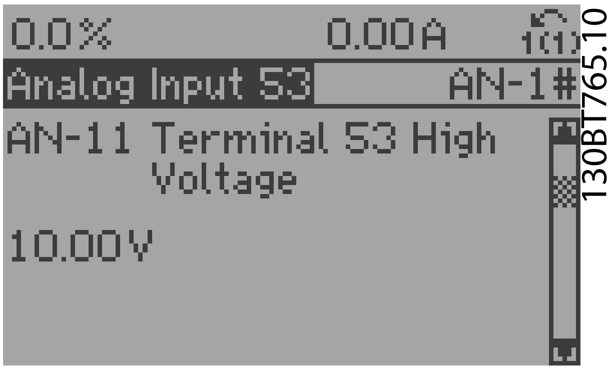


Illustration 5.5 Analog Reference *Parameter AN-11 Terminal 53 High Voltage*

6. *Parameter AN-14 Terminal 53 Low Ref./Feedb. Value*. Set minimum speed reference on Terminal 53 at 20 Hz. (This tells the frequency converter that the minimum voltage received on Terminal 53 (0 V) equals 20 Hz output.)

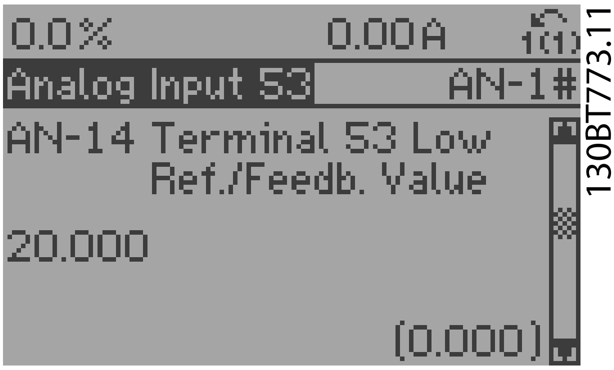


Illustration 5.6 Analog Reference *Parameter AN-14 Terminal 53 Low Ref./Feedb. Value*

7. *Parameter AN-15 Terminal 53 High Ref./Feedb. Value*. Set maximum speed reference on Terminal 53 at 50 Hz. (This tells the frequency converter that the maximum voltage received on Terminal 53 (10 V) equals 50 Hz output.)

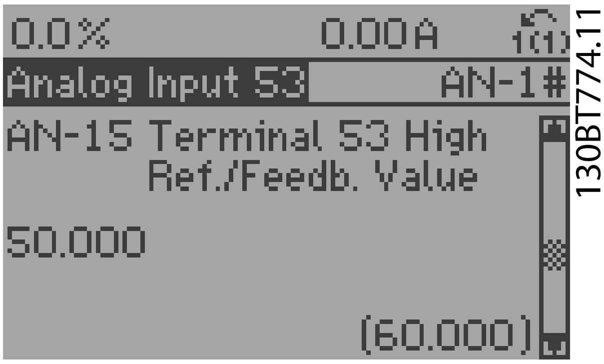


Illustration 5.7 Analog Reference *Parameter AN-15 Terminal 53 High Ref./Feedb. Value*

With an external device providing a 0–10 V control signal connected to frequency converter terminal 53, the system is now ready for operation. The scroll bar on the right in the last illustration of the display is at the bottom, indicating the procedure is complete.

Illustration 5.8 shows the wiring connections used to enable this set up.

5

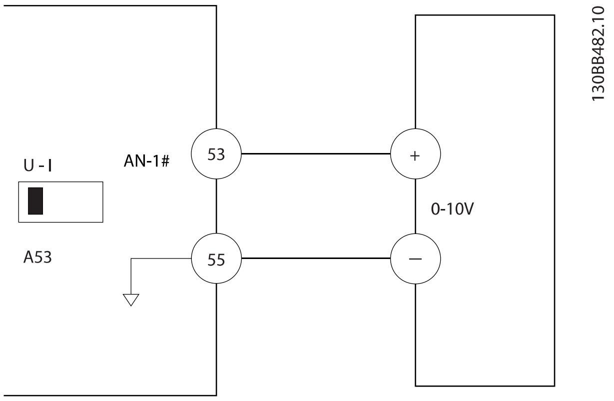


Illustration 5.8 Wiring Example for External Device Providing 0–10 V Control Signal (Frequency Converter Left, External Device Right)

5.3 Control Terminal Programming Examples

Control terminals can be programmed.

- Each terminal has specified functions it is capable of performing
- Parameters associated with the terminal enable the function

See *Table 2.5* for control terminal parameter number and default setting. (Default setting can change based on the selection in *parameter K-03 Regional Settings*.)

The following example shows accessing Terminal 18 to see the default setting.

1. Press [Main Menu] twice, scroll to *Parameter Data Set* and press [OK].

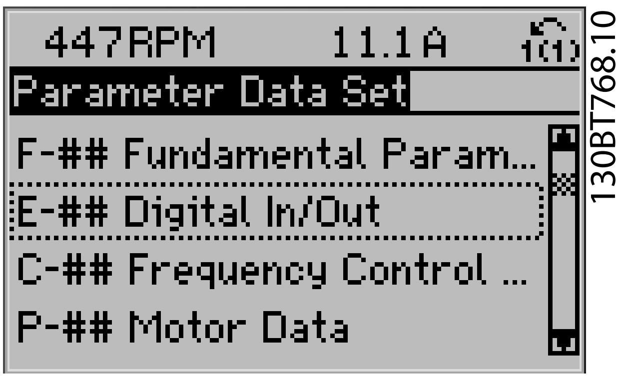


Illustration 5.9 *Parameter AN-15 Terminal 53 High Ref./Feedb. Value*

2. Scroll to parameter group E-## *Digital In/Out* and press [OK].

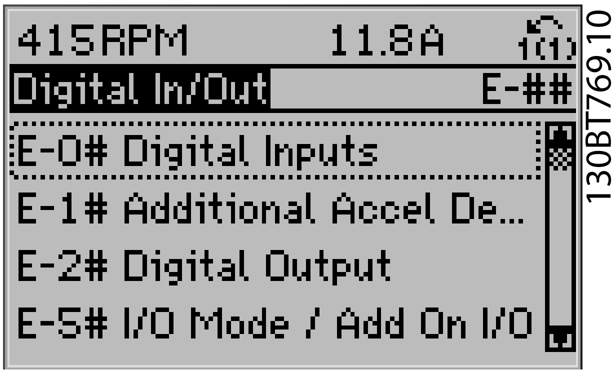


Illustration 5.10 Digital In/Out

3. Scroll to parameter group *E-0# Digital Inputs* and press [OK]
4. Scroll to *parameter E-01 Terminal 18 Digital Input*. Press [OK] to access function options. The default setting *Start* is shown.

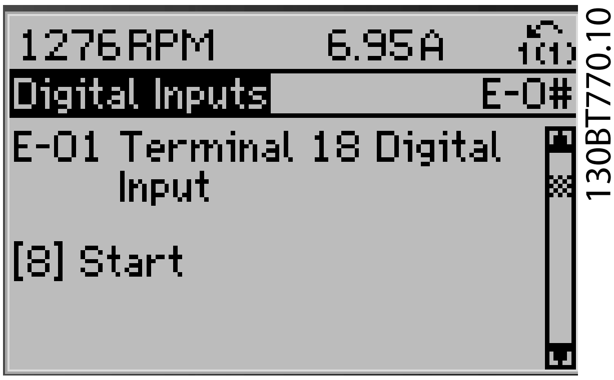


Illustration 5.11 Digital Inputs

5.4 International/North American Default Parameter Settings

Setting *parameter K-03 Regional Settings* to *[0] International* or *[1] North America* changes the default settings for some parameters. *Table 5.1* lists those parameters that are effected.

Parameter	International default parameter value	North American default parameter value
Parameter K-03 Regional Settings	International	North America
Parameter P-07 Motor Power [kW]	See Note 1	See Note 1
Parameter P-02 Motor Power [HP]	See Note 2	See Note 2
Parameter F-05 Motor Rated Voltage	230 V/400 V/575 V	208 V/460 V/575 V

Parameter	International default parameter value	North American default parameter value
Parameter F-04 Base Frequency	50 Hz	60 Hz
Parameter F-53 Max imum Reference	50 Hz	60 Hz
Parameter F-54 Refe rence Function	Sum	External/Preset
Parameter F-17 Mot or Speed High Limit [RPM] See Note 3 and 5	1500 PM	1800 RPM
Parameter F-15 Mot or Speed High Limit [Hz] See Note 4	50 Hz	60 Hz
Parameter F-03 Max Output Frequency 1	100 Hz	120 Hz
Parameter H-73 War ning Speed High	1500 RPM	1800 RPM
Parameter E-24 Fun ction Relay	Alarm	No alarm
Parameter AN-15 Te rminal 53 High Ref./ Feedb. Value	50	60
Parameter AN-50 Te rminal 42 Output	Speed 0–HighLim	Speed 4–20 mA
Parameter H-04 Auto -Reset (Times)	Manual reset	Infinite auto reset

Table 5.1 International/North American Default Parameter Settings

Note 1: Parameter P-07 Motor Power [kW] is only visible when parameter K-03 Regional Settings is set to [0] International.
Note 2: Parameter P-02 Motor Power [HP], is only visible when parameter K-03 Regional Settings is set to [1] North America.
Note 3: This parameter is only visible when parameter K-02 Motor Speed Unit is set to [0] RPM.
Note 4: This parameter is only visible when parameter K-02 Motor Speed Unit is set to [1] Hz.
Note 5: The default value depends on the number of motor poles. For a 4 poled motor, the international default value is 1500 RPM and for a 2 poled motor 3000 RPM. The corresponding values for North America are 1800 RPM and 3600 RPM, respectively.

5.4.1 Parameter Data Check

1. Press [Quick Menu].
2. Scroll to *Parameter Data Check* and press [OK].

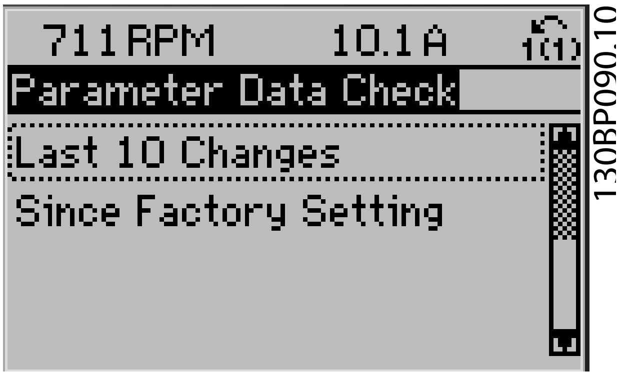


Illustration 5.12 Parameter Data Check

3. Select *Parameter Data Check* to view all programming changes or *Last 10 Changes* for the most recent.

5.5 Parameter Menu Structure

Establishing the correct programming for applications often requires setting functions in several related parameters. These parameter settings provide the frequency converter with system details it needs to operate properly. System details may include such things as input and output signal types, programming terminals, minimum and maximum signal ranges, custom displays, automatic restart, and other features.

- See the keypad display to view detailed parameter programming and setting options
- Press [Info] in any menu location to view more details for that function
- Press and hold [Main Menu] to enter a parameter number for direct access to that parameter
- Details for common application set-ups are provided in *chapter 6 Application Set-Up Examples*.

5

5.5.1 Quick Menu Structure

K-01	Language
K-02	Motor Speed Unit
P-02	Motor Power [HP]
P-07	Motor Power [kW]
F-05	Motor Rated Voltage
P-03	Motor Current
F-04	Base Frequency
P-06	Base Speed
F-01	Frequency Setting 1
F-02	Operation Method
F-07	Accel Time 1
F-08	Decel Time 1
F-10	Electronic Overload
F-15	Motor Speed High Limit [Hz]
F-16	Motor Speed Low Limit [Hz]
H-08	Reverse Lock
P-04	Auto Tune

Table 5.2 Quick Start

5.5.2 Main Menu Structure

Keypad Setup
K-0# Keypad Basic Settings
K-01 Language
K-02 Motor Speed Unit
K-03 Regional Settings
K-04 Operating State at Power-up
K-1# Keypad Set-up Operations
K-10 Active Set-up
K-11 Edit Set-up
K-12 This Set-up Linked to
K-13 Readout: Linked Set-ups
K-14 Readout: Edit Set-ups / Channel
K-15 Readout: Actual Set-up
K-2# Keypad Display
K-20 Display Line 1.1 Small
K-21 Display Line 1.2 Small
K-22 Display Line 1.3 Small
K-23 Display Line 2 Large
K-24 Display Line 3 Large
K-25 Quick Start
K-3# Keypad Custom Readout
K-30 Unit for Custom Readout
K-31 Min Value of Custom Readout
K-32 Max Value of Custom Readout
K-37 Display Text 1
K-38 Display Text 2
K-39 Display Text 3
K-4# Keypad Buttons
K-40 [Hand] Button on Keypad
K-41 [Off] Button on Keypad
K-42 [Auto] Button on Keypad
K-43 [Reset] Button on Keypad
K-5# Copy/Save
K-50 Keypad Copy
K-51 Set-up Copy
K-6# Password Protection
K-60 Main Menu Password
K-61 Access to Main Menu w/o Password
K-65 Quick Menu Password
K-66 Access to Quick Menu w/o Password
K-67 Bus Password Access
Parameter Data Set
F-## Fundamental Parameters
F-0# Fundamental 0
F-01 Frequency Setting 1
F-02 Operation Method
F-03 Max Output Frequency 1
F-04 Base Frequency
F-05 Motor Rated Voltage
F-07 Accel Time 1
F-08 Decel Time 1
F-09 Torque Boost
F-1# Fundamental 1
F-10 Electronic Overload
F-11 Motor External Fan
F-12 Motor Thermistor Input
F-15 Motor Speed High Limit [Hz]
F-16 Motor Speed Low Limit [Hz]
F-17 Motor Speed High Limit [RPM]
F-18 Motor Speed Low Limit [RPM]
F-2# Fundamental 2
F-20 PM Start Mode
F-22 Start Speed [RPM]
F-23 Start Speed [Hz]
F-24 Holding Time
F-25 Start Function
F-26 Motor Noise (Carrier Freq)
F-27 Motor Tone Random
F-28 Dead Time Compensation
F-29 Start Current
F-3# Fundamental 3
F-33 Source for User-defined Readout
F-37 Adv. Switching Pattern
F-38 Overmodulation
F-4# Fundamental 4
F-40 Torque Limiter (Driving)
F-41 Torque Limiter (Braking)
F-43 Current Limit
F-5# Extended References
F-50 Reference Range
F-51 Reference/Feedback Unit
F-52 Minimum Reference
F-53 Maximum Reference
F-54 Reference Function
F-6# References
F-62 Catch up/slow Down Value
F-64 Preset Relative Reference
F-68 Relative Scaling Reference Resource
F-9# Digital Potentiometer
F-90 Step Size
F-91 Accel/Decel Time
F-92 Power Restore
F-93 Maximum Limit
F-94 Minimum Limit
F-95 Accel/Decel Ramp Delay
E-## Digital In/Out
E-0# Digital Inputs
E-00 Digital I/O Mode
E-01 Terminal 18 Digital Input
E-02 Terminal 19 Digital Input
E-03 Terminal 27 Digital Input
E-04 Terminal 29 Digital Input
E-05 Terminal 32 Digital Input
E-06 Terminal 33 Digital Input
E-07 Terminal 37 Safe Stop
E-1# Additional Accel Decel Ramps
E-10 Accel Time 2
E-11 Decel Time 2
E-12 Accel Time 3
E-13 Decel Time 3
E-14 Accel Time 4
E-15 Decel Time 4
E-2# Digital Output
E-20 Terminal 27 Digital Output
E-21 Terminal 29 Digital Output
E-24 Function Relay
E-26 On Delay, Relay
E-27 Off Delay, Relay
E-5# I/O Mode / Add On I/O
E-51 Terminal 27 Mode
E-52 Terminal 29 Mode
E-53 Terminal X30/2 Digital Input
E-54 Terminal X30/3 Digital Input
E-55 Terminal X30/4 Digital Input
E-56 Term X30/6 Digi Out (OPCGPIO)
E-57 Term X30/7 Digi Out (OPCGPIO)
E-6# Pulse Input
E-60 Term. 29 Low Frequency
E-61 Term. 29 High Frequency
E-62 Term. 29 Low Ref./Feedb. Value
E-63 Term. 29 High Ref./Feedb. Value
E-64 Pulse Filter Time Constant #29
E-65 Term. 33 Low Frequency
E-66 Term. 33 High Frequency
E-67 Term. 33 Low Ref./Feedb. Value
E-68 Term. 33 High Ref./Feedb. Value
E-69 Pulse Filter Time Constant #33
E-7# Pulse Output
E-70 Terminal 27 Pulse Output Variable
E-72 Pulse Output Max Freq #27
E-73 Terminal 29 Pulse Output Variable
E-75 Pulse Output Max Freq #29
E-76 Terminal X30/6 Pulse Output Variable
E-78 Pulse Output Max Freq #X30/6
E-8# 24V Encoder Input
E-80 Term 32/33 Pulses Per Revolution
E-81 Term 32/33 Encoder Direction
E-9# Bus Controlled
E-90 Digital & Relay Bus Control
E-93 Pulse Out #27 Bus Control
E-94 Pulse Out #27 Timeout Preset
E-95 Pulse Out #29 Bus Control
E-96 Pulse Out #29 Timeout Preset
E-97 Pulse Out #X30/6 Bus Control
E-98 Pulse Out #X30/6 Timeout Preset
C-## Frequency Control Functions
C-0# Frequency Control Functions
C-01 Jump Frequency From [Hz]
C-02 Jump Speed From [RPM]
C-03 Jump Speed To [RPM]
C-04 Jump Frequency To [Hz]
C-05 Multi-step Frequency 1 - 8
C-2# Jog Setup
C-20 Jog Speed [Hz]
C-21 Jog Speed [RPM]
C-22 Jog Accel/Decel Time
C-23 Quick Stop Decel Time
C-24 Quick Stop Ramp Type
C-25 Quick Stop S-ramp Ratio at Decel. Start
C-26 Quick Stop S-ramp Ratio at Decel. End
C-29 Ramp Lowpass Filter Time
C-3# Frequency Setting 2 and 3
C-30 Frequency Command 2
C-34 Frequency Command 3
P-## Motor Data
P-0# Motor Data
P-01 Motor Poles
P-02 Motor Power [HP]
P-03 Motor Current
P-04 Auto Tune
P-05 Motor Cont. Rated Torque
P-06 Base Speed
P-07 Motor Power [kW]
P-09 Slip Compensation
P-10 Slip Compensation Time Constant
P-2# Motor Selection
P-20 Motor Construction
P-24 Damping Gain
P-25 Low Speed Filter Time Const.
P-26 High Speed Filter Time Const.
P-27 Voltage filter time const.
P-28 Min. Current at No Load
P-3# Adv. Motor Data
P-30 Stator Resistance (Rs)
P-31 Rotor Resistance (Rr)
P-33 Stator Leakage Reactance (X1)
P-34 Rotor Leakage Reactance (X2)
P-35 Main Reactance (Xh)
P-36 Iron Loss Resistance (Rfe)
P-37 d-axis Inductance (Ld)
P-38 q-axis Inductance (Lq)
P-44 d-axis Inductance Sat. (LdSat)
P-45 q-axis Inductance Sat. (LqSat)
P-46 Position Detection Gain
P-47 Torque Calibration
P-48 Inductance Sat. Point
H-## High Perf Parameters
H-0# High Perf Operations
H-01 Option Detection
H-02 Option Data Storage
H-03 Restore Factory Settings
H-04 Auto-Reset (Times)
H-05 Auto-Reset (Reset Interval)
H-07 Accel/Decel Time 1 Type
H-08 Reverse Lock
H-09 Start Mode
H-2# Motor Feedback Monitoring
H-20 Motor Feedback Loss Function
H-21 Motor Feedback Speed Error
H-22 Motor Feedback Loss Timeout
H-23 Motor Check At Start
H-24 Tracking Error Function
H-25 Tracking Error
H-26 Tracking Error Timeout
H-27 Tracking Error Ramping
H-28 Tracking Error Ramping Timeout
H-29 Tracking Error After Ramping Timeout
H-3# Speed Monitor
H-30 Motor Speed Monitor Function
H-31 Motor Speed Monitor Max
H-32 Motor Speed Monitor Timeout
H-4# Advanced Settings
H-40 Configuration Mode
H-41 Motor Control Principle
H-42 Flux Motor Feedback Source
H-43 Torque Characteristics
H-44 Constant or Variable Torque OL
H-45 Local Mode Configuration
H-46 Back EMF at 1000 RPM
H-47 Motor Angle Offset
H-48 Clockwise Direction
H-49 Motor Angle Offset Adjust
H-5# Load Indep. Settings
H-50 Motor Magnetisation at Zero Speed
H-51 Min Speed Normal Magnetising [RPM]
H-52 Min Speed Normal Magnetising [Hz]
H-53 Model Shift Frequency
H-54 Voltage reduction in fieldweakening
H-55 U/f Characteristic - U
H-56 U/f Characteristic - F
H-58 Flying Start Test Pulses Current
H-59 Flying Start Test Pulses Frequency
H-6# Load Depen. Settings
H-61 High Speed Load Compensation
H-62 Brake Check Limit Factor Source
H-63 Brake Check Limit Factor
H-64 Resonance Dampening
H-65 Resonance Dampening Time Constant
H-66 Min. Current at Low Speed
H-67 Torque Limit Factor Source
H-68 Speed Limit Factor Source
H-7# Adjustable Warnings
H-70 Warning Current Low
H-71 Warning Current High
H-72 Warning Speed Low
H-73 Warning Speed High
H-74 Warning Reference Low
H-75 Warning Reference High
H-76 Warning Feedback Low
H-77 Warning Feedback High
H-78 Missing Motor Phase Function
H-8# Stop Adjustments
H-80 Function at Stop
H-81 Min Speed for Function at Stop [RPM]
H-82 Min Speed for Function at Stop [Hz]
H-83 Precise Stop Function
H-84 Precise Stop Counter Value
H-85 Precise Stop Speed Compensation Delay
H-87 Load Type
H-88 Motor Inertia
H-89 System Inertia
H-9# Motor Temperature
H-94 ATEX overload cur.lim. speed reduction
H-95 KTY Sensor Type
H-96 KTY Thermistor Input
H-97 KTY Threshold level
H-98 ATEX overload interpol. points freq.
H-99 ATEX overload interpol points current

5

5

AN-## Analog In / Out
AN-0# Analog I/O Mode
AN-00 Live Zero Timeout Time
AN-01 Live Zero Timeout Function
AN-1# Analog Input 53
AN-10 Terminal 53 Low Voltage
AN-11 Terminal 53 High Voltage
AN-12 Terminal 53 Low Current
AN-13 Terminal 53 High Current
AN-14 Terminal 53 Low Ref./Feedb. Value
AN-15 Terminal 53 High Ref./Feedb. Value
AN-16 Terminal 53 Filter Time Constant
AN-17 Terminal 53 Live Zero
AN-2# Analog Input 54
AN-20 Terminal 54 Low Voltage
AN-21 Terminal 54 High Voltage
AN-22 Terminal 54 Low Current
AN-23 Terminal 54 High Current
AN-24 Terminal 54 Low Ref./Feedb. Value
AN-25 Terminal 54 High Ref./Feedb. Value
AN-26 Terminal 54 Filter Time Constant
AN-27 Terminal 54 Live Zero
AN-3# Analog Input X30/11
AN-30 Terminal X30/11 Low Voltage
AN-31 Terminal X30/11 High Voltage
AN-34 Term. X30/11 Low Ref./Feedb. Value
AN-35 Term. X30/11 High Ref./Feedb. Value
AN-36 Term. X30/11 Filter Time Constant
AN-37 Term. X30/11 Live Zero
AN-4# Analog Input X30/12
AN-40 Terminal X30/12 Low Voltage
AN-41 Terminal X30/12 High Voltage
AN-44 Term. X30/12 Low Ref./Feedb. Value
AN-45 Term. X30/12 High Ref./Feedb. Value
AN-46 Term. X30/12 Filter Time Constant
AN-47 Term. X30/12 Live Zero
AN-5# Analog Output 42
AN-50 Terminal 42 Output
AN-51 Terminal 42 Output Min Scale
AN-52 Terminal 42 Output Max Scale
AN-53 Terminal 42 Output Bus Control
AN-54 Terminal 42 Output Timeout Preset
AN-55 Terminal 42 Output Filter
AN-6# Analog Output X30/8
AN-60 Terminal X30/8 Output
AN-61 Terminal X30/8 Min. Scale
AN-62 Terminal X30/8 Max. Scale
AN-63 Terminal X30/8 Bus Control
AN-64 Terminal X30/8 Output Timeout Preset
SP-## Special Functions
SP-0# Fault Settings
SP-00 Fault Level
SP-1# Line On/Off
SP-10 Line failure
SP-11 Line Voltage at Input Fault
SP-12 Function at Line Imbalance
SP-14 Kin. Backup Time Out
SP-15 Kin. Backup Trip Recovery Level
SP-16 Kin. Backup Gain
SP-2# Reset Functions
SP-23 Typecode Setting
SP-24 Trip Delay at Current Limit
SP-25 Trip Delay at Torque Limit
SP-26 Trip Delay at Drive Fault
SP-29 Service Code
SP-3# Current Limit Ctrl.
SP-30 Current Lim Cont, Proportional Gain
SP-31 Current Lim Contr, Integration Time
SP-32 Current Lim Ctrl, Filter Time
SP-35 Stall Protection
SP-36 Fieldweakening Function
SP-37 Fieldweakening Speed
SP-4# Energy Savings
SP-40 VT Level
SP-41 Energy Savings Min. Magnetisation
SP-42 Energy Savings Min. Frequency
SP-43 Motor Cosphi
SP-5# Environment
SP-50 RFI Filter
SP-51 DC Link Compensation
SP-52 Fan Operation
SP-53 Fan Monitor
SP-54 AHF Cap Reconnect Delay
SP-55 Output Filter
SP-56 Capacitance Output Filter
SP-57 Inductance Output Filter
SP-59 Actual Number of Inverter Units
SP-6# Automatic Derate
SP-7# Additional ACC/DEC settings
SP-71 Accel Time 1 S-ramp Ratio at Accel. Start
SP-72 Accel Time 1 S-ramp Ratio at Accel. End
SP-73 Decel Time 1 S-ramp Ratio at Decel. Start
SP-74 Decel Time 1 S-ramp Ratio at Decel. End
SP-76 Accel/Decel Time 2 Type
SP-79 Accel Time 2 S-ramp Ratio at Accel. Start
SP-80 Accel Time 2 S-ramp Ratio at Accel. End
SP-81 Decel Time 2 S-ramp Ratio at Decel. Start
SP-82 Decel Time 2 S-ramp Ratio at Decel. End
SP-84 Accel/Decel Ramp 3 Type
SP-87 Accel Time 3 S-ramp Ratio at Accel. Start
SP-88 Accel Time 3 S-ramp Ratio at Accel. End
SP-89 Decel Time 3 S-ramp Ratio at Decel. Start
SP-90 Decel Time 3 S-ramp Ratio at Decel. End
SP-92 Accel/Decel Ramp 4 Type
SP-95 Accel Time 4 S-ramp Ratio at Accel. Start
SP-96 Accel Time 4 S-ramp Ratio at Accel. End
SP-97 Decel Time 4 S-ramp Ratio at Decel. Start
SP-98 Decel Time 4 S-ramp Ratio at Decel. End
O-## Options / Comms
O-0# General Settings
O-01 Control Site
O-02 Control Word Source
O-03 Control Word Timeout Time
O-04 Control Word Timeout Function
O-05 End-of-Timeout Function
O-06 Reset Control Word Timeout
O-07 Diagnosis Trigger
O-08 Readout Filtering
O-1# Control Settings
O-10 Control Word Profile
O-13 Configurable Status Word STW
O-14 Configurable Control Word CTW
O-16 Store Data Values
O-17 Configurable Alarm and Warningword
O-19 Product Code
O-3# Drive Port Settings
O-30 Protocol
O-31 Address
O-32 Drive Port Baud Rate
O-33 Drive Port Parity
O-34 Estimated cycle time
O-35 Minimum Response Delay
O-36 Max Response Delay
O-37 Max Inter-Char Delay
O-4# Drive MC Port Settings
O-40 Telegram Selection
O-41 Parameters for Signals
O-42 PCD Write Configuration
O-43 PCD Read Configuration
O-5# Digital / Bus
O-50 Coasting Select
O-51 Quick Stop Select
O-52 DC Brake Select
O-53 Start Select
O-54 Reversing Select
O-55 Set-up Select
O-56 Preset Reference Select
O-57 Profidrive OFF2 Select
O-58 Profidrive OFF3 Select
O-8# Drive Port Diagnostics
O-80 Bus Message Count
O-81 Bus Error Count
O-82 Slave Messages Rcvd
O-83 Slave Error Count
O-9# Bus Jog / Feedback
O-90 Bus Jog 1 Speed
O-91 Bus Jog 2 Speed
DN-## Devicenet Fieldbus
DN-0# Common Settings
DN-00 DeviceNet Protocol
DN-01 Baud Rate Select
DN-02 MAC ID
DN-05 Readout Transmit Error Counter
DN-06 Readout Receive Error Counter
DN-07 Readout Bus Off Counter
DN-1# DeviceNet
DN-10 Process Data Type Selection
DN-11 Process Data Config Write
DN-12 Process Data Config Read
DN-13 Warning Parameter
DN-14 Net Reference
DN-15 Net Control
DN-18 internal_process_data_config_write
DN-19 internal_process_data_config_read
DN-2# COS Filters
DN-20 COS Filter 1
DN-21 COS Filter 2
DN-22 COS Filter 3
DN-23 COS Filter 4
DN-3# Parameter Access
DN-30 Array Index
DN-31 Store Data Values
DN-32 Devicenet Revision
DN-33 Store Always
DN-34 DeviceNet Product Code
DN-39 Devicenet F Parameters
DN-5# DeviceNet Process Data
PB-## PROFIdrive
PB-00 Setpoint
PB-07 Actual Value
PB-15 PCD Write Configuration
PB-16 PCD Read Configuration
PB-18 Node Address
PB-22 Telegram Selection
PB-23 Parameters for Signals
PB-27 Parameter Edit
PB-28 Process Control
PB-44 Fault Message Counter
PB-45 Fault Code
PB-47 Fault Number
PB-52 Fault Situation Counter
PB-53 Profibus Warning Word
PB-63 Actual Baud Rate
PB-64 Device Identification
PB-65 Profile Number
PB-67 Control Word 1
PB-68 Status Word 1
PB-70 Edit Set-up
PB-71 Profibus Save Data Values
PB-72 ProfibusDriveReset
PB-75 DO Identification
PB-80 Defined Parameters (1)
PB-81 Defined Parameters (2)
PB-82 Defined Parameters (3)
PB-83 Defined Parameters (4)
PB-84 Defined Parameters (5)
PB-85 Defined Parameters (6)
PB-90 Changed Parameters (1)
PB-91 Changed Parameters (2)
PB-92 Changed Parameters (3)
PB-93 Changed Parameters (4)
PB-94 Changed Parameters (5)
PB-99 Profibus Revision Counter
EN-## Ethernet
EN-0# IP Settings
EN-00 IP Address Assignment
EN-01 IP Address
EN-02 Subnet Mask
EN-03 Default Gateway
EN-04 DHCP Server
EN-05 Lease Expires
EN-06 Name Servers
EN-07 Domain Name
EN-08 Host Name
EN-09 Physical Address
EN-1# Ethernet Link Parameters
EN-10 Link Status
EN-11 Link Duration
EN-12 Auto Negotiation
EN-13 Link Speed
EN-14 Link Duplex
EN-2# Process Data
EN-20 Control Instance
EN-21 Process Data Config Write
EN-22 Process Data Config Read
EN-23 Process Data Config Write Size
EN-24 Process Data Config Read Size
EN-27 Primary Master
EN-28 Store Data Values
EN-29 Store Always
EN-3# EtherNet/IP
EN-30 Warning Parameter
EN-31 Net Reference
EN-32 Net Control
EN-33 CIP Revision
EN-34 CIP Product Code
EN-35 EDS Parameter
EN-37 COS Inhibit Timer
EN-38 COS Filter
EN-4# Modbus TCP
EN-40 Status Parameter
EN-41 Slave Message Count
EN-42 Slave Exception Message Count
EN-8# Other Ethernet Services
EN-80 FTP Server
EN-81 HTTP Server
EN-82 SMTP Service
EN-89 Transparent Socket Channel Port
EN-9# Advanced Ethernet Services
EN-90 Cable Diagnostic
EN-91 MDI-X
EN-92 IGMP Snooping
EN-93 Cable Error Length
EN-94 Broadcast Storm Protection
EN-95 Broadcast Storm Filter
EN-96 Port Mirroring
EN-98 Interface Counters
EN-99 Media Counters

EC-## Feedback Option
EC-1# Inc. Enc. Interface
EC-10 Signal Type
EC-11 Resolution (PPR)
EC-2# Abs. Enc. Interface
EC-20 Protocol Selection
EC-21 Resolution (Positions/Rev)
EC-24 SSI Data Length
EC-25 Clock Rate
EC-26 SSI Data Format
EC-34 HIPERFACE Baudrate
RS-56 Encoder Sim. Resolution
EC-6# Monitoring and App.
EC-60 Feedback Direction
EC-61 Feedback Signal Monitoring
RS-## Resolver Interface
RS-50 Poles
RS-51 Input Voltage
RS-52 Input Frequency
RS-53 Transformation Ratio
RS-56 Encoder Sim. Resolution
RS-59 Resolver Interface
IO-## Programmable I/O Option
IO-0# I/O Mode
IO-00 Terminal X49/1 Mode
IO-01 Terminal X49/3 Mode
IO-02 Terminal X49/5 Mode
IO-03 Terminal X49/7 Mode
IO-04 Terminal X49/9 Mode
IO-05 Terminal X49/11 Mode
IO-1# Analog Input X49/1
IO-10 Terminal X49/1 Low Voltage
IO-11 Terminal X49/1 Low Current
IO-12 Terminal X49/1 High Voltage
IO-13 Terminal X49/1 High Current
IO-14 Term. X49/1 Low Ref./Feedb. Value
IO-15 Term. X49/1 High Ref./Feedb. Value
IO-16 Term. X49/1 Filter Time Constant
IO-17 Term. X49/1 Live Zero
IO-2# Analog Input X49/3
IO-20 Terminal X49/3 Low Voltage
IO-21 Terminal X49/3 Low Current
IO-22 Terminal X49/3 High Voltage
IO-23 Terminal X49/3 High Current
IO-24 Term. X49/3 Low Ref./Feedb. Value
IO-25 Term. X49/3 High Ref./Feedb. Value
IO-26 Term. X49/3 Filter Time Constant
IO-27 Term. X49/3 Live Zero
IO-3# Analog Input X49/5
IO-30 Terminal X49/5 Low Voltage
IO-31 Terminal X49/5 Low Current
IO-32 Terminal X49/5 High Voltage
IO-33 Terminal X49/5 High Current
IO-34 Term. X49/5 Low Ref./Feedb. Value
IO-35 Term. X49/5 High Ref./Feedb. Value
IO-36 Term. X49/5 Filter Time Constant
IO-37 Term. X49/5 Live Zero
IO-4# Output X49/7
IO-40 Terminal X49/7 Analogue Output
IO-41 Terminal X49/7 Digital Output
IO-42 Terminal X49/7 Min. Scale
IO-43 Terminal X49/7 Max. Scale
IO-44 Terminal X49/7 Bus Control
IO-45 Terminal X49/7 Timeout Preset
IO-5# Output X49/9
IO-50 Terminal X49/9 Analogue Output
IO-51 Terminal X49/9 Digital Output
IO-52 Terminal X49/9 Min. Scale
IO-53 Terminal X49/9 Max. Scale
IO-54 Terminal X49/9 Bus Control
IO-55 Terminal X49/9 Timeout Preset
IO-6# Output X49/11
IO-60 Terminal X49/11 Analogue Output
IO-61 Terminal X49/11 Digital Output
IO-62 Terminal X49/11 Min. Scale
IO-63 Terminal X49/11 Max. Scale
IO-64 Terminal X49/11 Bus Control
IO-65 Terminal X49/11 Timeout Preset

Parameter Data Check
Last 10 Changes
Since Factory Setting

Drive Information
ID-0# Operating Data
ID-00 Operating hours
ID-01 Running Hours
ID-02 kWh Counter
ID-03 Power Up's
ID-04 Over Temp's
ID-05 Over Volt's
ID-06 Reset kWh Counter
ID-07 Reset Running Hours Counter
ID-1# Data Trending Settings
ID-10 Trending Source
ID-11 Trending Interval
ID-12 Trigger Event
ID-13 Trending Mode
ID-14 Samples Before Trigger
ID-2# Historic Log
ID-20 Historic Log: Event
ID-21 Historic Log: Value
ID-22 Historic Log: Time
ID-3# Alarm Log
ID-30 Fault Log: Error Code
ID-31 Fault Log: Value
ID-32 Fault Log: Time
ID-4# Drive Identification
ID-40 Drive Type
ID-41 Power Section
ID-42 Voltage
ID-43 Software Version
ID-44 Ordered Typecode String
ID-45 Actual Typecode String
ID-46 GE Product No.
ID-47 Power Card Ordering No
ID-48 Keypad ID Number
ID-49 SW ID Control Card
ID-50 SW ID Power Card
ID-51 Drive Serial Number
ID-53 Power Card Serial Number
ID-59 Filename
ID-6# Option Ident
ID-60 Option Mounted
ID-61 Option SW Version
ID-62 Option Ordering No
ID-63 Option Serial No
ID-70 Option in Slot A
ID-71 Slot A Option SW Version
ID-72 Option in Slot B
ID-73 Slot B Option SW Version
ID-74 Option in Slot C1
ID-75 Slot C0 Option SW Version
ID-76 Option in Slot C2
ID-77 Slot C1 Option SW Version
ID-8# Operating Data II
ID-80 Fan Running Hours
ID-81 Preset Fan Running Hours
ID-9# Parameter Info
ID-92 Defined Parameters
ID-93 Modified Parameters
ID-98 Drive Identification
ID-99 Parameter Metadata

Data Readouts
DR-0# General Status
DR-00 Control Word
DR-01 Reference [Unit]
DR-02 Reference %
DR-03 Status Word
DR-05 Main Actual Value [%]
DR-09 Custom Readout
DR-1# Motor Status
DR-10 Power [kW]
DR-11 Power [hp]
DR-12 Motor Voltage
DR-13 Frequency
DR-14 Motor current
DR-15 Frequency [%]
DR-16 Torque [Nm]
DR-17 Speed [RPM]
DR-18 Motor Thermal
DR-19 KTY sensor temperature
DR-20 Motor Angle
DR-21 Torque [%] High Res.
DR-22 Torque [%]
DR-23 Motor Shaft Power [kW]
DR-24 Calibrated Stator Resistance
DR-25 Torque [Nm] High
DR-3# Drive Status
DR-30 DC Link Voltage
DR-32 Brake Energy /s
DR-33 Brake Energy Average
DR-34 Heatsink Temp.
DR-35 Drive Thermal
DR-36 Drive Nominal Current
DR-37 Drive Max. Current
DR-38 Logic Controller State
DR-39 Control Card Temp.
DR-40 Trending Buffer Full
DR-45 Motor Phase U Current
DR-46 Motor Phase V Current
DR-47 Motor Phase W Current
DR-48 Speed Ref. After Ramp [RPM]
DR-49 Current Fault Source
DR-5# Ref. & Feedb.
DR-50 External Reference
DR-51 Pulse Reference
DR-52 Feedback[Unit]
DR-53 Digi Pot Reference
DR-57 Feedback [RPM]
DR-6# Inputs & Outputs
DR-60 Digital Input
DR-61 Terminal 53 Switch Setting
DR-62 Analog Input 53
DR-63 Terminal 54 Switch Setting
DR-64 Analog Input 54
DR-65 Analog Output 42 [mA]
DR-66 Digital Output [bin]
DR-67 Freq. Input #29 [Hz]
DR-68 Freq. Input #33 [Hz]
DR-69 Pulse Output #27 [Hz]
DR-70 Pulse Output #29 [Hz]
DR-71 Relay Output [bin]
DR-72 Counter A
DR-73 Counter B
DR-74 Prec. Stop Counter
DR-75 Analog In X30/11
DR-76 Analog In X30/12
DR-77 Analog Out X30/8 [mA]
DR-8# Fieldbus & Drive Port
DR-80 Fieldbus CTW 1
DR-82 Fieldbus REF 1
DR-84 Comm. Option STW
DR-85 Drive Port CTW 1
DR-86 Drive Port REF 1
DR-87 Bus Readout Alarm/Warning
DR-89 Configurable Alarm/Warning Word
99-30 internal_ProfibusPCD_Config_Write
99-31 internal_ProfibusPCD_Config_Read
DR-9# Diagnosis Readouts
DR-90 Alarm Word
DR-91 Alarm Word 2
DR-92 Warning Word
DR-93 Warning Word 2
DR-94 Ext. Status Word
DR-95 Ext. Status Word 2

Logs & I/O Opt Status
LG-4# OPCPRGIO Data Readouts
LG-40 Analog Input X49/1
LG-41 Analog Input X49/3
LG-42 Analog Input X49/5
LG-43 Analog Out X49/7
LG-44 Analog Out X49/9
LG-45 Analog Out X49/11
LG-46 X49 Digital Output [bin]
LG-5# Active Alarms/Warnings
LG-55 Active Alarm Numbers
LG-56 Active Warning Numbers

Adv Parameter Data Set
LC-## Logic Controller
LC-0# LC Settings
LC-00 Logic Controller Mode
LC-01 Start Event
LC-02 Stop Event
LC-03 Reset Logic Controller
LC-1# Comparators
LC-10 Comparator Operand
LC-11 Comparator Operator
LC-12 Comparator Value
LC-1# RS Flip Flops
LC-15 RS-FF Operand S
LC-16 RS-FF Operand R
LC-2# Timers
LC-20 Logic Controller Timer
LC-4# Logic Rules
LC-40 Logic Rule Boolean 1
LC-41 Logic Rule Operator 1
LC-42 Logic Rule Boolean 2
LC-43 Logic Rule Operator 2
LC-44 Logic Rule Boolean 3
LC-5# States
LC-51 Logic Controller Event
LC-52 Logic Controller Action
B-## Braking Functions
B-0# DC-Brake
B-00 DC Hold Current
B-01 DC Brake Current
B-02 DC Braking Time
B-03 DC Brake Cut In Speed [RPM]
B-04 DC Brake Cut In Speed [Hz]
B-05 Maximum Reference
B-06 Parking Current
B-07 Parking Time
B-1# Brake Energy Funct.
B-10 Brake Function
B-11 Brake Resistor (ohm)
B-12 Brake Power Limit (kW)
B-13 Braking Thermal Overload
B-15 Brake Check
B-16 AC brake Max. Current
B-17 Over-voltage Control
B-18 Brake Check Condition
B-19 Over-voltage Gain
B-2# Mechanical Brake
B-20 Release Brake Current
B-21 Activate Brake Speed [RPM]
B-22 Activate Brake Speed [Hz]
B-23 Activate Brake Delay
B-24 Stop Delay
B-25 Brake Release Time
B-26 Torque Ref
B-27 Torque Ramp Time
B-28 Gain Boost Factor
PI-## PID Controls
PI-0# Speed PID Control
PI-00 Speed PID Feedback Source
PI-01 Speed PID Droop

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PI-02 Speed PID Proportional Gain
PI-03 Speed PID Integral Time
PI-04 Speed PID Differentiation Time
PI-05 Speed PID Diff. Gain Limit
PI-06 Speed PID Lowpass Filter Time
PI-07 Speed PID Feedback Gear Ratio
PI-08 Speed PID Feed Forward Factor
PI-09 Speed PID Error Correction w/ Ramp
PI-1# Torque PI Ctrl.
PI-10 Torque PI Feedback Source
PI-12 Torque PI Proportional Gain
PI-13 Torque PI Integration Time
PI-16 Torque PI Lowpass Filter Time
PI-18 Torque PI Feed Forward Factor
PI-19 Current Controller Rise Time
PI-2# Process PID Feedback
PI-20 Process CL Feedback 1 Resource
PI-22 Process CL Feedback 2 Resource
PI-3# Process PID Control
PI-30 Process PID Normal/ Inverse Control
PI-31 Process PID Anti Windup
PI-32 Process PID Start Speed
PI-33 Process PID Proportional Gain
PI-34 Process PID Integral Time
PI-35 Process PID Differentiation Time
PI-36 Process PID Diff. Gain Limit
PI-38 Process PID Feed Forward Factor
PI-39 On Reference Bandwidth
PI-4# Adv. Process PID I
PI-40 Process PID I-part Reset
PI-41 Process PID Output Neg. Clamp
PI-42 Process PID Output Pos. Clamp
PI-43 Process PID Gain Scale at Min. Ref.
PI-44 Process PID Gain Scale at Max. Ref.
PI-45 Process PID Feed Fwd Resource
PI-46 Process PID Feed Fwd Normal/ Inv. Ctrl.
PI-48 PCD Feed Forward
PI-49 Process PID Output Normal/ Inv. Ctrl.
PI-5# Adv. Process PID II
PI-50 Process PID Extended PID
PI-51 Process PID Feed Fwd Gain
PI-52 Process PID Feed Fwd Ramp up
PI-53 Process PID Feed Fwd Ramp down
PI-56 Process PID Ref. Filter Time
PI-57 Process PID Fb. Filter Time
PI-6# PID Readouts
PI-60 Process PID Error
PI-61 Process PID Output
PI-62 Process PID Clamped Output
PI-63 Process PID Gain Scaled Output
SF-## Special Features
SF-0# Wobbler
SF-00 Wobble Mode
SF-01 Wobble Delta Frequency [Hz]
SF-02 Wobble Delta Frequency [%]
SF-03 Wobble Delta Freq. Scaling Resource
SF-04 Wobble Jump Frequency [Hz]
SF-05 Wobble Jump Frequency [%]
SF-06 Wobble Jump Time
SF-07 Wobble Sequence Time
SF-08 Wobble Up/ Down Time
SF-09 Wobble Random Function
SF-10 Wobble Ratio
SF-11 Wobble Random Ratio Max.
SF-12 Wobble Random Ratio Min.
SF-19 Wobble Delta Freq. Scaled
SF-2# Adv. Start Adjust
SF-20 High Starting Torque Time [s]
SF-21 High Starting Torque Current [%]
SF-22 Locked Rotor Protection
SF-23 Locked Rotor Detection Time [s]
SF-24 Locked Rotor Detection Speed Error [%]
SF-25 Light Load Delay [s]
SF-26 Light Load Current [%]
SF-27 Light Load Speed [%]
SF-3# Miscellaneous
SF-30 External Interlock Delay
SF-84 Process PID Proportional Gain

5.6 Remote Programming with DCT-10

GE has a software program available for developing, storing, and transferring frequency converter programming. The DCT-10 allows the user to connect a PC to the frequency converter and perform live programming rather than using the keypad. Also, all frequency converter programming can be done off-line and downloaded to the frequency converter. Or the entire frequency converter profile can be loaded onto the PC for back-up storage or analysis.

The USB connector or RS485 terminal is available for connecting to the frequency converter.

For more details, go to *www.geelectrical.com/drives*

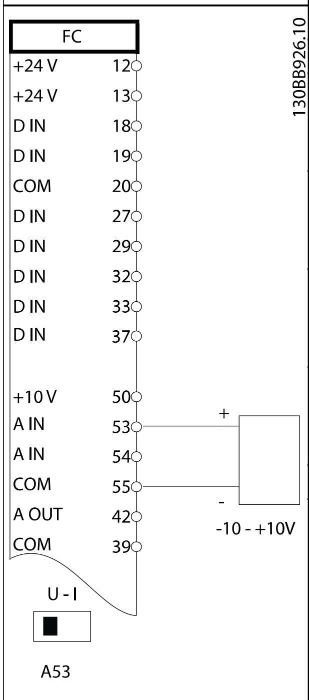
6 Application Set-Up Examples

6.1 Introduction

The examples in this section are intended as a quick reference for common applications.

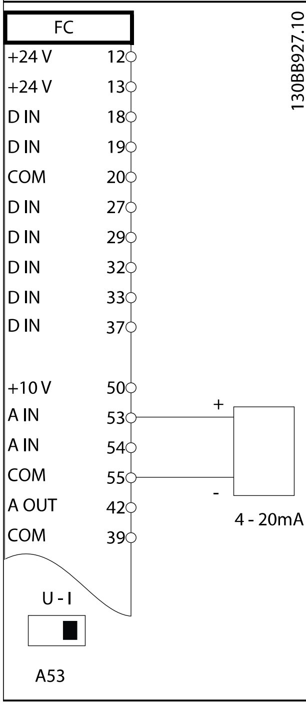
- Parameter settings are the regional default values unless otherwise indicated (selected in *parameter K-03 Regional Settings*).
- Parameters associated with the terminals and their settings are shown next to the drawings.
- Where switch settings for analog terminals A53 or A54 are required, these are also shown.
- For STO, a jumper wire may be required between terminal 12 and terminal 37 when using factory default programming values.

6.2 Application Examples



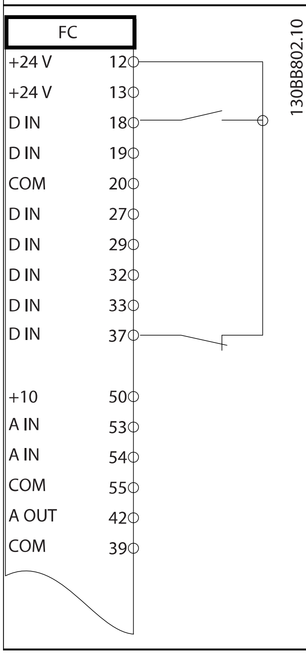
Parameters	
Function	**Setting**
Parameter AN-10 Terminal 53 Low Voltage	0.07 V*
Parameter AN-11 Terminal 53 High Voltage	10 V*
Parameter AN-14 Terminal 53 Low Ref./Feedb. Value	0 RPM
Parameter AN-15 Terminal 53 High Ref./Feedb. Value	1500 RPM
* = Default Value	
Notes/comments:	

Table 6.1 Analog Speed Reference (Voltage)



Parameters	
Function	**Setting**
Parameter AN-12 Terminal 53 Low Current	4 mA*
Parameter AN-13 Terminal 53 High Current	20 mA*
Parameter AN-14 Terminal 53 Low Ref./Feedb. Value	0 RPM
Parameter AN-15 Terminal 53 High Ref./Feedb. Value	1500 RPM
* = Default Value	
Notes/comments:	

Table 6.2 Analog Speed Reference (Current)



Parameters	
Function	**Setting**
Parameter E-01 Terminal 18 Digital Input	[8] Start*
Parameter E-07 Terminal 37 Safe Stop	[1] Safe Stop Alarm
* = Default Value	
Notes/comments:	

Table 6.3 Start/Stop Command with Safe Torque Off

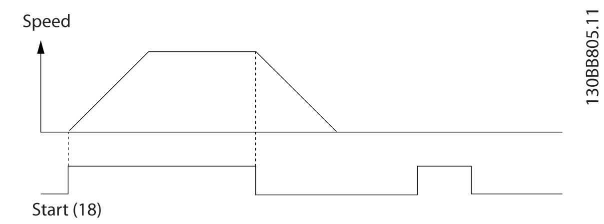
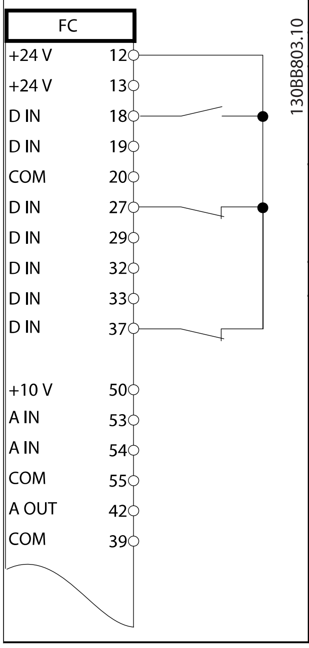


Illustration 6.1



Parameters	
Function	**Setting**
Parameter E-01 Terminal 18 Digital Input	[9] Latched Start
Parameter E-03 Terminal 27 Digital Input	[6] Stop Inverse
* = Default Value	
Notes/comments:	

Table 6.4 Pulse Start/Stop

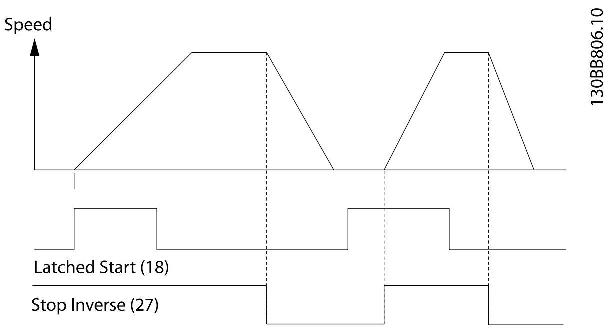
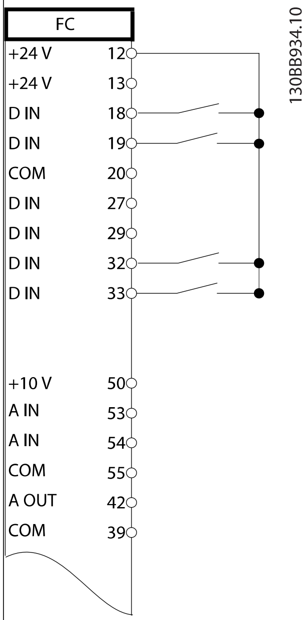
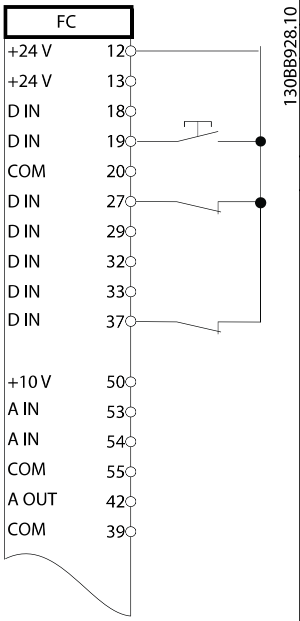


Illustration 6.2



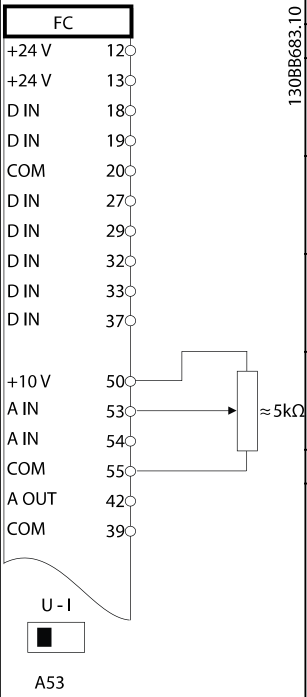
Parameters	
Function	**Setting**
Parameter E-01 Terminal 18 Digital Input	[8] Start
Parameter E-02 Terminal 19 Digital Input	[10] Reversing*
Parameter E-05 Terminal 32 Digital Input	[16] Preset ref bit 0
Parameter E-06 Terminal 33 Digital Input	[17] Preset ref bit 1
Parameter C-05 Multi-step Frequency 1 - 8	
Preset ref. 0	25%
Preset ref. 1	50%
Preset ref. 2	75%
Preset ref. 3	100%
* = Default Value	
Notes/comments:	

Table 6.5 Start/Stop with Reversing and 4 Preset Speeds



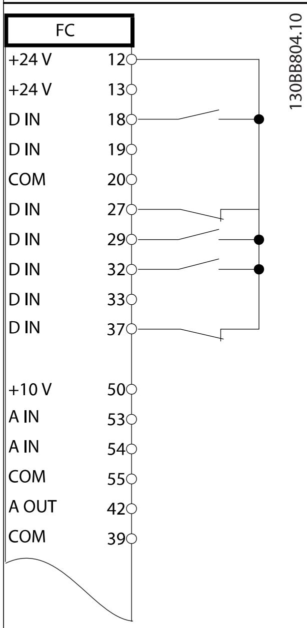
Parameters	
Function	**Setting**
Parameter E-02 Terminal 19 Digital Input	[1] Reset
* = Default Value	
Notes/comments:	

Table 6.6 External Alarm Reset



Parameters	
Function	**Setting**
Parameter AN-10 Terminal 53 Low Voltage	0.07 V*
Parameter AN-11 Terminal 53 High Voltage	10 V*
Parameter AN-14 Terminal 53 Low Ref./Feedb. Value	0 RPM
Parameter AN-15 Terminal 53 High Ref./Feedb. Value	1500 RPM
* = Default Value	
Notes/comments:	

Table 6.7 Speed Reference (using a Manual Potentiometer)



Parameters	
Function	**Setting**
Parameter E-01 Terminal 18 Digital Input	[8] Start*
Parameter E-03 Terminal 27 Digital Input	[19] Freeze Reference
Parameter E-04 Terminal 29 Digital Input	[21] Speed Up
Parameter E-05 Terminal 32 Digital Input	[22] Speed Down
* = Default Value	
Notes/comments:	

Table 6.8 Speed Up/Speed Down

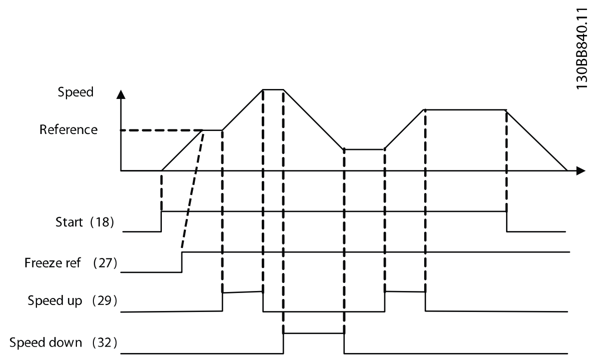
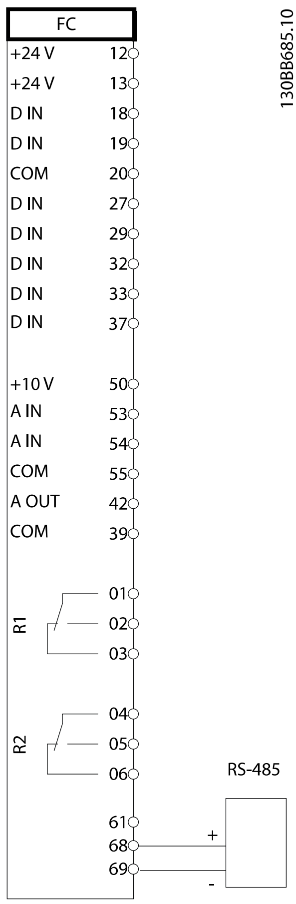


Illustration 6.3 Illustration for *Table 6.8*

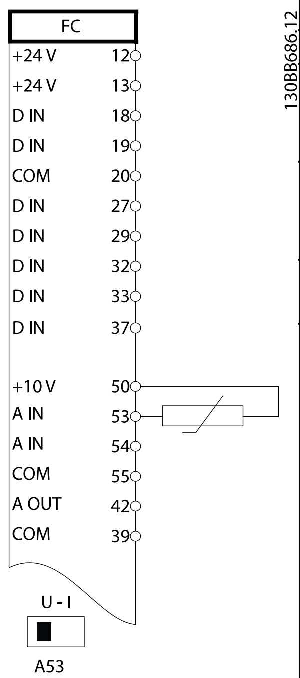


Parameters	
Function	**Setting**
Parameter O-30 Protocol	Modbus*
Parameter O-31 Address	1*
Parameter O-32 Drive Port Baud Rate	9600*
* = Default Value	
Notes/comments: Select protocol, address, and baud rate in the above mentioned parameters.	

Table 6.9 RS485 Network Connection

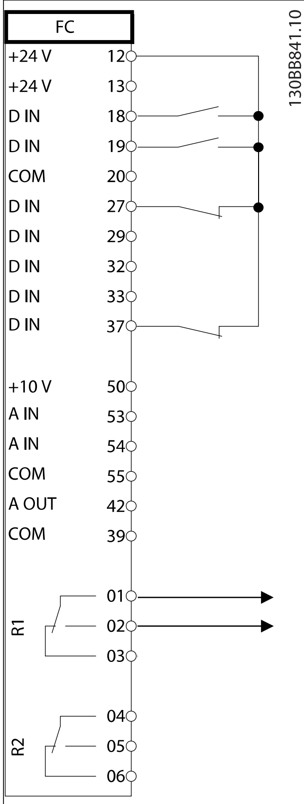
⚠CAUTION

Thermistors must use reinforced or double insulation to meet PELV insulation requirements.



Parameters	
Function	**Setting**
Parameter F-10 Electronic Overload	[2] Thermistor trip
Parameter F-12 Motor Thermistor Input	[1] Analog input 53
* = Default Value	
Notes/comments: If only a warning is desired, *parameter F-10 Electronic Overload* should be set to *[1] Thermistor warning*.	

Table 6.10 Motor Thermistor



Parameters	
Function	**Setting**
Parameter E-24 Function Relay	[32] Mech. brake ctrl.
Parameter E-01 Terminal 18 Digital Input	[8] Start*
Parameter E-02 Terminal 19 Digital Input	[11] Start reversing
Parameter F-24 Holding Time	0.2
Parameter F-25 Start Function	[5] Advanced Vector Control/FLUX Clockwise
Parameter F-29 Start Current	Im,n
Parameter B-20 Release Brake Current	Application dependent
Parameter B-21 Activate Brake Speed [RPM]	Half of nominal slip of the motor
* = Default Value	
Notes/comments:	

Table 6.11 Mechanical Brake Control

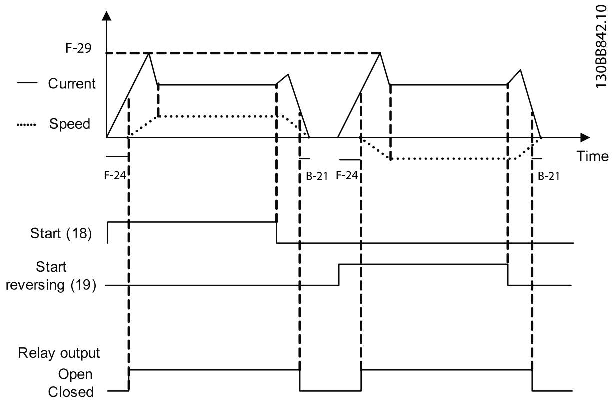
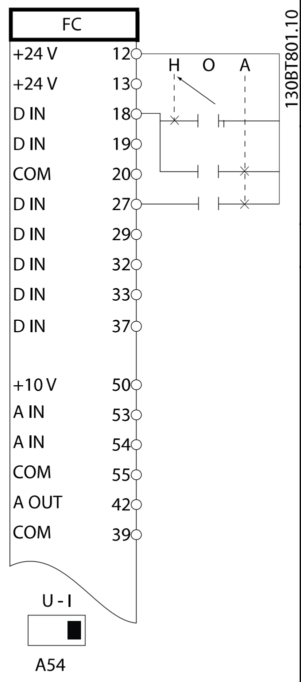


Illustration 6.4 Illustration for *Table 6.11*

In the upper right corner of the keypad, 2 numbers are shown – like 1(1). The number outside the parenthesis is the active set-up and the number inside the parenthesis is the set-up which is edited. Default is always 1(1). Make sure that you edit set-up 1.

1. Make all the parameter changes you need, that is common for auto and hand mode, like motor parameters.
2. Set *K-10 Active set-up* to *[9] Multi Set-up*. This parameter change is needed to be able to change set-up from an external source, like a digital input.
3. Set *K-11 Edit Set-up* to *[9] Active Set-up*. This is recommended because then the active set-up is always the set-up that is edited. If you prefer, you can also ignore this and manually control what set-up you want to edit through K-11.
4. Set *E-03 Terminal 27 Digital Input* to *[23] Set-up select bit 0*. When terminal 27 is OFF, set-up 1 (hand) is active, when it is ON, set-up 2 (auto) is active.
5. Set *F-01 Frequency Setting 1* to *[1] Analog input 53 (hand mode)*.
6. Copy set-up 1 to set-up 2. Set *K-51 Set up Copy* to *[2] Copy to set-up 2*. Now set-up 1 and 2 are identical.
7. If you need to be able to change between hand and auto mode while the motor is running, you have to link the 2 set-ups together. Set *K-12 This Set-up Linked to* to *[2] set-up 2*.
8. Change to set-up 2 by setting input 27 ON (if K-11 is [9]) or by setting K-11 Edit Set-up to set-up 2.
9. Set *F-01 Frequency Setting 1* to *[2] Analog input 54* (auto mode). If you want different settings in hand and auto mode, like different accel/decel ramps, speed limits you can now program them. You have to make sure that you edit the correct set-up. Set-up 1 is Hand mode and set-up 2 is Auto mode.



	Parameters	
	Function	**Setting**
	Parameter E-01 T erminal 18 Digital Input	[8] Start*
	Parameter E-03 T erminal 27 Digital Input	[23[Set-up select bit 0
	* = Default Value	
	Notes/comments: GE 30 mm HOA Cat# (1) 104PSG34B & (3) CR104PXC1	

Table 6.12 HOA

6.3 Controls

The frequency converter is capable of controlling either the speed or the torque on the motor shaft. Setting *parameter H-40 Configuration Mode* determines the type of control.

Speed control

There are 2 types of speed control:

- Speed open loop control which does not require any feedback from motor (sensorless).
- Speed closed loop PID control requires a speed feedback to an input. A properly optimized speed closed loop control has higher accuracy than a speed open loop control.

Selects which input to use as speed PID feedback in *parameter PI-00 Speed PID Feedback Source*.

Torque control
The torque control function is used in applications where the torque on motor output shaft is controlling the application as tension control. Torque control can be selected in *parameter H-40 Configuration Mode*, either in Advanced Vector Control *[4] Torque open loop* or Flux control closed loop with *[2] motor speed feedback*. Torque setting is done by setting an analog, digital, or bus controlled reference. When running torque control, it is recommended to make a full Auto tune procedure as the correct motor data are of high importance for optimal performance.

- Closed loop in Flux mode with encoder feedback offers superior performance in all 4 quadrants and at all motor speeds.
- Open loop in Advanced Vector Control mode. The function is used in mechanical robust applications, but the accuracy is limited. Open loop torque function works basically only in one speed direction. The torque is calculated on basic of current measurement internal in the frequency converter.

Speed/torque reference
The reference to these controls can either be a single reference or be the sum of various references including relatively scaled references. The handling of references is explained in detail in *chapter 6.4 References*.

The frequency converter is capable of controlling either the speed or the torque on the motor shaft. Setting *parameter H-40 Configuration Mode* determines the type of control.

Speed control

There are two types of speed control:

- Speed open loop control which does not require any feedback from motor (sensorless).
- Speed closed loop PID control requires a speed feedback to an input. A properly optimized speed closed loop control has higher accuracy than a speed open loop control.

Selects which input to use as speed PID feedback in *parameter PI-00 Speed PID Feedback Source*.

Torque control
The torque control function is used in applications where the torque on motor output shaft is controlling the application as tension control. Torque control can be selected in *parameter H-40 Configuration Mode*, either in Advanced Vector Control *[4] Torque open loop* or Flux control closed loop with motor speed feedback [2]. Torque setting is done by setting an analog, digital, or bus controlled reference. When running torque control, it is recommended to make a full Auto tune procedure as the correct motor data are of high importance for optimal performance.

- Closed loop in Flux mode with encoder feedback offers superior performance in all four quadrants and at all motor speeds.
- Open loop in Advanced Vector Control mode. The function is used in mechanical robust applications, but the accuracy is limited. Open loop torque function works basically only in one speed direction. The torque is calculated on basic of current measurement internal in the frequency converter.

Speed/torque reference
The reference to these controls can either be a single reference or be the sum of various references including relatively scaled references. The handling of references is explained in detail later in this section.

6.3.1 Control Structure in Advanced Vector Control

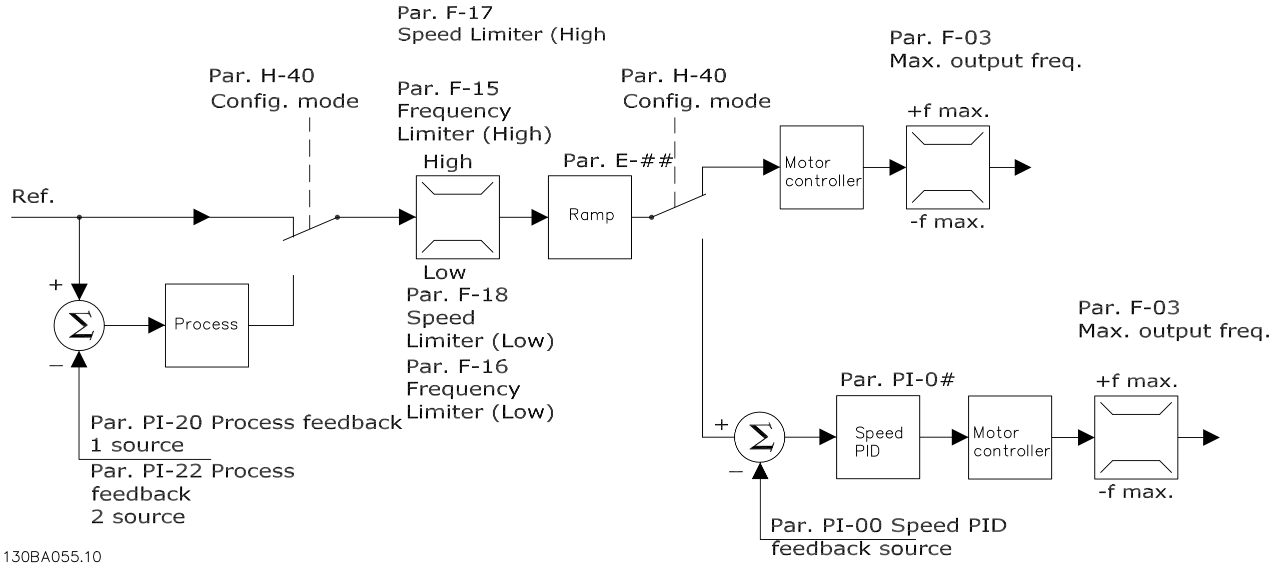


Illustration 6.5 Control Structure in Advanced Vector Control Open Loop and Closed Loop Configurations

See *Active/Inactive Parameters in Different Drive Control Modes* in the *Programming Guide* for an overview of which control configuration is available, depending on selection of AC motor or PM non-salient motor. In the configuration shown in *Illustration 6.5*, *parameter H-41 Motor Control Principle* is set to *[1] Advanced Vector Control* and *parameter H-40 Configuration Mode* is set to *[0] Speed open loop*. The resulting reference from the reference handling system is received and fed through the ramp limitation and speed limitation before being sent to the motor control. The output of the motor control is then limited by the maximum frequency limit.

If *parameter H-40 Configuration Mode* is set to *[1] Speed closed loop*, the resulting reference is passed from the ramp limitation and speed limitation into a speed PID control. The Speed PID control parameters are located in parameter group PI-0#. The resulting reference from the Speed PID control is sent to the motor control limited by the frequency limit.

Select *[3] Process* in *parameter H-40 Configuration Mode* to use the process PID control for closed loop control of for example, speed or pressure in the controlled application. The Process PID parameters are located in parameter group PI-2# and PI-3#.

6.3.2 Control Structure in Flux Sensorless

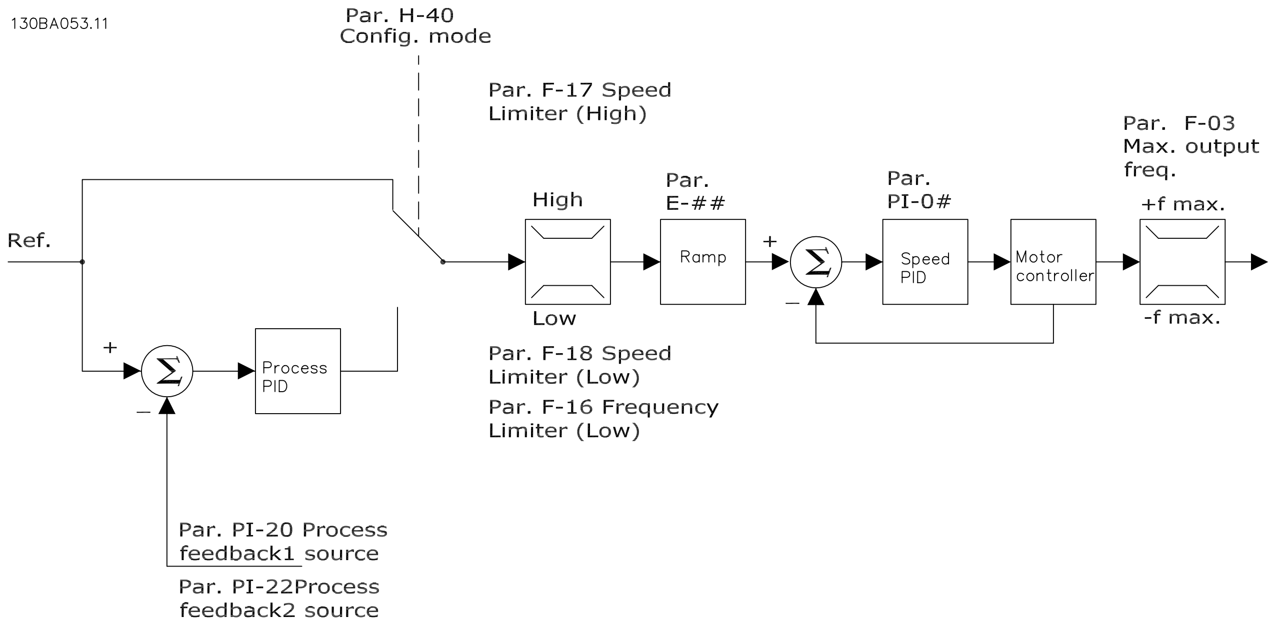


Illustration 6.6 Control Structure in Flux Sensorless Open Loop and Closed Loop Configurations

See *Active/Inactive Parameters in Different Drive Control Modes* in the *Programming Guide* for an overview of which control configuration is available, depending on selection of AC motor or PM non-salient motor. In the shown configuration, *parameter H-41 Motor Control Principle* is set to *[2] Flux Sensorless* and *parameter H-40 Configuration Mode* is set to *[0] Speed open loop*. The resulting reference from the reference handling system is fed through the ramp and speed limitations as determined by the parameter settings indicated.

An estimated speed feedback is generated to the Speed PID to control the output frequency.
The Speed PID must be set with its P, I, and D parameters (parameter group PI-0#).

Select *[3] Process* in *parameter H-40 Configuration Mode* to use the process PID control for closed loop control of that is, speed or pressure in the controlled application. The Process PID parameters are found in parameter group PI-2# and PI-3#.

6.3.3 Control Structure in Flux with Motor Feedback

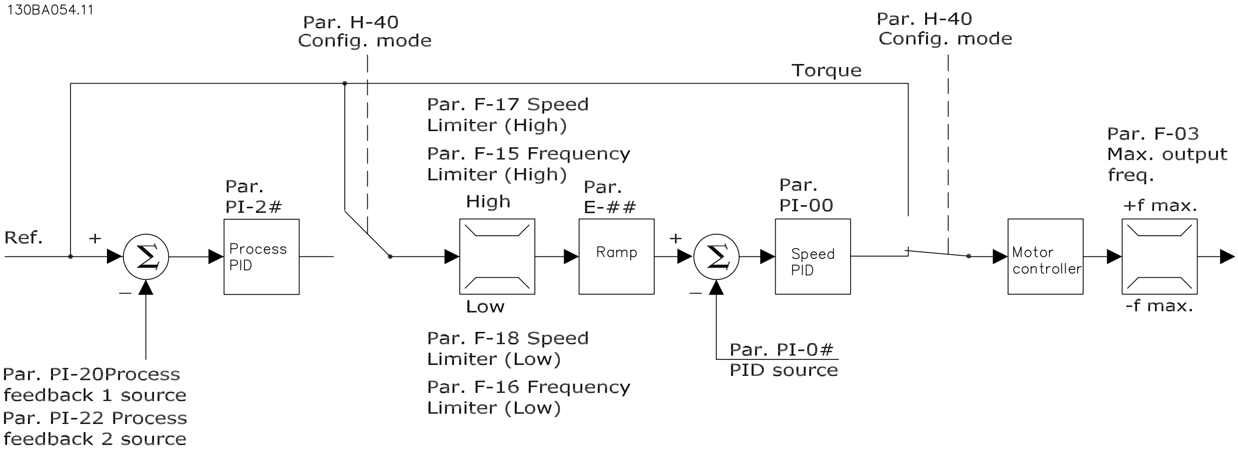


Illustration 6.7 Control Structure in Flux with Motor Feedback Configuration

See *Active/Inactive Parameters in Different Drive Control Modes* in the *Programming Guide* for an overview of which control configuration is available, depending on selection of AC motor or PM non-salient motor. In the shown configuration, *parameter H-41 Motor Control Principle* is set to *[3] Flux w motor feedb* and *parameter H-40 Configuration Mode* is set to *[1] Speed closed loop*.

The motor control in this configuration relies on a feedback signal from an encoder or resolver mounted directly on the motor (set in *parameter H-42 Flux Motor Feedback Source*).

Select *[1] Speed closed loop* in *parameter H-40 Configuration Mode* to use the resulting reference as an input for the Speed PID control. The Speed PID control parameters are located in parameter group *PI-0#*.

Select *[2] Torque* in *parameter H-40 Configuration Mode* to use the resulting reference directly as a torque reference. Torque control can only be selected in the *Flux with motor feedback* (*parameter H-41 Motor Control Principle*) configuration. When this mode has been selected, the reference uses the Nm unit. It requires no torque feedback, since the actual torque is calculated based on the current measurement of the frequency converter.

Select *[3] Process* in *parameter H-40 Configuration Mode* to use the process PID control for closed loop control of for example, speed or a process variable in the controlled application.

6.3.4 Internal Current Control

When the motor current/torque exceed the torque limits set in *parameter F-40 Torque Limiter (Driving)*, *parameter F-41 Torque Limiter (Braking)* and *parameter F-43 Current Limit*, the integral current limit control is activated.
When the frequency converter is at the current limit during motor operation or regenerative operation, it tries to get below the preset torque limits as quickly as possible without losing control of the motor.

6.4 References

6.4.1 Local (Hand) and Remote (Auto) Control

The frequency converter can be operated manually via the keypad or remotely via analog and digital inputs and serial bus. If allowed in *parameter K-40 [Hand] Button on Keypad*, *parameter K-41 [Off] Button on Keypad*, *parameter K-42 [Auto] Button on Keypad*, and *parameter K-43 [Reset] Button on Keypad*, it is possible to start and stop the frequency converter via the keypad pressing [Hand] and [Off]. Alarms can be reset via [Reset]. After pressing [Hand], the frequency converter goes into Hand mode and follows (as default) the local reference that can be set using the navigation keys on the keypad.

After pressing [Auto], the frequency converter enters Auto mode and follows (as default) the remote reference. In this mode, it is possible to control the frequency converter via the digital inputs and various serial interfaces (RS485, USB, or an optional network). See more about starting, stopping, changing ramps and parameter set-ups and so on, in parameter group E-0# or parameter group *O-5#*.

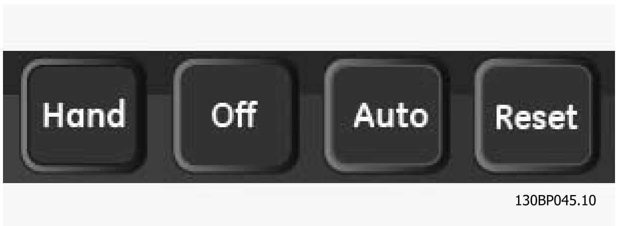


Illustration 6.8 Operation Keys

Active reference and configuration mode
The active reference can be either the local reference or the remote reference.

In *parameter F-02 Operation Method*, the local reference can be permanently selected by selecting *[2] Local*.
To permanently select the remote reference, select *[1] Remote*. By selecting *[0] Linked to Hand/Auto* (default), the reference site depends on which mode is active. (Hand mode or Auto mode).

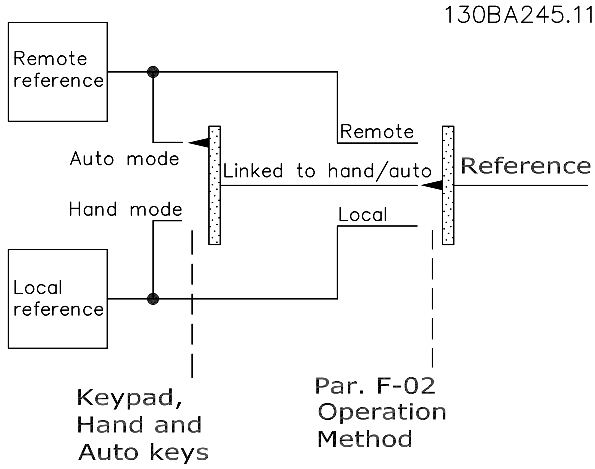


Illustration 6.9 Active Reference

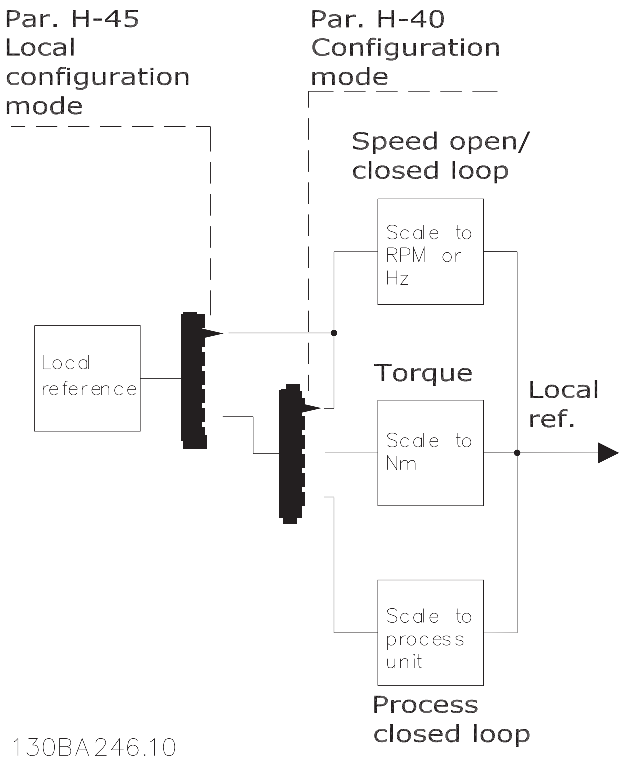


Illustration 6.10 Configuration Mode

[Hand] [Auto] keys	*Parameter F-02 Operation Method*	Active reference
Hand	Linked to Hand/ Auto	Local
Hand ⇒ Off	Linked to Hand/ Auto	Local
Auto	Linked to Hand/ Auto	Remote
Auto ⇒ Off	Linked to Hand/ Auto	Remote
All keys	Local	Local
All keys	Remote	Remote

Table 6.13 Conditions for Local/Remote Reference Activation

Parameter H-40 Configuration Mode determines what kind of application control principle (that is, Speed, Torque, or Process Control) is used when the remote reference is active. *Parameter H-45 Local Mode Configuration* determines the kind of application control principle that is used when the local reference is active. One of them is always active, but both cannot be active at the same time.

6.4.2 Reference Handling

Local reference

The local reference is active when the frequency converter is operated with 'Hand' key active. Adjust the reference by [▲]/[▼] and [◄]/[►] navigation keys respectively.

Remote reference

The reference handling system for calculating the remote reference is shown in *Illustration 6.11*.

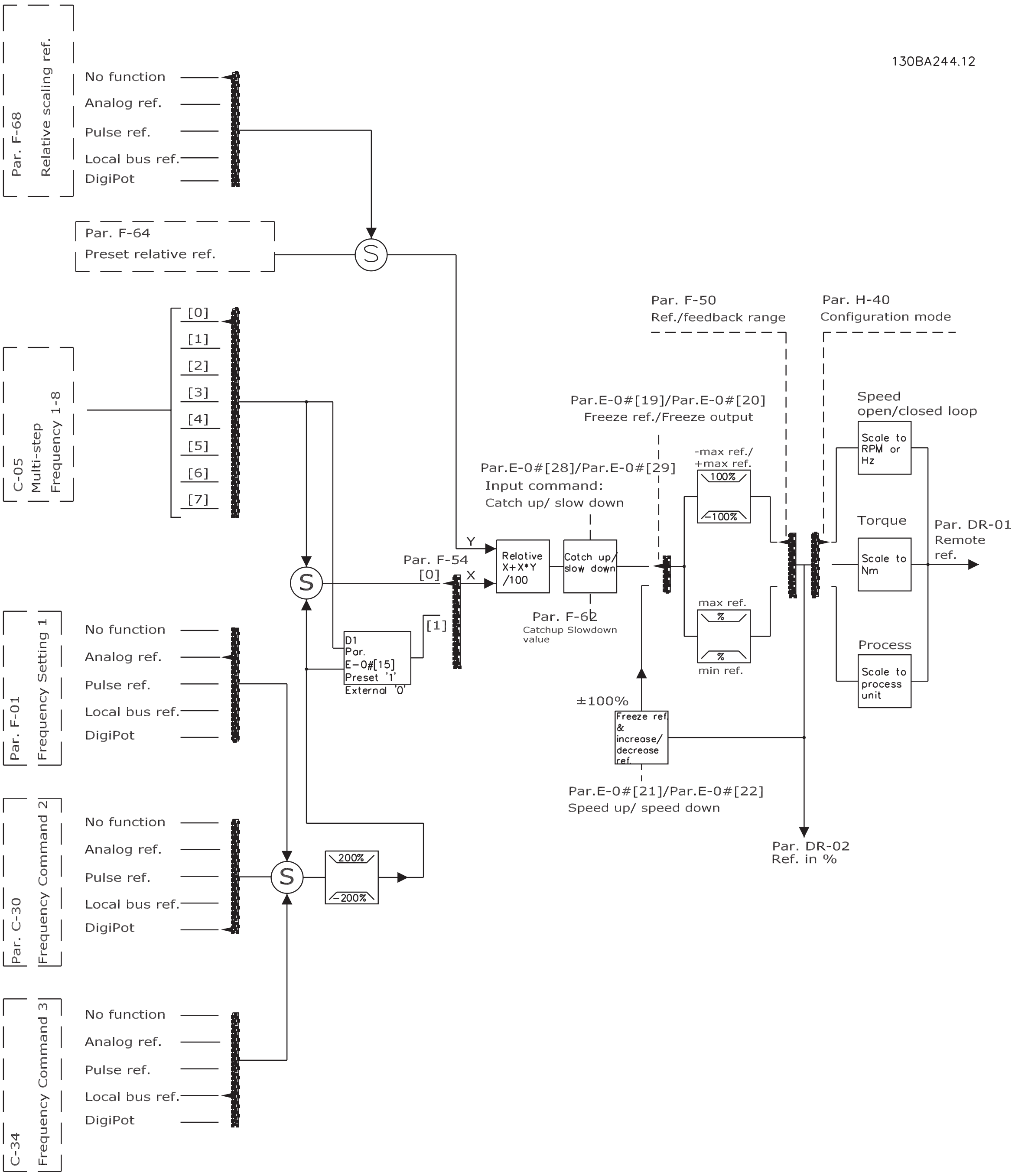


Illustration 6.11 Remote Reference

The scaling of analog references is described in parameter groups AN-1# and AN-2#, and the scaling of digital pulse references are described in parameter group E-6#.
Reference limits and ranges are set in parameter group F-5#.

6.4.3 Reference Limits

Parameter F-50 Reference Range, *parameter F-52 Minimum Reference* and *parameter F-53 Maximum Reference* define the allowed range of the sum of all references. The sum of all references is clamped when necessary. The relation between the resulting reference (after clamping) and the sum of all references is shown in *Illustration 6.12*.

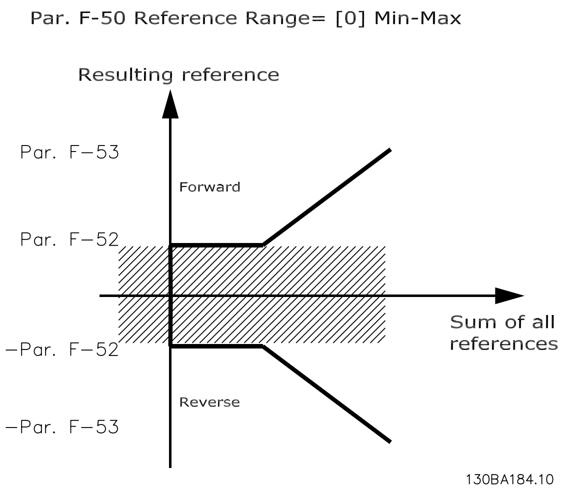


Illustration 6.12 Relation between Resulting Reference and the Sum of all References

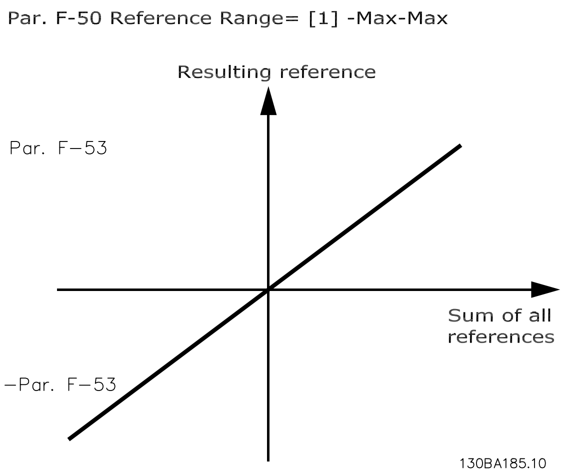


Illustration 6.13 Resulting Reference

The value of *parameter F-52 Minimum Reference* cannot be set to less than 0, unless *parameter H-40 Configuration Mode* is set to *[3] Process*. In that case, the following relations between the resulting reference (after clamping) and the sum of all references is shown in *Illustration 6.14*.

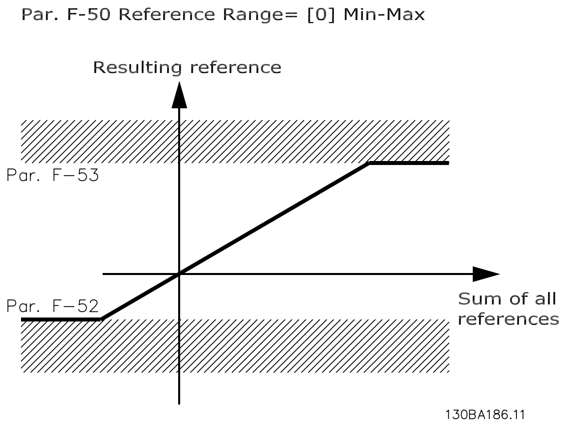


Illustration 6.14 Sum of all References with *parameter H-40 Configuration Mode* set to *[3] Process*

6.4.4 Scaling of Preset References and Bus References

Preset references are scaled according to the following rules:

- When *parameter F-50 Reference Range*: [0] Min - Max 0% reference equals 0 [unit] where unit can be any unit for example, RPM, m/s, bar and so on, 100% reference equals the Max (abs (*parameter F-53 Maximum Reference*), abs (*parameter F-52 Minimum Reference*)).
- When *parameter F-50 Reference Range*: [1] -Max - +Max 0% reference equals 0 [unit] -100% reference equals -Max Reference 100% reference equals Max Reference.

Bus references are scaled according to the following rules:

- When *parameter F-50 Reference Range*: [0] Min - Max. To obtain max resolution on the bus reference the scaling on the bus is: 0% reference equals Min Reference and 100% reference equals Max reference.
- When *parameter F-50 Reference Range*: [1] -Max - +Max -100% reference equals -Max Reference 100% reference equals Max Reference.

6.4.5 Scaling of Analog and Pulse References and Feedback

References and feedback are scaled from analog and pulse inputs in the same way. The only difference is that a reference above or below the specified minimum and maximum "endpoints" (P1 and P2 in *Illustration 6.15*) are clamped whereas feedback above or below is not.

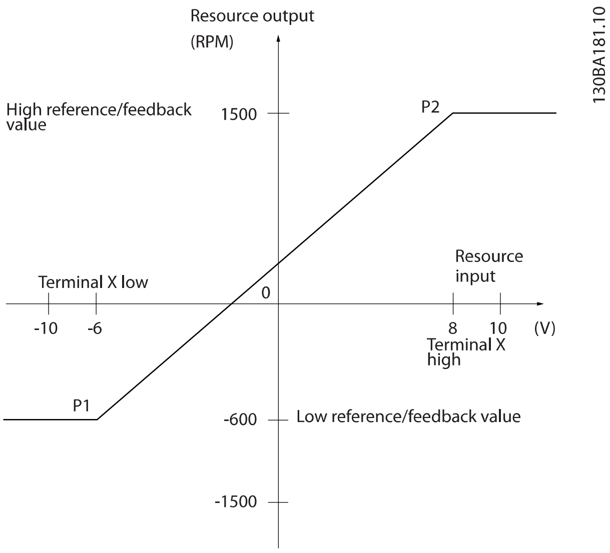


Illustration 6.15 Scaling of Analog and Pulse References and Feedback

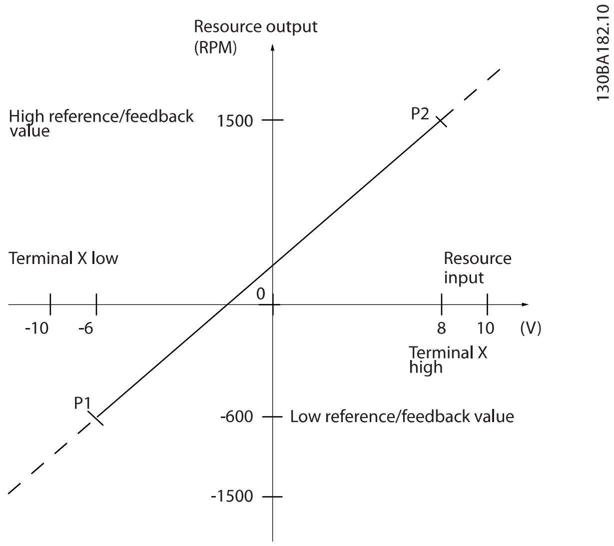


Illustration 6.16 Scaling of Reference Output

6

	Analog 53 S201=OFF	Analog 53 S201=ON	Analog 54 S202=OFF	Analog 54 S202=ON	Pulse Input 29	Pulse Input 33
P1 = (Minimum input value, Minimum reference value)						
Minimum reference value	*Parameter AN-14 Terminal 53 Low Ref./Feedb. Value*	*Parameter AN-14 Terminal 53 Low Ref./Feedb. Value*	*Parameter AN-24 Terminal 54 Low Ref./Feedb. Value*	*Parameter AN-24 Terminal 54 Low Ref./Feedb. Value*	*Parameter E-62 Term. 29 Low Ref./Feedb. Value*	*Parameter E-67 Term. 33 Low Ref./Feedb. Value*
Minimum input value	*Parameter AN-10 Terminal 53 Low Voltage* [V]	*Parameter AN-12 Terminal 53 Low Current* [mA]	*Parameter AN-20 Terminal 54 Low Voltage* [V]	*Parameter AN-22 Terminal 54 Low Current* [mA]	*Parameter E-60 Term. 29 Low Frequency* [Hz]	*Parameter E-65 Term. 33 Low Frequency* [Hz]
P2 = (Maximum input value, Maximum reference value)						
Maximum reference value	*Parameter AN-15 Terminal 53 High Ref./ Feedb. Value*	*Parameter AN-15 Terminal 53 High Ref./Feedb. Value*	*Parameter AN-25 Terminal 54 High Ref./ Feedb. Value*	*Parameter AN-25 Terminal 54 High Ref./Feedb. Value*	*Parameter E-63 Term. 29 High Ref./Feedb. Value*	*Parameter E-68 Term. 33 High Ref./Feedb. Value*
Maximum input value	*Parameter AN-11 Terminal 53 High Voltage* [V]	*Parameter AN-13 Terminal 53 High Current* [mA]	*Parameter AN-21 Terminal 54 High Voltage* [V]	*Parameter AN-23 Terminal 54 High Current* [mA]	*Parameter E-61 Term. 29 High Frequency* [Hz]	*Parameter E-66 Term. 33 High Frequency* [Hz]

Table 6.14 Parameters Defining the Endpoints P1 and P2 depending on which Analog or Pulse Input is used

6.5 PID Control

6.5.1 Speed PID Control

Parameter H-40 Configuration Mode	*Parameter H-41 Motor Control Principle*			
	U/f	**Advanced Vector Control**	**Flux Sensorless**	**Flux w/ enc. feedb**
[0] Speed open loop	Not Active	Not Active	ACTIVE	N.A.
[1] Speed closed loop	N.A.	ACTIVE	N.A.	ACTIVE
[2] Torque	N.A.	N.A.	N.A.	Not Active
[3] Process		Not Active	ACTIVE	ACTIVE

Table 6.15 Control Configurations where the Speed Control is active

"N.A." means that the specific mode is not available at all. "Not Active" means that the specific mode is available but the Speed Control is not active in that mode.

6

NOTICE

The Speed Control PID works under the default parameter setting, but tuning the parameters is highly recommended to optimize the motor control performance. The two Flux motor control principles are particularly dependent on proper tuning to yield their full potential.

Example of how to program the speed control

In this case, the Speed PID Control is used to maintain a constant motor speed regardless of the changing load on the motor. The required motor speed is set via a potentiometer connected to terminal 53. The speed range is 0 to 1500 RPM corresponding to 0–10 0 V to 10 V over the potentiometer. Starting and stopping is controlled by a switch connected to terminal 18. The Speed PID monitors the actual RPM of the motor by using a 24 V (HTL) incremental encoder as feedback. The feedback sensor is an encoder (1024 pulses per revolution) connected to terminals 32 and 33.

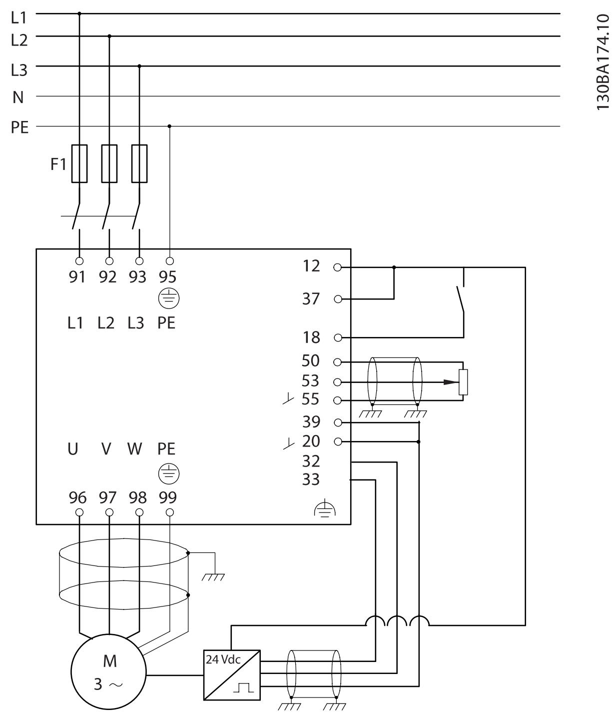


Illustration 6.17 Example - Speed Control Connections

<table>
<tr><th>Parameter</th><th>Description of function</th></tr>
<tr><td>Parameter PI-00 Speed PID Feedback Source</td><td>Select from which input the Speed PID should get its feedback.</td></tr>
<tr><td>Parameter PI-02 Speed PID Proportional Gain</td><td>The higher the value - the quicker the control. However, too high value may lead to oscillations.</td></tr>
<tr><td>Parameter PI-03 Speed PID Integral Time</td><td>Eliminates steady state speed error. Lower value means quick reaction. However, too low value may lead to oscillations.</td></tr>
<tr><td>Parameter PI-04 Speed PID Differentiation Time</td><td>Provides a gain proportional to the rate of change of the feedback. A setting of zero disables the differentiator.</td></tr>
<tr><td>Parameter PI-05 Speed PID Diff. Gain Limit</td><td>If there are quick changes in reference or feedback in a given application - which means that the error changes swiftly - the differentiator may soon become too dominant. This is because it reacts to changes in the error. The quicker the error changes, the stronger the differentiator gain is. The differentiator gain can thus be limited to allow setting of the reasonable differentiation time for slow changes and a suitably quick gain for quick changes.</td></tr>
<tr><td>Parameter PI-06 Speed PID Lowpass Filter Time</td><td>A low-pass filter that dampens oscillations on the feedback signal and improves steady state performance. However, too large filter time deteriorates the dynamic performance of the Speed PID control.
Practical settings of parameter PI-06 taken from the number of pulses per revolution on from encoder (PPR):
<table>
<tr><th>Encoder PPR</th><th>Parameter PI-06 Speed PID Lowpass Filter Time</th></tr>
<tr><td>512</td><td>10 ms</td></tr>
<tr><td>1024</td><td>5 ms</td></tr>
<tr><td>2048</td><td>2 ms</td></tr>
<tr><td>4096</td><td>1 ms</td></tr>
</table></td></tr>
</table>

Table 6.16 Speed Control Parameters

In *Table 6.17* it is assumed that all other parameters and switches remain at their default setting.

Function	Parameter	Setting
1) Make sure that the motor runs properly. Do the following:		
Set the motor parameters using nameplate data	P-02 to P-07 F-04 & F-05	As specified by motor nameplate
Have the frequency converter makes an auto tune	*Parameter P-04 Auto Tune*	[1] Enable complete auto tune
2) Check the motor is running and the encoder is attached properly. Do the following:		
Press the “Hand” keypad key. Check that the motor is running and note in which direction it is turning (henceforth referred to as the “positive direction”).		Set a **positive** reference.
Go to *parameter DR-20 Motor Angle*. Turn the motor slowly in the positive direction. It must be turned so slowly (only a few RPM) that it can be determined if the value in *parameter DR-20 Motor Angle* is increasing or decreasing.	*Parameter DR-20 Motor Angle*	N.A. (read-only parameter) Note: An increasing value overflows at 65535 and starts again at 0.
If *parameter DR-20 Motor Angle* is decreasing then change the encoder direction in *parameter E-81 Term 32/33 Encoder Direction*.	*Parameter E-81 Term 32/33 Encoder Direction*	[1] Counter clockwise (if *parameter DR-20 Motor Angle* is decreasing)
3) Make sure that the drive limits are set to safe values		
Set acceptable limits for the references.	*Parameter F-52 Minimum Reference* parameter F-53 Maximum Reference	0 RPM 1500 RPM

Function	Parameter	Setting
Check that the ramp settings are within frequency converter capabilities and allowed application operating specifications.	*Parameter F-07 Accel Time 1* *parameter F-08 Decel Time 1*	Default setting default setting
Set acceptable limits for the motor speed and frequency.	*Parameter F-18 Motor Speed Low Limit [RPM]* *parameter F-17 Motor Speed High Limit [RPM]* *parameter F-03 Max Output Frequency 1*	0 RPM 1500 RPM 60 Hz (default 132 Hz)
4) Configure the Speed Control and select the motor control principle		
Activation of Speed Control	*Parameter H-40 Configuration Mode*	[1] Speed closed loop
Selection of Motor Control Principle	*Parameter H-41 Motor Control Principle*	[3] Flux w motor feedb
5) Configure and scale the reference to the Speed Control		
Set up Analog Input 53 as a reference Source	*Parameter F-01 Frequency Setting 1*	Not necessary (default)
Scale Analog Input 53 0 RPM (0V) to 1500 RPM (10 V)	*AN-1#*	Not necessary (default)
6) Configure the 24 V HTL encoder signal as feedback for the Motor Control and the Speed Control		
Set up digital input 32 and 33 as encoder inputs	*Parameter E-05 Terminal 32 Digital Input* *parameter E-06 Terminal 33 Digital Input*	[0] No operation (default)
Select terminal 32/33 as motor feedback	*Parameter H-42 Flux Motor Feedback Source*	Not necessary (default)
Select terminal 32/33 as Speed PID feedback	*Parameter PI-00 Speed PID Feedback Source*	Not necessary (default)
7) Tune the Speed Control PID parameters		
Use the tuning guidelines when relevant or tune manually	*PI-0#*	See the guidelines below.
8) Finished!		
Save the parameter setting to the keypad for safe keeping	*Parameter K-50 Keypad Copy*	[1] All to keypad

Table 6.17 Programming Order

6.5.1.1 Tuning PID Speed Control

The following tuning guidelines are relevant when using one of the Flux motor control principles in applications where the load is mainly inertial (with a low amount of friction).

The value of *parameter PI-02 Speed PID Proportional Gain* depends the combined inertia of the motor and load, and the selected bandwidth can be calculated using the following formula:

$$Par.\ PI-02\ =\ \frac{Total\ inertia\ [kgm^2]\ x\ par.\ P-06}{Par.\ P-07\ x\ 9550}\ x\ Bandwidth\ [rad/s]$$

NOTICE

***Parameter P-07 Motor Power [kW]* is the motor power in [kW] (that is, enter ‘4’ kW instead of ‘4000’ W in the formula).**

Generally the practical maximum limit of *parameter PI-02 Speed PID Proportional Gain* is determined by the encoder resolution and the feedback filter time but other factors in the application might limit the *parameter PI-02 Speed PID Proportional Gain* to a lower value.

To minimize the overshoot, *parameter PI-03 Speed PID Integral Time* could be set to approx. 2.5 s (varies with the application).

Parameter PI-04 Speed PID Differentiation Time should be set to 0 until everything else is tuned. If necessary, finish the tuning by experimenting with small increments of this setting.

6.5.2 Process PID Control

The Process PID Control can be used to control application parameters that can be measured by a sensor (that is, pressure, temperature, flow) and can be affected by the connected motor through a pump, fan or otherwise.

Table 6.18 shows the control configurations where the Process Control is possible. When a Flux Vector motor control principle is used, take care also to tune the Speed Control PID parameters. Refer to the section about the Control Structure to see where the Speed Control is active.

Parameter H-40 Configuration Mode	***Parameter H-41 Motor Control Principle***			
	U/f	**Advanced Vector Control**	**Flux Sensorless**	**Flux w/ enc. feedb**
[3] Process	N.A.	Process	Process & Speed	Process & Speed

Table 6.18 Control Figurations - Process Control

NOTICE

The Process Control PID works under the default parameter setting, but tuning the parameters is highly recommended to optimize the application control performance. The two Flux motor control principles are specially dependent on proper Speed Control PID tuning (before tuning the Process Control PID) to yield their full potential.

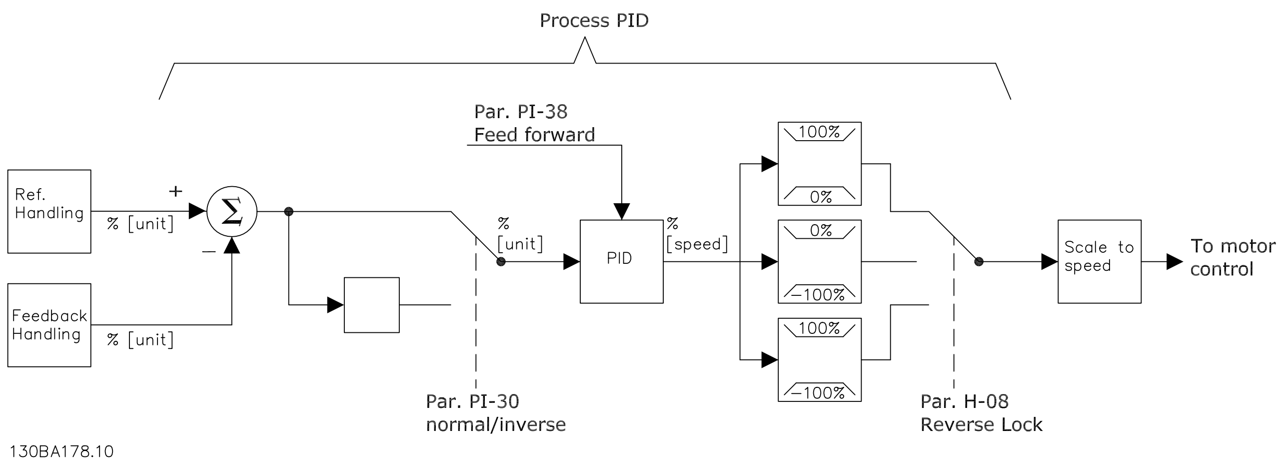


Illustration 6.18 Process PID Control Diagram

6.5.2.1 Example of Process PID Control

Illustration 6.19 is an example of a Process PID Control used in a ventilation system.

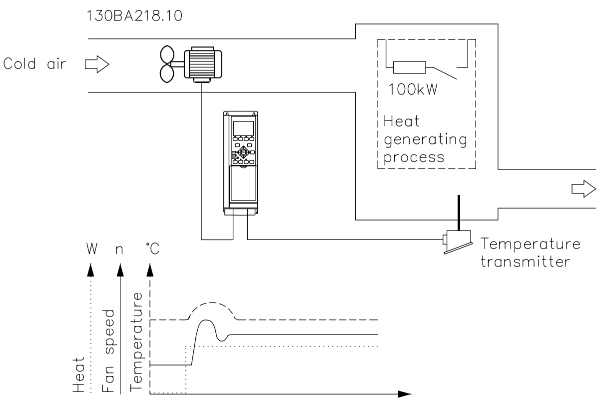


Illustration 6.19 Example - Process PID Control in a Ventilation System

In a ventilation system, the temperature is to be settable from -5 to 35 °C with a potentiometer of 0–10 V. The set temperature must be kept constant, for which purpose the Process Control is to be used.

The control is of the inverse type, which means that when the temperature increases, the ventilation speed is increased as well, to generate more air. When the temperature drops, the speed is reduced. The transmitter used is a temperature sensor with a working range of -10 to 40°C, 4–20 mA. Minimum/Maximum speed 300/1500 RPM.

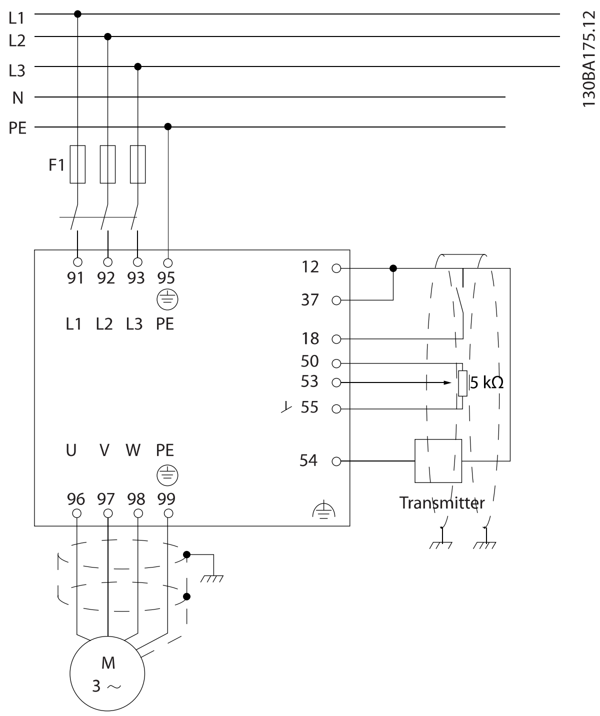


Illustration 6.20 Two-wire Transmitter

1. Start/Stop via switch connected to terminal 18.
2. Temperature reference via potentiometer (-5 to 35 °C, 0–10 V DC) connected to terminal 53.
3. Temperature feedback via transmitter (-10 to 40 °C, 4–20 mA) connected to terminal 54. Switch S202 set to ON (current input).

6.5.2.2 Ziegler Nichols Tuning Method

NOTICE

The method described must not be used on applications that could be damaged by the oscillations created by marginally stable control settings.

The criteria for adjusting the parameters are based on evaluating the system at the limit of stability rather than on taking a step response. We increase the proportional gain until we observe continuous oscillations (as measured on the feedback), that is, until the system becomes marginally stable. The corresponding gain *(K_u)* is called the ultimate gain. The period of the oscillation *(P_u)* (called the ultimate period) is determined as shown in the figure.

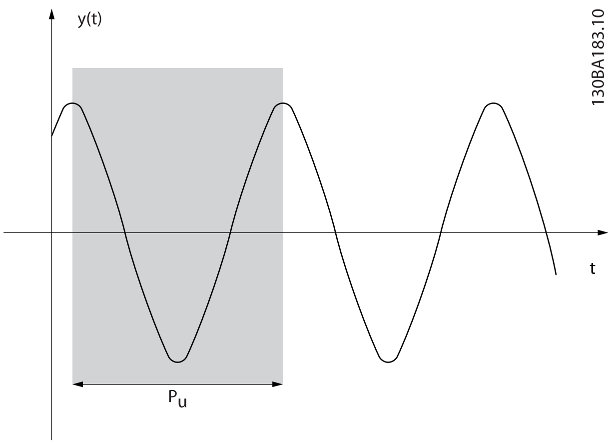


Illustration 6.21 Marginally Stable System

Step-by-step description

Step 1: Select only Proportional Control, meaning that the integral time is selected to the maximum value, while the differentiation time is selected to zero.

Step 2: Increase the value of the proportional gain until the point of instability is reached (sustained oscillations) and the critical value of gain, K_u, is reached.

Step 3: Measure the period of oscillation to obtain the critical time constant, P_u.

Step 4: Use *Table 6.19* to calculate the necessary PID control parameters.

P_u should be measured when the amplitude of oscillation is quite small. Then we "back off" from this gain again, as shown in Table 1.

K_u is the gain at which the oscillation is obtained.

Type of control	Proportional gain	Integral time	Differentiation time
PI-control	0.45 * K_u	0.833 * P_u	–
PID tight control	0.6 * K_u	0.5 * P_u	0.125 * P_u
PID some overshoot	0.33 * K_u	0.5 * P_u	0.33 * P_u

Table 6.19 Ziegler Nichols Tuning for Regulator, Based on a Stability Boundary

Parameter	Description of function
Parameter PI-20 Process CL Feedback 1 Resource	Select from which Source (that is, analog or pulse input) the Process PID should get its feedback.
Parameter PI-22 Process CL Feedback 2 Resource	Optional: Determine if (and from where) the Process PID should get an additional feedback signal. If an additional feedback source is selected, the 2 feedback signals are added before being used in the Process PID Control.
Parameter PI-30 Process PID Normal/ Inverse Control	Under *[0] Normal operation*, the Process Control responds with an increase of the motor speed, if the feedback is getting lower than the reference. In the same situation, but under *[1] Inverse operation*, the Process Control responds with a decreasing motor speed instead.
Parameter PI-31 Process PID Anti Windup	The anti-windup function ensures that when either a frequency limit or a torque limit is reached, the integrator is set to a gain that corresponds to the actual frequency. This avoids integrating on an error that cannot in any case be compensated for with a speed change. This function can be disabled by selecting *[0] Off*.
Parameter PI-32 Process PID Start Speed	In some applications, reaching the required speed/set point can take a long time. In such applications, it might be an advantage to set a fixed motor speed from the frequency converter before the process control is activated. This is done by setting a Process PID Start Value (speed) in *parameter PI-32 Process PID Start Speed*.
Parameter PI-33 Process PID Proportional Gain	The higher the value - the quicker the control. However, too large value may lead to oscillations.
Parameter PI-34 Process PID Integral Time	Eliminates steady state speed error. Lower value means quick reaction. However, too small value may lead to oscillations.
Parameter PI-35 Process PID Differentiation Time	Provides a gain proportional to the rate of change of the feedback. A setting of zero disables the differentiator.

Parameter	Description of function
Parameter PI-36 Process PID Diff. Gain Limit	If there are quick changes in reference or feedback in a given application - which means that the error changes swiftly - the differentiator may soon become too dominant. This is because it reacts to changes in the error. The quicker the error changes, the stronger the differentiator gain is. The differentiator gain can thus be limited to allow setting of the reasonable differentiation time for slow changes.
Parameter PI-38 Process PID Feed Forward Factor	In application where there is a good (and approximately linear) correlation between the process reference and the motor speed necessary for obtaining that reference, the Feed Forward Factor can be used to achieve better dynamic performance of the Process PID Control.
Parameter E-64 Pulse Filter Time Constant #29 (Pulse term. 29), *parameter E-69 Pulse Filter Time Constant #33* (Pulse term. 33), *parameter AN-16 Terminal 53 Filter Time Constant* (Analog term 53), *parameter AN-26 Terminal 54 Filter Time Constant* (Analog term. 54)	If there are oscillations of the current/voltage feedback signal, these can be dampened by a low-pass filter. This time constant represents the speed limit of the ripples occurring on the feedback signal. Example: If the low-pass filter has been set to 0.1s, the limit speed is 10 RAD/s (the reciprocal of 0.1 s), corresponding to (10/(2 x π)) = 1.6 Hz. This means that all currents/ voltages that vary by more than 1.6 oscillations per second is damped by the filter. The control is only carried out on a feedback signal that varies by a frequency (speed) of less than 1.6 Hz. The low-pass filter improves steady state performance, but selecting a too large filter time deteriorates the dynamic performance of the Process PID Control.

Table 6.20 Relevant Parameters for Process Control

Function	Parameter	Setting
Restore the frequency converter	*H-03*	*[2] Restore* - make a power cycling - press reset
1) Set motor parameters:		
Set the motor parameters according to nameplate data	*P-02 to P-07* *F-04 & F-05*	As stated on motor nameplate
Perform a full auto tune	*P-04*	*[1] Enable complete auto tune*
2) Check that motor is running in the right direction. When motor is connected to frequency converter with straight forward phase order as U–U; V–V; W–W motor shaft usually turns clockwise seen into shaft end.		
Press [Hand]. Check shaft direction by applying a manual reference.		
If motor turns opposite of required direction: 1. Change motor direction in *parameter H-08 Reverse Lock* 2. Turn off mains - wait for DC-link to discharge - switch 2 of the motor phases	*H-08*	Select correct motor shaft direction
Set configuration mode	*H-40*	*[3] Process*
Set local mode configuration	*H-45*	*[0] Speed Open Loop*
3) Set reference configuration, i.e. the range for reference handling. Set scaling of analog input in parameter group *AN-##*		
Set reference/feedback units Set min. reference (10 °C) Set max. reference (80 °C) If set value is determined from a preset value (array parameter), set other reference sources to No Function	*F-51* *F-52* *F-53* *C-05*	[60] °C Unit shown on display 10 °C 80 °C [0] 35% $Ref = \frac{Par.\ C-05_{(0)}}{100} \times ((Par.\ F-53) - (par.\ F-52))$ $= 24{,}5°\ C$ *Parameter F-64 Preset Relative Reference* to *parameter F-68 Relative Scaling Reference Resource* [0] = No Function
4) Adjust limits for the frequency converter:		
Set ramp times to an appropriate value as 20 s	*F-07* *F-08*	20 s 20 s

Function	Parameter	Setting
Set min. speed limits	*F-18*	300 RPM
Set motor speed max. limit	*F-17*	1500 RPM
Set max. output frequency	*F-03*	60 Hz
Set S201 or S202 to wanted analog input function (Voltage (V) or current (I)). **NOTICE** **Switches are sensitive - Make a power cycling keeping default setting of V.**		
5) Scale analog inputs used for reference and feedback		
Set terminal 53 low voltage	*AN-10*	0 V
Set terminal 53 high voltage	*AN-11*	10 V
Set terminal 54 low feedback value	*AN-24*	-5 °C
Set terminal 54 high feedback value	*AN-25*	35 °C
Set feedback source	*PI-20*	*[2] Analog input 54*
6) Basic PID settings		
Process PID Normal/Inverse	*PI-30*	*[0] Normal*
Process PID Anti Wind-up	*PI-31*	*[1] On*
Process PID start speed	*PI-32*	300 RPM
Save parameters to keypad	*K-50*	*[1] All to keypad*

Table 6.21 Example of Process PID Control set-up

6.5.3 Optimization of the Process Regulator

After completing the basic settings, optimize the proportional gain, the integration time, and the differentiation time (*parameter PI-33 Process PID Proportional Gain*, *parameter PI-34 Process PID Integral Time*, *parameter PI-35 Process PID Differentiation Time*). In most processes, this can be done by following the guidelines:

1. Start the motor.
2. Set *parameter PI-33 Process PID Proportional Gain* to 0.3 and increase it until the feedback signal again begins to vary continuously.
3. Reduce the value until the feedback signal has stabilized.
4. Lower the proportional gain by 40–60%.
5. Set *parameter PI-34 Process PID Integral Time* to 20 s.
6. Reduce the value until the feedback signal again begins to vary continuously.
7. Increase the integration time until the feedback signal stabilizes, followed by an increase of 15–50%.
8. Only use *parameter PI-35 Process PID Differentiation Time* for very fast-acting systems only (differentiation time). The typical value is 4 times the set integration time. Only use the differentiator when the setting of the proportional gain and the integration time has been fully optimized. Make sure that oscillations on the feedback signal are sufficiently dampened by the lowpass filter on the feedback signal.

NOTICE

If necessary, start/stop can be activated several times to provoke a variation of the feedback signal.

6.6 Brake Functions

Brake function is applied for braking the load on the motor shaft, either as dynamic braking or mechanical braking.

6.6.1 Mechanical Holding Brake

A mechanical holding brake mounted directly on the motor shaft normally performs static braking. In some applications, the static holding torque is working as static holding of the motor shaft (usually synchronous permanent motors). A holding brake is either controlled by a PLC or directly by a digital output from the frequency converter (relay or solid state).

NOTICE

When the holding brake is included in a safety chain:
A frequency converter cannot provide a safe control of a mechanical brake. A redundancy circuitry for the brake control must be included in the total installation.

6.6.2 Dynamic Braking

Dynamic Brake established by:

- Resistor brake: A brake IGBT keeps the overvoltage under a certain threshold by directing the brake energy from the motor to the connected brake resistor (*parameter B-10 Brake Function* = [1]).
- AC brake: The brake energy is distributed in the motor by changing the loss conditions in the motor. The AC brake function cannot be used in applications with high cycling frequency since this overheats the motor (*parameter B-10 Brake Function* = [2]).
- DC brake: An over-modulated DC current added to the AC current works as an eddy current brake (parameter B-02 and B-03 ≠ off).

6

6.6.2.1 Selection of Brake Resistor

To handle higher demands by generatoric braking a brake resistor is necessary. Using a brake resistor ensures that the energy is absorbed in the brake resistor and not in the frequency converter. For more information, see the *Brake Resistor Design Guide, DET-700*

If the amount of kinetic energy transferred to the resistor in each braking period is not known, the average power can be calculated based on the cycle time and braking time also called intermittent duty cycle. The resistor intermittent duty cycle is an indication of the duty cycle at which the resistor is active. *Illustration 6.22* shows a typical braking cycle.

NOTICE

Motor suppliers often use S5 when stating the permissible load which is an expression of intermittent duty cycle.

The intermittent duty cycle for the resistor is calculated as follows:

Duty cycle = t_b/T

T = cycle time in s

t_b is the braking time in s (of the cycle time)

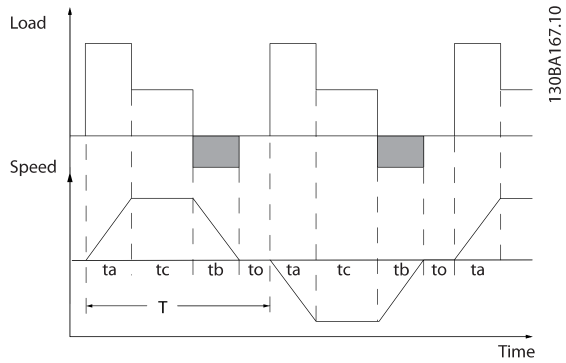


Illustration 6.22 Typical Braking Cycle

NOTICE

Make sure that the resistor is designed to handle the required braking time.

The maximum permissible load on the brake resistor is stated as a peak power at a given intermittent duty cycle and can be calculated as:

The brake resistance is calculated as shown:

$$R_{br}\,[\Omega] = \frac{U_{dc}^2}{P_{peak}}$$

where

$P_{peak} = P_{motor} \times M_{br}\,[\%] \times \eta_{motor} \times \eta_{DRIVE}[W]$

As can be seen, the brake resistance depends on the DC-link voltage (U_{dc}).

Size	Brake active	Warning before cut out	Cut out (trip)
3 x 200–240 V	390 V (UDC)	405 V	410 V
3 x 380–500 V[1)]	810 V/795 V	840 V/828 V	850 V/855 V
3 x 525–600 V	943 V	965 V	975 V
3 x 525–690 V	1084 V	1109 V	1130 V

Table 6.22 Main Areas for Brake Function

1) Power size dependent

NOTICE

Check that the brake resistor can cope with a voltage of 410 V, 850 V, 975 V, or 1130 V.

The recommended brake resistance guarantees that the frequency converter is able to brake at the highest braking torque ($M_{br(\%)}$) of 160%. The formula can be written as:

$$R_{rec}\,[\Omega] = \frac{U_{dc}^2 \times 100}{P_{motor} \times M_{br\,(\%)} \times \eta_{DRIVE} \times \eta_{motor}}$$

η_{motor} is typically at 0.90

η_{DRIVE} is typically at 0.98.

For 200 V, 500 V, and 600 V frequency converters, R_{rec} at 160% braking torque is written as:

$$200\,V : R_{\text{rec}} = \frac{107780}{P_{\text{motor}}}\,[\Omega]$$

$$500\ V : R_{rec} = \frac{464923}{P_{motor}}\ [\Omega]$$

$$600\ V : R_{rec} = \frac{630137}{P_{motor}}\ [\Omega]$$

$$690\ V : R_{rec} = \frac{832664}{P_{motor}}\ [\Omega]$$

NOTICE

If a brake resistor with a higher ohmic value is selected, the 160% braking torque may not be achieved because there is a risk that the frequency converter cuts out for safety reasons.

NOTICE

If a short circuit in the brake transistor occurs, power dissipation in the brake resistor is only prevented by using a mains switch or contactor to disconnect the mains for the frequency converter. (The contactor can be controlled by the frequency converter).

NOTICE

Do not touch the brake resistor as it can get hot while/ after braking. The brake resistor must be placed in a secure environment to avoid fire risk.

CAUTION

Unit size 4x to 6x frequency converters contain more than one brake chopper. Therefore, use one brake resistor per brake chopper for those frame sizes.

6.6.2.2 Brake Resistor Cabling

EMC (twisted cables/shielding)
To reduce the electrical noise from the wires between the brake resistor and the frequency converter, the wires must be twisted.

For enhanced EMC performance, a metal shield can be used.

6.6.2.3 Overvoltage Control

Overvoltage control (OVC) (exclusive brake resistor) can be selected as an alternative brake function in *parameter B-17 Over-voltage Control*. This function is active for all units. The function ensures that a trip can be avoided if the DC-link voltage increases. This is done by increasing the output frequency to limit the voltage from the DC link. It is a useful function, for example, if the decel time is too short since tripping of the frequency converter is avoided. In this situation, the decel time is extended.

6.6.3 Mechanical Brake in Open Loop

For hoisting applications, it is necessary to be able to control an electro-magnetic brake.

For controlling the brake, a relay output (relay1 or relay2) or a programmed digital output (terminal 27 or 29) is required. Normally, this output must be closed for as long as the frequency converter is unable to 'hold' the motor, for example, because of too large load. In *parameter E-24 Function Relay* (Array parameter), *parameter E-20 Terminal 27 Digital Output*, or *parameter E-21 Terminal 29 Digital Output*, select *[32] Mechanical brake control* for applications with an electro-magnetic brake.

When *[32] Mechanical brake control* is selected, the mechanical brake relay stays closed during start until the output current is above the level selected in *parameter B-20 Release Brake Current*. During stop, the mechanical brake closes when the speed is below the level selected in *parameter B-21 Activate Brake Speed [RPM]*. If the frequency converter is brought into an alarm condition, that is, overvoltage situation, the mechanical brake immediately cuts in. This is also the case during Safe Torque Off.

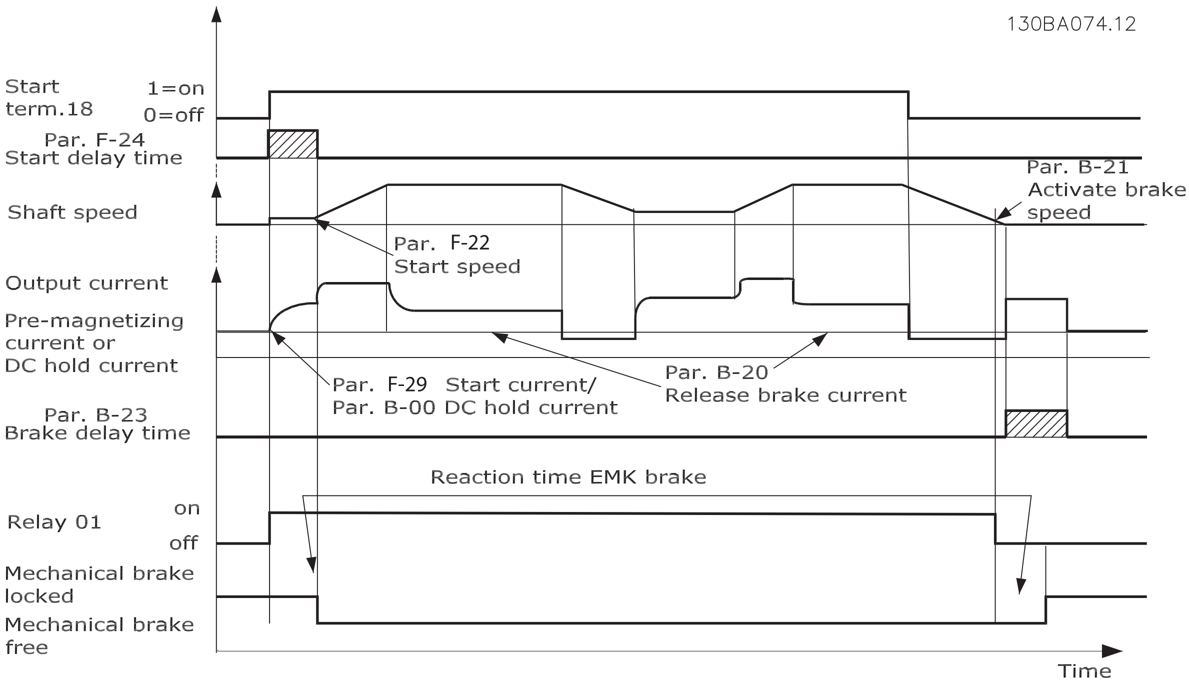


Illustration 6.23 Mechanical Brake Control in Open Loop

In hoisting/lowering applications, it must be possible to control an electromechanical brake.

Step-by-step description

- To control the mechanical brake, any relay output or digital output (terminal 27 or 29) can be used. If necessary, use a suitable contactor.
- Ensure that the output is switched off as long as the frequency converter is unable to drive the motor, for example due to the load being too heavy or as the motor has not been mounted yet.
- Select *[32] Mechanical brake control* in parameter groups E-2# before connecting the mechanical brake.
- The brake is released when the motor current exceeds the preset value in *parameter B-20 Release Brake Current*.
- The brake is engaged when the output frequency is less than the frequency set in *parameter B-21 Activate Brake Speed [RPM]* or *parameter B-22 Activate Brake Speed [Hz]* and only if the frequency converter carries out a stop command.

NOTICE

For vertical lifting or hoisting applications, it is recommended to ensure that the load can be stopped if there is an emergency or a malfunction of a single part such as a contactor,.
If the frequency converter is in alarm mode or in an overvoltage situation, the mechanical brake cuts in.

NOTICE

For hoisting applications, make sure that the torque limits in *parameter F-40 Torque Limiter (Driving)* and *parameter F-41 Torque Limiter (Braking)* are set lower than the current limit in *parameter F-43 Current Limit*. Also it is recommendable to set *parameter SP-25 Trip Delay at Torque Limit* to "0", *parameter SP-26 Trip Delay at Drive Fault* to "0" and *parameter SP-10 Line failure* to "*[3] Coasting*".

6.6.4 Hoist Mechanical Brake

The General Purpose Drives AF-650 GP features a mechanical brake control designed for hoisting applications. The hoist mechanical brake is activated by option [6] in *parameter F-25 Start Function*. The main difference compared to the regular mechanical brake control, where a relay function monitoring the output current is used, is that the hoist mechanical brake function has direct control over the brake relay. This means that instead of setting a current for release of the brake, the torque applied against the closed brake before release is

defined. Because the torque is defined directly the set-up is more straightforward for hoisting applications.
By using *parameter B-28 Gain Boost Factor* a quicker control when releasing the brake can be obtained. The hoist mechanical brake strategy is based on a 3-step sequence, where motor control and brake release are synchronized in order to obtain the smoothest possible brake release.

3-step sequence

1. **Pre-magnetize the motor**
   In order to ensure that there is a hold on the motor and to verify that it is mounted correctly, the motor is first pre-magnetized.
2. **Apply torque against the closed brake**
   When the load is held by the mechanical brake, its size cannot be determined, only its direction. The moment the brake opens, the load must be taken over by the motor. To facilitate the takeover, a user-defined torque, set in *parameter B-26 Torque Ref*, is applied in hoisting direction. This is used to restore the speed controller that will finally take over the load. In order to reduce wear on the gearbox due to backlash, the torque is acceled.
3. **Release brake**
   When the torque reaches the value set in *parameter B-26 Torque Ref* the brake is released. The value set in *parameter B-25 Brake Release Time* determines the delay before the load is released. In order to react as quickly as possible on the load-step that follows after brake release, the speed-PID control can be boosted by increasing the proportional gain.

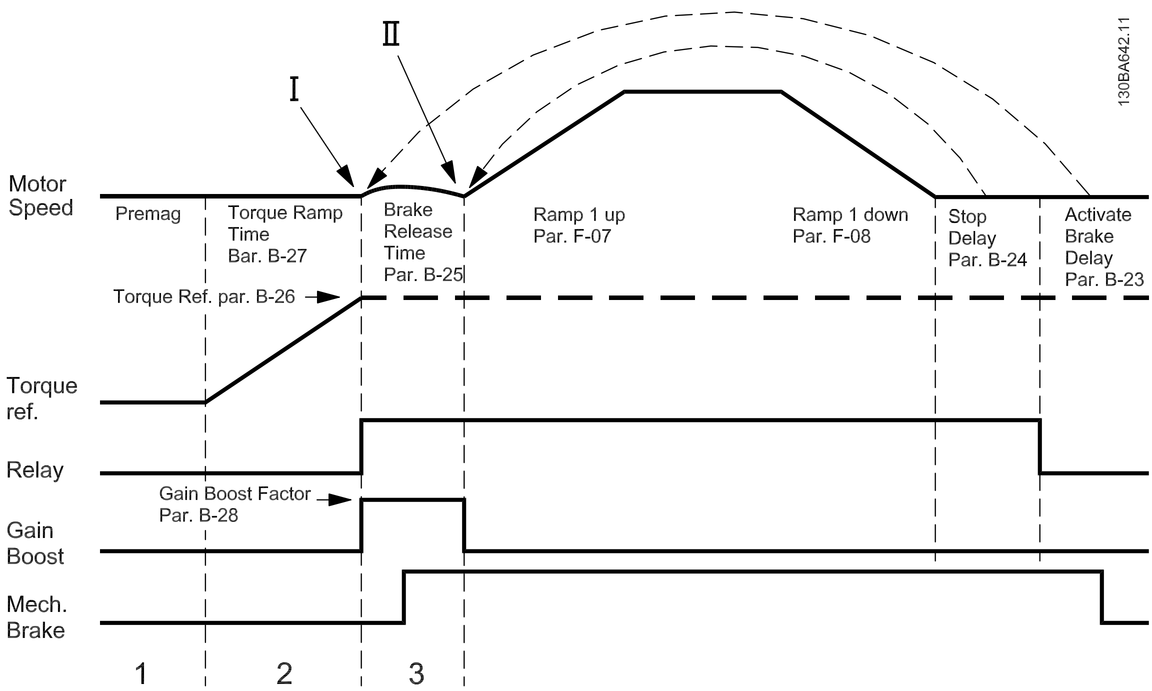


Illustration 6.24 Brake release sequence for hoist mechanical brake control

I) *Activate brake delay:* The frequency converter starts again from the *mechanical brake engaged* position.

II) *Stop delay:* When the time between successive starts is shorter than the setting in *parameter B-24 Stop Delay*, the frequency converter starts without applying the mechanical brake (that is reversing).

NOTICE

For an example of advanced mechanical brake control for hoisting applications, see *chapter 6.2 Application Examples*.

6.7 Logic Control

6.7.1 Logic Control (LC)

Logic Controller (LC) is a sequence of user-defined actions (see *parameter LC-52 Logic Controller Action* [x]) executed by the LC when the associated user-defined event (see *parameter LC-51 Logic Controller Event* [x]) is evaluated as TRUE by the LC.
The condition for an event can be a particular status or that the output from a logic rule or a comparator operand becomes TRUE. That leads to an associated action as shown in *Illustration 6.25*.

Events and actions are each numbered and linked in pairs (states). This means that when event [0] is fulfilled (attains the value TRUE), action [0] is executed. After this, the conditions of event [1] is evaluated and if evaluated TRUE, action [1] is executed, and so on. Only one event is evaluated at any time. If an event is evaluated as FALSE, nothing happens (in the LC) during the current scan interval and no other events are evaluated. This means that when the LC starts, it evaluates event [0] (and only event [0]) each scan interval. Only when event [0] is evaluated TRUE, the LC executes action [0] and starts evaluating event [1]. It is possible to program 1–20 events and actions.
When the last event/action has been executed, the sequence starts over again from event [0]/action [0]. *Illustration 6.25* shows an example with 4 event/actions:

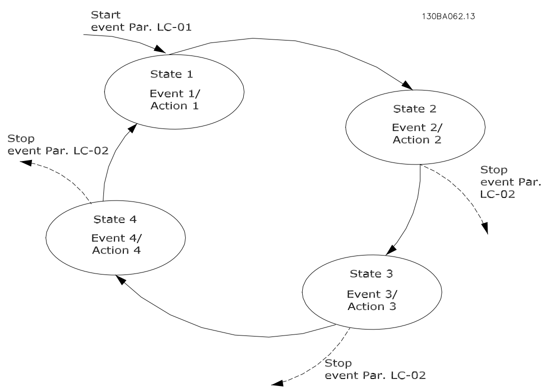


Illustration 6.25 Order of Execution when 4 Events/Actions are Programmed

Comparators
Comparators are used for comparing continuous variables (output frequency, output current, analog input, and so on) to fixed preset values.

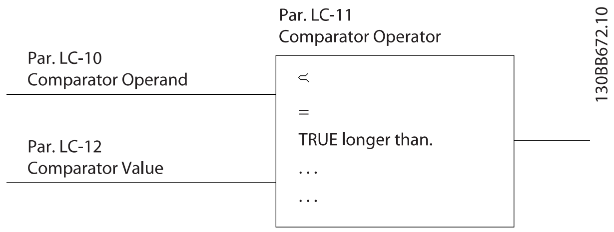


Illustration 6.26 Comparators

Logic rules
Combine up to 3 boolean inputs (TRUE/FALSE inputs) from timers, comparators, digital inputs, status bits, and events using the logical operators AND, OR, and NOT.

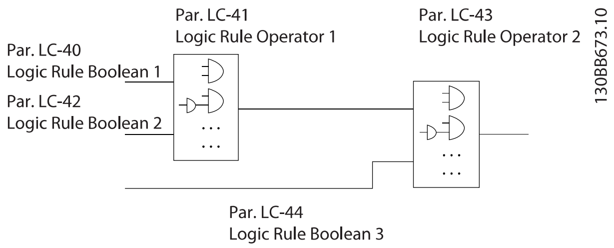


Illustration 6.27 Logic Rules

6.8 Extreme Running Conditions

Short circuit (motor phase – phase)
The frequency converter is protected against short circuits by current measurement in each of the three motor phases or in the DC link. A short circuit between two output phases causes an overcurrent in the inverter. The inverter is turned off individually when the short circuit current exceeds the permitted value (Alarm 16 Trip Lock).

Switching on the output
Switching on the output between the motor and the frequency converter is fully permitted. Switching on the output does not damage the frequency converter in any way. However, fault messages may appear.

Motor-generated overvoltage
The voltage in the DC link is increased when the motor acts as a generator.

This occurs in following cases:

1. The load drives the motor (at constant output frequency from the frequency converter), i.e. the load generates energy.
2. During deceleration if the moment of inertia is high, the friction is low and the decel time is too short for the energy to be dissipated as a loss in the frequency converter, the motor, and the installation.
3. Incorrect slip compensation setting may cause higher DC-link voltage.

See *parameter B-10 Brake Function* and *parameter B-17 Over-voltage Control* to select the method used for controlling the DC-link voltage level.

Mains drop-out

During a mains drop-out, the frequency converter keeps running until the DC-link voltage drops below the minimum stop level, which is typically 15% below the frequency converter's lowest rated supply voltage. The mains voltage before the drop-out and the motor load determines how long it takes for the inverter to coast.

Static overload in Advanced Vector Control mode

When the frequency converter is overloaded (the torque limit in *parameter F-40 Torque Limiter (Driving)*/ *parameter F-41 Torque Limiter (Braking)* is reached), the control reduces the output frequency to reduce the load. If the overload is excessive, a current may occur that makes the frequency converter cut out after approximately 5–10 s.

Operation within the torque limit is limited in time (0–60 s) in *parameter SP-25 Trip Delay at Torque Limit*.

6.9 Motor Thermal Protection

To protect the application from serious damages General Purpose Drives offers several dedicated features

Torque Limit: The torque limit feature the motor is protected for being overloaded independent of the speed. Torque limit is controlled in *parameter F-40 Torque Limiter (Driving)* and or *parameter F-41 Torque Limiter (Braking)* and the time before the torque limit warning shall trip is controlled in *parameter SP-25 Trip Delay at Torque Limit*.

Current Limit: The current limit is controlled in *parameter F-43 Current Limit* and the time before the current limit warning shall trip is controlled in *parameter SP-24 Trip Delay at Current Limit*.

Min Speed Limit: (*parameter F-18 Motor Speed Low Limit [RPM]* or *parameter F-16 Motor Speed Low Limit [Hz]*) limit the operating speed range to for instance between 30 and 50/60Hz. Max Speed Limit: (*parameter F-17 Motor Speed High Limit [RPM]* or *parameter F-03 Max Output Frequency 1*) limit the maximum output speed the frequency converter can provide

Electronic Thermal Overload: The frequency converter Electronic Thermal Overload function measures actual current, speed, and time to calculate motor temperature and protect the motor from being overheated (Warning or trip). An external thermistor input is also available. Electronic Thermal Overload is an electronic feature that simulates a bimetal relay based on internal measurements. The characteristic is shown in *Illustration 6.28*:

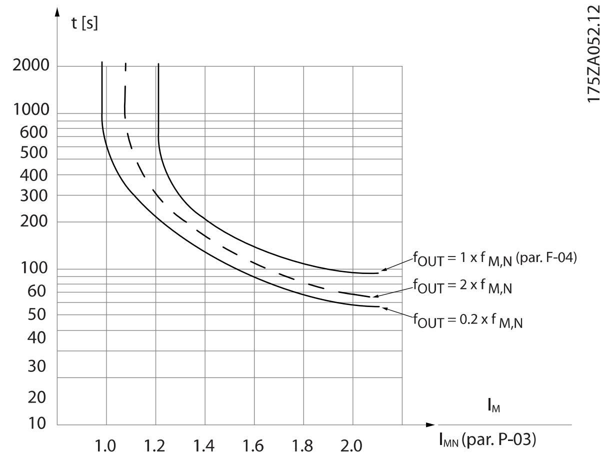


Illustration 6.28 Electronic Thermal Overload: The X-axis shows the ratio between I_{motor} and I_{motor} nominal. The Y- axis shows the time in seconds before the Electronic Thermal Overload cut of and trips the frequency converter. The curves show the characteristic nominal speed, at twice the nominal speed and at 0.2 x the nominal speed.

At lower speed the Electronic Thermal Overload cuts of at lower heat due to less cooling of the motor. In that way, the motor are protected from being over heated even at low speed.

6.10 Safe Torque Off

For information about Safe Torque Off, refer to the *Safe Torque Off Operating Instructions*.

6.11 Certificates

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Product Service

CERTIFICATE

No. Z10 15 12 94536 001

Holder of Certificate: **GE Power Controls Ibérica, S.L.**
Avda. Cámara de Industria 9
28938 Móstoles
SPAIN

Factory(ies): 82282, 83010

Certification Mark:

Product: **Safety components**
AC Frequency Converter

Model(s): **AF-650-GP**

Parameters:

Supply Voltage:	200-690 VAC
Power Output:	0,25 kW – 1,2 MW
Safety Parameters:	SIL 2 (IEC 61508, EN 61800-5-2) SIL CL 2 (EN 62061) Cat 3, PL d (EN ISO 13849-1)
Safety Function:	Safe Torque Off (STO) according to EN 61800-5-2

The report GM87986C and the user manuals in the currently valid revisions are mandatory parts of this certificate.

Tested according to:
IEC 61508-1(ed.2)
IEC 61508-2(ed.2)
EN ISO 13849-1:2008/AC:2009
EN 62061:2005/A1:2013
EN 61800-5-2:2007

The product was tested on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition the certification holder must not transfer the certificate to third parties. See also notes overleaf.

Test report no.: GM87986C

Valid until: 2020-12-15

Date, 2015-12-18

(Jürgen Blum)

685203

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TÜV SÜD Product Service GmbH · Zertifizierstelle · Ridlerstraße 65 · 80339 München · Germany

TÜV®

Illustration 6.29 TÜV Certificate

7 Installation Consideration

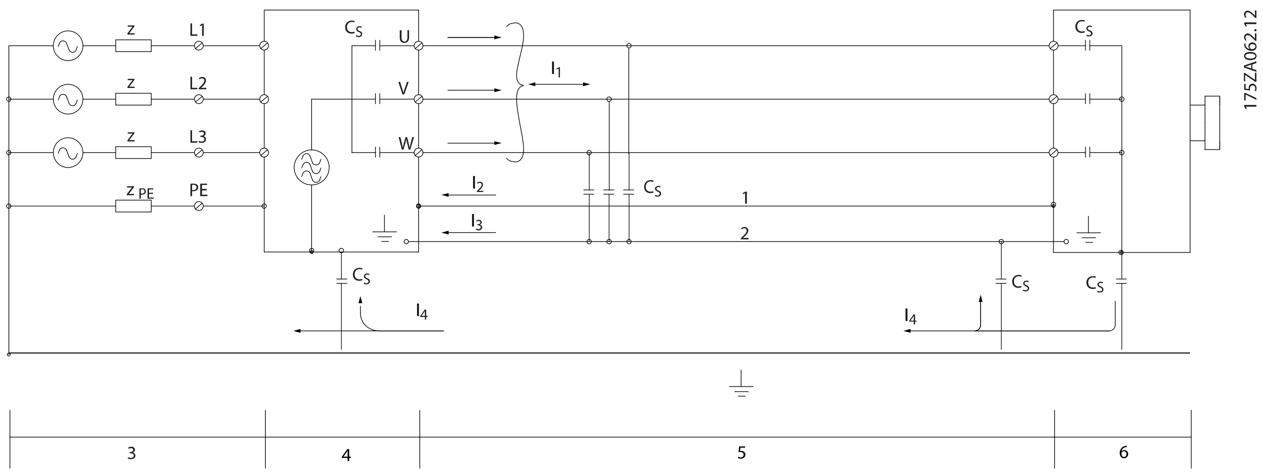
7.1 General Aspects of EMC

7.1.1 General Aspects of EMC Emissions

Burst transient is conducted at frequences in the range 150 kHz to 30 MHz. Airborne interference from the frequency converter system in the range 30 MHz to 1 GHz is generated from the inverter, motor cable, and the motor.
Capacitive currents in the motor cable coupled with a high dU/dt from the motor voltage generate leakage currents.
The use of a shielded motor cable increases the leakage current (see *Illustration 7.1*) because shielded cables have higher capacitance to ground than unshielded cables. If the leakage current is not filtered, it causes greater interference on the mains in the radio frequency range below approximately 5 MHz. Since the leakage current (I_1) is carried back to the unit through the shield (I_3), there is only a small electro-magnetic field (I_4) from the shielded motor cable.

The shield reduces the radiated interference but increases the low-frequency interference on the mains. The motor cable screen must be connected to the frequency converter enclosure and to the motor enclosure. This is best done by using integrated shield clamps to avoid twisted shield ends (pigtails). These increase the shield impedance at higher frequencies, which reduces the shield effect and increases the leakage current (I_4).
If a shielded cable is used for networknetwork, relay, control cable, signal interface, and brake, the shield must be mounted on the enclosure at both ends. In some situations, however, it is necessary to break the shield to avoid current loops.

7



1	Ground wire
2	Shield
3	AC mains supply
4	Frequency converter
5	Shielded motor cable
6	Motor

Illustration 7.1 EMC Emission

If the shield is to be placed on a mounting plate for the frequency converter, the mounting plate must be made of metal, because the shield currents have to be conveyed back to the unit. Moreover, ensure good electrical contact from the mounting plate through the mounting screws to the frequency converter chassis.

When unshielded cables are used, some emission requirements are not complied with, although the immunity requirements are observed.

To reduce the interference level from the entire system (unit + installation), make motor and brake cables as short as possible. Avoid placing cables with a sensitive signal level alongside motor and brake cables. Radio interference higher than 50 MHz (airborne) is especially generated by the control electronics.

7.1.2 Emission Requirements

According to the EMC product standard for adjustable speed frequency converters EN/IEC61800-3:2004 the EMC requirements depend on the intended use of the frequency converter. Four categories are defined in the EMC product standard. The definitions of the four categories together with the requirements for mains supply voltage conducted emissions are given in *Table 7.1*:

Category	**Definition**	**Conducted emission requirement according to the limits given in EN 55011**
C1	Frequency converters installed in the first environment (home and office) with a supply voltage less than 1000 V.	Class B
C2	Frequency converters installed in the first environment (home and office) with a supply voltage less than 1000 V, which are neither plug-in nor movable and are intended to be installed and commissioned by a professional.	Class A Group 1
C3	Frequency converters installed in the second environment (industrial) with a supply voltage lower than 1000 V.	Class A Group 2
C4	Frequency converters installed in the second environment with a supply voltage equal to or above 1000 V or rated current equal to or above 400 A or intended for use in complex systems.	No limit line. An EMC plan should be made.

Table 7.1 Categories

When the generic emission standards are used, the frequency converters are required to comply with the limits in *Table 7.2*:

Environment	**Generic standard**	**Conducted emission requirement according to the limits given in EN 55011**
First environment (home and office)	EN/IEC61000-6-3 Emission standard for residential, commercial, and light industrial environments.	Class B
Second environment (industrial environment)	EN/IEC61000-6-4 Emission standard for industrial environments.	Class A Group 1

Table 7.2 Limits

7.1.3 EMC Test Results (Emission)

The following test results have been obtained using a system with a frequency converter (with options if relevant), a shielded control cable, a control box with potentiometer, and a motor and motor shielded cable.

RFI filter type	Conducted emission Maximum shielded cable length			Radiated emission	
	Industrial environment		Housing, trades, and light industries	Industrial environment	Housing, trades, and light industries
Standard	EN 55011 Class A2	EN 55011 Class A1	EN 55011 Class B	EN 55011 Class A1	EN 55011 Class B
Class A1/B RFI Filter installed					
0.75–45 kW 200–240 V	150 m	150 m	50 m	Yes	No
0.75–90 kW 380–500 V	150 m	150 m	50 m	Yes	No
Class A2 RFI Filter installed					
0.75–3.7 kW 200–240 V	5 m	No	No	No	No
5.5–37 kW 200–240 V	25 m	No	No	No	No
0.75–7.5 kW 380–500 V	5 m	No	No	No	No
11–75 kW 380–500 V	25 m	No	No	No	No
90–800 kW 380–500 V	150 m	No	No	No	No
90–1200 kW 525–690 V	150 m	No	No	No	No
No RFI Filter installed					
0.75–75 kW 525–600 V	–	–	–	–	–

Table 7.3 EMC Test Results (Emission)

7.2 Immunity Requirements

The immunity requirements for frequency converters depend on the environment where they are installed. The requirements for the industrial environment are higher than the requirements for the home and office environment. All GE frequency converters comply with the requirements for the industrial environment and therefore comply also with the lower requirements for home and office environment with a large safety margin.

In order to document immunity against burst transient from electrical phenomena, the following immunity tests have been made on a system consisting of a frequency converter (with options if relevant), a shielded control cable and a control box with potentiometer, motor cable, and motor.

The tests were performed in accordance with the following basic standards:

- **EN 61000-4-2 (IEC 61000-4-2):** Electrostatic discharges (ESD): Simulation of electrostatic discharges from human beings.
- **EN 61000-4-3 (IEC 61000-4-3):** Incoming electromagnetic field radiation, amplitude modulated simulation of the effects of radar and radio communication equipment and mobile communications equipment.
- **EN 61000-4-4 (IEC 61000-4-4):** Burst transients: Simulation of interference brought about by switching a contactor, relay, or similar devices.
- **EN 61000-4-5 (IEC 61000-4-5):** Surge transients: Simulation of transients brought about for example, by lightning that strikes near installations.
- **EN 61000-4-6 (IEC 61000-4-6):** RF Common mode: Simulation of the effect from radio-transmission equipment joined by connection cables.

See *Table 7.4*.

Voltage range: 200–240 V, 380–500 V					
Basic standard	**Burst IEC 61000-4-4**	**Surge IEC 61000-4-5**	**ESD IEC 61000-4-2**	**Radiated electromagnetic field IEC 61000-4-3**	**RF common mode voltage IEC 61000-4-6**
Acceptance criterion	**B**	**B**	**B**	**A**	**A**
Line	4 kV CM	2 kV/2 Ω DM 4 kV/12 Ω CM	—	—	10 V_{RMS}
Motor	4 kV CM	4 kV/2 Ω[1)]	—	—	10 V_{RMS}
Brake	4 kV CM	4 kV/2 Ω[1)]	—	—	10 V_{RMS}
Load sharing	4 kV CM	4 kV/2 Ω[1)]	—	—	10 V_{RMS}
Control wires	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
Standard bus	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
Relay wires	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
Application and network options	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
Keypad cable	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
External 24 V DC	2 kV CM	0.5 kV/2 Ω DM 1 kV/12 Ω CM	—	—	10 V_{RMS}
Enclosure	—	—	8 kV AD 6 kV CD	10 V/m	—
AD: Air Discharge CD: Contact Discharge CM: Common mode DM: Differential mode 1) Injection on cable shield.					

Table 7.4 EMC Immunity Form

7.3 General Aspects of Harmonics Emission

A frequency converter takes up a non-sinusoidal current from mains, which increases the input current I_{RMS}. A non-sinusoidal current is transformed with a Fourier analysis and split up into sine-wave currents with different frequencies, that is, different harmonic currents I_N with 50 Hz as the basic frequency:

Harmonic currents	I_1	I_5	I_7
Hz	50 Hz	250 Hz	350 Hz

Table 7.5 Harmonics Emission

The harmonics do not affect the power consumption directly but increase the heat losses in the installation (transformer, cables). So, in plants with a high percentage of rectifier load, maintain harmonic currents at a low level to avoid overload of the transformer and high temperature in the cables.

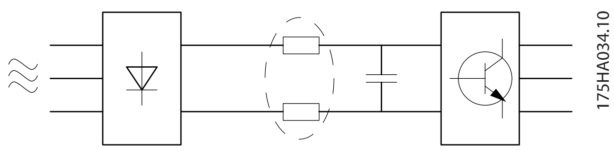


Illustration 7.2 Harmonics

NOTICE

Some of the harmonic currents might disturb communication equipment connected to the same transformer or cause resonance with power factor correction batteries.

To ensure low harmonic currents, the frequency converter is equipped with DC link coils as standard. This normally reduces the input current I_{RMS} by 40%.

The voltage distortion on the mains supply voltage depends on the size of the harmonic currents multiplied by the mains impedance for the frequency in question. The total voltage distortion THD is calculated based on the individual voltage harmonics using this formula:

$$THD\% = \sqrt{U_5^2 + U_7^2 + ... + U_N^2}$$

(U_N% of U)

7.3.1 Harmonics Emission Requirements

Equipment connected to the public supply network:

Options	Definition
1	IEC/EN 61000-3-2 Class A for 3-phase balanced equipment (for professional equipment only up to 1 kW total power).
2	IEC/EN 61000-3-12 Equipment 16A-75A and professional equipment as from 1 kW up to 16A phase current.

Table 7.6 Connected Equipment

7.3.2 Harmonics Test Results (Emission)

Power sizes from 0.75 kW and up to 18.5 kW in 200 V and up to 90 kW in 460 V complies with IEC/EN 61000-3-12, Table 4. Power sizes 110–450 kW in 460 V also complies with IEC/EN 61000-3-12 even though not required because currents are above 75 A.

If the short circuit power of the supply S_{sc} is greater than or equal to:

$$S_{SC} = \sqrt{3} \times R_{SCE} \times U_{mains} \times I_{equ} = \sqrt{3} \times 120 \times 400 \times I_{equ}$$

at the interface point between the user's supply and the public system (R_{sce}).

It is the responsibility of the installer or user of the equipment to ensure, by consultation with the distribution network operator if necessary, that the equipment is connected only to a supply with a short circuit power S_{sc} greater than or equal to the above specified .
Other power sizes can be connected to the public supply network by consultation with the distribution network operator.

Compliance with various system level guidelines:
The harmonic current data in the table are given in accordance with IEC/EN61000-3-12 regarding the Power Drive Systems product standard. They may be used as the basis for calculation of the harmonic currents' influence on the power supply system and for the documentation of compliance with relevant regional guidelines: IEEE 519 -1992; G5/4.

7.4 Galvanic Isolation (PELV)

7.4.1 PELV - Protective Extra Low Voltage

PELV offers protection by way of extra low voltage. Protection against electric shock is ensured when the electrical supply is of the PELV type and the installation is made as described in local/national regulations on PELV supplies.

All control terminals and relay terminals 01-03/04-06 comply with PELV (Protective Extra Low Voltage) (Does not apply to grounded Delta leg above 400 V).

Galvanic (ensured) isolation is obtained by fulfilling requirements for higher isolation and by providing the relevant creapage/clearance distances. These requirements are described in the EN 61800-5-1 standard.

The components that make up the electrical isolation, as described below, also comply with the requirements for higher isolation and the relevant test as described in EN 61800-5-1.
The PELV galvanic isolation can be shown in six locations (see *Illustration 7.3*):

In order to maintain PELV all connections made to the control terminals must be PELV, for example, thermistor must be reinforced/double insulated.

1. Power supply (SMPS) incl. signal isolation of U_{DC}, indicating the intermediate current voltage.
2. Gate drive that runs the IGBTs (trigger transformers/opto-couplers).
3. Current transducers.
4. Opto-coupler, brake module.
5. Internal inrush, RFI, and temperature measurement circuits.
6. Custom relays.

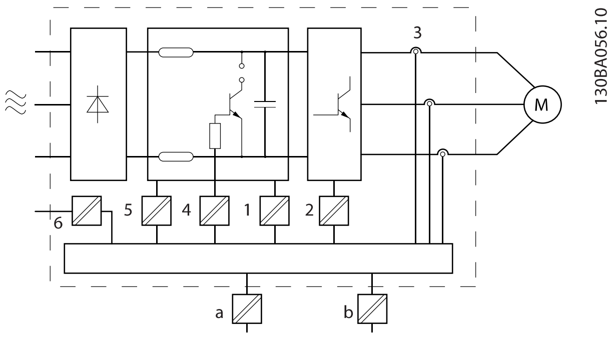


Illustration 7.3 Galvanic Isolation

The functional galvanic isolation (a and b on drawing) is for the 24 V back-up option and for the RS485 standard bus interface.

WARNING

Installation at high altitude:
380–500 V, unit size 1x, 2x and 3x: At altitudes above 2 km, contact GE regarding PELV.
380–500 V, unit size 4x, 4xh, 5x and 6x: At altitudes above 3 km, contact GE regarding PELV.
525–690 V: At altitudes above 2 km, contact GE regarding PELV.

7.5 Derating

7.5.1 Purpose of Derating

Derating must be taken into account when using the frequency converter at low air pressure (heights), at low speeds, with long motor cables, cables with a large cross-section or at high ambient temperature. The required action is described in this section.

7.5.2 Derating for Ambient Temperature

90% frequency converter output current can be maintained up to maximum 50 °C ambient temperature.

With a typical full load current of EFF 2 motors, full output shaft power can be maintained up to 50 °C.
For more specific data and/or derating information for other motors or conditions, contact GE.

7.5.3 Automatic Adaptations to Ensure Performance

The frequency converter constantly checks for critical levels of internal temperature, load current, high voltage on the intermediate circuit, and low motor speeds. As a response to a critical level, the frequency converter can adjust the switching frequency and/or change the switching pattern in order to ensure the performance of the frequency converter. The capability to automatically reduce the output current extends the acceptable operating conditions even further.

7.5.4 Derating for Low Air Pressure

The cooling capability of air is decreased at lower air pressure.

Below 1000 m altitude no derating is necessary but above 1000 m the ambient temperature (T_{AMB}) or max. output current (I_{out}) should be derated in accordance with the shown diagram.

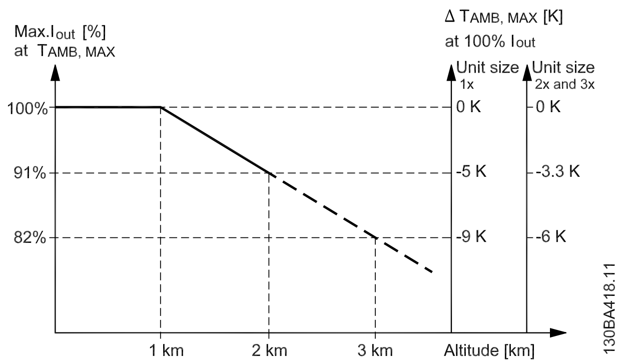


Illustration 7.4 Derating of output current versus altitude at $T_{AMB, MAX}$ for unit sizes 1x, 2x, and 3x. At altitudes above 2 km, contact GE regarding PELV.

An alternative is to lower the ambient temperature at high altitudes and as a result of that ensure 100% output current at high altitudes. As an example of how to read the graph, the situation at 2 km is elaborated. At a temperature of 45 °C ($T_{AMB, MAX}$ - 3.3 K), 91% of the rated output current is available. At a temperature of 41.7 °C, 100% of the rated output current is available.

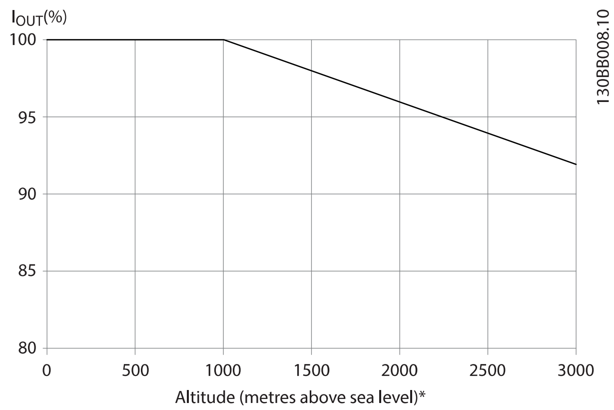


Illustration 7.5 Derating of Output Current versus Altitude at $T_{AMB, MAX}$ for Unit Sizes 4x, 4xh, 5x, and 6x

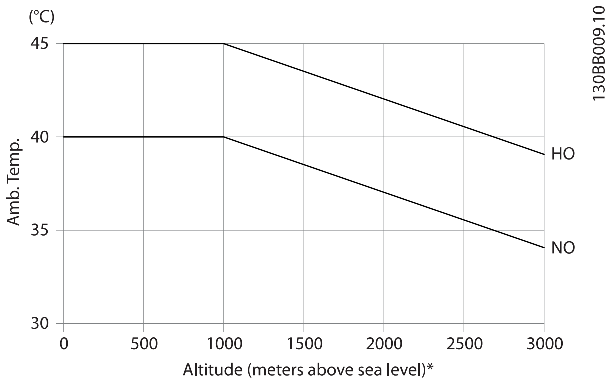


Illustration 7.6 Derating of Output Current versus Altitude at $T_{AMB, MAX}$ for Unit Sizes 4x, 4xh, 5x, and 6x

7.5.5 Derating for Running at Low Speed

When a motor is connected to a frequency converter, it is necessary to check that the cooling of the motor is adequate.
The level of heating depends on the load on the motor, and the operating speed and time.

Constant torque applications (CT mode)
Variable (quadratic) torque applications (VT)
In VT applications such as centrifugal pumps and fans, where the torque is proportional to the square of the speed and the power is proportional to the cube of the speed, there is no need for extra cooling or derating of the motor.

In the graphs in *Illustration 7.7*, the typical VT curve is below the maximum torque with derating and maximum torque with forced cooling at all speeds.

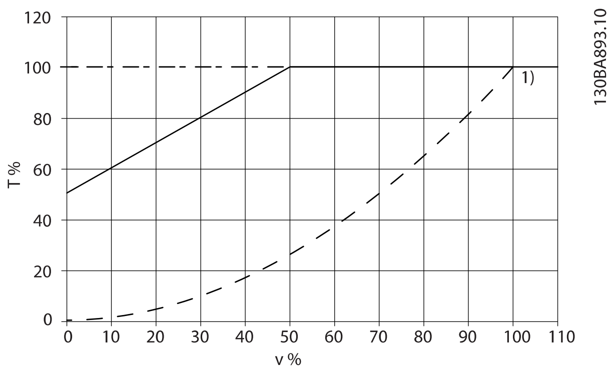


Illustration 7.7 Maximum load for a standard motor at 40 °C driven by a drive

– – – –	Typical torque at VT load
–•–•–•–	Max torque with forced cooling
———	Max torque

Table 7.7 Legend to *Illustration 7.7*

Note 1) Over-syncronous speed operation results in the available motor torque decreasing inversely proportional with the increase in speed. This must be considered during the design phase to avoid over-loading of the motor.

7.6 Motor Insulation

For motor cable lengths ≤ the maximum cable length listed in the General Specifications tables the following motor insulation ratings are recommended because the peak voltage can be up to twice the DC-link voltage, 2.8 times the mains voltage, due to transmission line effects in the motor cable. If a motor has lower insulation rating, it is recommended to use a dU/dt or sine-wave filter.

Nominal Mains Voltage	Motor Insulation
U_N ≤ 420 V	Standard U_{LL} = 1300 V
420 V < U_N ≤ 500 V	Reinforced U_{LL} = 1600 V
500 V < U_N ≤ 600 V	Reinforced U_{LL} = 1800 V
600 V < U_N ≤ 690 V	Reinforced U_{LL} = 2000 V

Table 7.8 Motor Insulation

7.7 Motor Bearing Currents

All motors installed with 150 hp or higher power frequency converters should have NDE (Non-Drive End) insulated bearings installed to eliminate circulating bearing currents. To minimize DE (Drive End) bearing and shaft currents proper grounding of the frequency converter, motor, driven machine, and motor to the driven machine is required.

Standard mitigation strategies:

1. Use an insulated bearing.
2. Apply rigorous installation procedures
   - 2a Ensure that the motor and load motor are aligned.
   - 2b Strictly follow the EMC Installation guideline.
   - 2c Reinforce the PE so the high frequency impedance is lower in the PE than the input power leads.
   - 2d Provide a good high frequency connection between the motor and the frequency converter for instance by shielded cable which has a 360° connection in the motor and the frequency converter.

7

2e Make sure that the impedance from frequency converter to building ground is lower that the grounding impedance of the machine. This can be difficult for pumps.

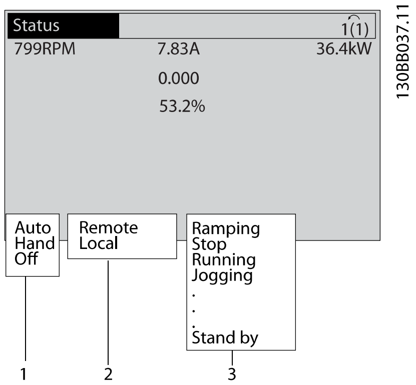
2f Make a direct ground connection between the motor and load motor.

3. Lower the IGBT switching frequency.
4. Modify the inverter waveform, 60° AVM vs. SFAVM.
5. Install a shaft grounding system or use an isolating coupling.
6. Apply conductive lubrication.
7. Use minimum speed settings if possible.
8. Try to ensure that the line voltage is balanced to ground. This can be difficult for IT, TT, TN-CS, or Grounded leg systems.
9. Use a dU/dt or sinus filter.

8 Status Messages

8.1 Status Display

When the frequency converter is in *Status mode*, status messages are generated automatically and appear in the bottom line of the display (see *Illustration 8.1*).



1	Operating mode (see *Table 8.1*)
2	Reference site (see *Table 8.2*)
3	Operation status (see *Table 8.3*)

Illustration 8.1 Status Display

8.2 Status Message Definitions

Table 8.1 to *Table 8.3* describe the shown status messages.

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

Table 8.1 Operating mode

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

Table 8.2 Reference Site

AC Brake	AC Brake was selected in *parameter B-10 Brake Function*. The AC brake over-magnetizes the motor to achieve a controlled slow down.
Auto Tune finish OK	Auto Tune was carried out successfully.
Auto Tune ready	Auto Tune is ready to start. Press [Hand] to start.
Auto Tune running	Auto Tune process is in progress.
Coast	• Coast inverse was selected as a function for a digital input. The corresponding terminal is not connected. • Coast activated by serial communication
Ctrl. Decel	Ctrl. Decel was selected in *parameter SP-10 Line failure*. • The mains voltage is below the value set in *parameter SP-11 Line Voltage at Input Fault* at mains fault • The frequency converter ramps down the motor using a controlled ramp down
Current High	The frequency converter output current is above the limit set in *parameter H-71 Warning Current High*.
Current Low	The frequency converter output current is below the limit set in *parameter H-70 Warning Current Low*
DC Hold	DC hold is selected in *parameter H-80 Function at Stop* and a stop command is active. The motor is held by a DC current set in *parameter B-00 DC Hold Current*.
DC Stop	The motor is held with a DC current (*parameter B-01 DC Brake Current*) for a specified time (*parameter B-02 DC Braking Time*). • DC brake is activated in *parameter B-03 DC Brake Cut In Speed [RPM]* and a stop command is active. • DC brake (inverse) is selected as a function for a digital input. The corresponding terminal is not active. • The DC brake is activated via serial communication.
Feedback high	The sum of all active feedbacks is above the feedback limit set in *parameter H-77 Warning Feedback High*.
Feedback low	The sum of all active feedbacks is below the feedback limit set in *parameter H-76 Warning Feedback Low*.

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Freeze output	The remote reference is active, which holds the present speed. • Freeze output was selected as a function for a digital input. The corresponding terminal is active. Speed control is only possible via the terminal functions speed up and speed down. • Hold ramp is activated via serial communication.
Freeze output request	A freeze output command has been given, but the motor remains stopped until a run permissive signal is received.
Freeze ref.	*Freeze Reference* was selected as a function for a digital input. The corresponding terminal is active. The frequency converter saves the actual reference. Changing the reference is now only possible via terminal functions speed up and speed down.
Jog request	A jog command has been given, but the motor remains stopped until a run permissive signal is received via a digital input.
Jogging	The motor is running as programmed in *parameter C-21 Jog Speed [RPM]*. • *Jog* was selected as function for a digital input. The corresponding terminal is active. • The jog function is activated via the serial communication. • The jog function was selected as a reaction for a monitoring function. The monitoring function is active.
OVC Control	*Overvoltage* control was activated in *parameter B-17 Over-voltage Control*, *[2] Enabled*. The connected motor supplies the frequency converter with generative energy. The overvoltage control adjusts the V/Hz ratio to run the motor in controlled mode and to prevent the frequency converter from tripping.
Power Unit Off	(Only frequency converters with a 24 V external supply installed). Mains supply to the frequency converter is removed, but the control card is supplied by the external 24 V.
Protection md	Protection mode is active. The unit has detected a critical status (an overcurrent or overvoltage). • To avoid tripping, the switching frequency is reduced to 4 kHz. • If possible, protection mode ends after approximately 10 s. • Protection mode can be restricted in *parameter SP-26 Trip Delay at Drive Fault*.

QStop	The motor is decelerating using *parameter C-23 Quick Stop Decel Time*. • *Quick stop inverse* was selected as a function for a digital input. The corresponding terminal is not active. • The quick stop function was activated via serial communication.
Ramping	The motor is accelerating/decelerating using the active ramp up/down. The reference, a limit value, or a standstill is not yet reached.
Ref. high	The sum of all active references is above the reference limit set in *parameter H-75 Warning Reference High*.
Ref. low	The sum of all active references is below the reference limit set in *parameter H-74 Warning Reference Low*.
Run on ref.	The frequency converter is running in the reference range. The feedback value matches the setpoint value.
Run request	A start command has been given, but the motor is stopped until a run permissive signal is received via digital input.
Running	The frequency converter drives the motor.
Sleep Mode	The energy saving function is enabled. The motor has stopped, but restarts automatically when required.
Speed high	Motor speed is above the value set in *parameter H-73 Warning Speed High*.
Speed low	Motor speed is below the value set in *parameter H-72 Warning Speed Low*.
Standby	In Auto mode, the frequency converter starts the motor with a start signal from a digital input or serial communication.
Start delay	In *parameter F-24 Holding Time*, a delay starting time was set. A start command is activated and the motor starts after the start delay time expires.
Start fwd/rev	Start forward and start reverse were selected as functions for 2 different digital inputs. The motor starts in forward or reverse depending on which corresponding terminal is activated.
Stop	The frequency converter has received a stop command from the keypad, digital input, or serial communication.
Trip	An alarm occurred and the motor is stopped. Once the cause of the alarm is cleared, the frequency converter can be reset manually by pressing [Reset] or remotely by control terminals or serial communication.

Trip lock	An alarm occurred and the motor is stopped. Once the cause of the alarm is cleared, power must be cycled to the frequency converter. The frequency converter can then be reset manually by pressing [Reset] or remotely by control terminals or serial communication.

Table 8.3 Operation Status

NOTICE

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

9 RS485 Installation and Set-up

9.1 Installation and Set-up

9.1.1 Network Connection

One or more frequency converters can be connected to a control (or master) using the RS485 standardized interface. Terminal 68 is connected to the P signal (TX+, RX+), while terminal 69 is connected to the N signal (TX-, RX-).

If more than 1 frequency converter is connected to a master, use parallel connections.

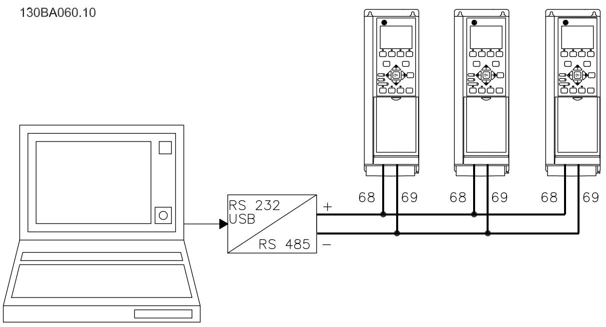

Illustration 9.1 Parallel Connections

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To avoid potential equalizing currents in the shield, wire according to *Illustration 2.5*.

9.1.2 RS485 Bus Termination

Terminate the RS485 bus by a resistor network at both ends. For this purpose, set switch S801 on the control card for "ON".

9.1.3 EMC Precautions

The following EMC precautions are recommended to achieve interference-free operation of the RS485 network.

Observe relevant national and local regulations, for example, regarding protective ground connection. Keep the RS485 communication cable away from motor and brake resistor cables to avoid coupling of high frequency noise from one cable to another. Normally, a distance of 200 mm (8 inches) is sufficient, but keeping the greatest possible distance between the cables is recommended, especially where cables run in parallel over long distances. When crossing is unavoidable, the RS485 cable must cross motor and brake resistor cables at an angle of 90°.

9.2 Network Configuration

To enable Modbus RTU on the frequency converter, set the parameters in *Table 9.1*.

Parameter	Setting
Parameter O-30 Protocol	Modbus RTU
Parameter O-31 Address	1–247
Parameter O-32 Drive Port Baud Rate	2400–115200
Parameter O-33 Drive Port Parity	Even parity, 1 stop bit (default)

Table 9.1 Modbus RTU Parameters

9.2.1 Modbus RTU Message Framing Structure

The controllers are set up to communicate on the Modbus network using RTU (Remote Terminal Unit) mode, with each byte in a message containing 2 4 bit hexadecimal characters. The format for each byte is shown in *Table 9.2*.

Start bit	Data byte								Stop/ parity	Stop

Table 9.2 Format for Each Byte

Coding System	8-bit binary, hexadecimal 0–9, A-F. 2 hexadecimal characters contained in each 8-bit field of the message
Bits Per Byte	1 start bit 8 data bits, least significant bit sent first 1 bit for even/odd parity; no bit for no parity 1 stop bit if parity is used; 2 bits if no parity
Error Check Field	Cyclic Redundancy Check (CRC)

Table 9.3 Formats

9.2.2 Modbus RTU Message Structure

The transmitting device places a Modbus RTU message into a frame with a known beginning and ending point. This allows receiving devices to begin at the start of the message, read the address portion, determine which device is addressed (or all devices, if the message is broadcast), and to recognize when the message is completed. Partial messages are detected and errors set as a result. Characters for transmission must be in hexadecimal 00 to FF format in each field. The frequency converter continuously monitors the network bus, also during 'silent' intervals. When the first field (the address field) is received, each frequency converter or device decodes it to determine which device is being addressed. Modbus RTU messages addressed to zero are broadcast messages. No response is permitted for broadcast messages. A typical message frame is shown in *Table 9.4*.

Start	Address	Function	Data	CRC check	End
T1-T2-T3-T4	8 bits	8 bits	N x 8 bits	16 bits	T1-T2-T3-T4

Table 9.4 Typical Modbus RTU Message Structure

9.2.2.1 Start/Stop Field

Messages start with a silent period of at least 3.5 character intervals. This is implemented as a multiple of character intervals at the selected network baud rate (shown as Start T1-T2-T3-T4). The first field to be transmitted is the device address. Following the last transmitted character, a similar period of at least 3.5 character intervals marks the end of the message. A new message can begin after this period. The entire message frame must be transmitted as a continuous stream. If a silent period of more than 1.5 character intervals occurs before completion of the frame, the receiving device flushes the incomplete message and assumes that the next byte is the address field of a new message. Similarly, if a new message begins prior to 3.5 character intervals after a previous message, the receiving device will consider it a continuation of the previous message. This causes a timeout (no response from the slave), since the value in the final CRC field is not valid for the combined messages.

9.2.2.2 Address Field

The address field of a message frame contains 8 bits. Valid slave device addresses are in the range of 0–247 decimal. The individual slave devices are assigned addresses in the range of 1–247. (0 is reserved for broadcast mode, which all slaves recognize.) A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response, it places its own address in this address field to let the master know which slave is responding.

9.2.2.3 Function Field

The function field of a message frame contains 8 bits. Valid codes are in the range of 1-FF. Function fields are used to send messages between master and slave. When a message is sent from a master to a slave device, the function code field tells the slave what kind of action to perform. When the slave responds to the master, it uses the function code field to indicate either a normal (error-free) response, or that some kind of error occurred (called an exception response). For a normal response, the slave simply echoes the original function code. For an exception response, the slave returns a code that is equivalent to the original function code with its most significant bit set to logic 1. In addition, the slave places a unique code into the data field of the response message. This tells the master what kind of error occurred, or the reason for the exception.

Function	Function code
Read coils	1 hex
Read holding registers	3 hex
Write single coil	5 hex
Write single register	6 hex
Write multiple coils	F hex
Write multiple registers	10 hex
Get comm. event counter	B hex
Report slave ID	11 hex

Table 9.5

Function	Function code	Subfunction code	Subfunction
Diagnostics	8	1	Restart communication
		2	Return diagnostic register
		10	Clear counters and diagnostic register
		11	Return bus message count
		12	Return bus communication error count
		13	Return bus exception error count
		14	Return slave message count

Table 9.6

Code	Name	Meaning
1	Illegal function	The function code received in the query is not an allowable action for the server (or slave). This may be because the function code is only applicable to newer devices, and was not implemented in the unit selected. It could also indicate that the server (or slave) is in the wrong state to process a request of this type, for example because it is not configured and is being asked to return register values.
2	Illegal data address	The data address received in the query is not an allowable address for the server (or slave). More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, a request with offset 96 and length 4 would succeed, a request with offset 96 and length 5 generates exception 02.

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Code	Name	Meaning
3	Illegal data value	A value contained in the query data field is not an allowable value for server (or slave). This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does NOT mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the Modbus protocol is unaware of the significance of any particular value of any particular register.
4	Slave device failure	An unrecoverable error occurred while the server (or slave) was attempting to perform the requested action.

Table 9.7 Modbus Exception Codes

9.2.2.4 Data Field

The data field is constructed using sets of two hexadecimal digits, in the range of 00 to FF hexadecimal. These are made up of one RTU character. The data field of messages sent from a master to slave device contains additional information which the slave must use to take the action defined by the function code. This can include items such as coil or register addresses, the quantity of items to be handled, and the count of actual data bytes in the field.

9.2.2.5 CRC Check Field

Messages include an error-checking field, operating based on a Cyclic Redundancy Check (CRC) method. The CRC field checks the contents of the entire message. It is applied regardless of any parity check method used for the individual characters of the message. The CRC value is calculated by the transmitting device, which appends the CRC as the last field in the message. The receiving device recalculates a CRC during receipt of the message and compares the calculated value to the actual value received in the CRC field. If the two values are unequal, a bus timeout results. The error-checking field contains a 16-bit binary value implemented as two 8-bit bytes. When this is done, the low-order byte of the field is appended first, followed by the high-order byte. The CRC high-order byte is the last byte sent in the message.

9.2.3 Register Addressing

In Modbus, all data are organised in coils and holding registers. Coils hold a single bit, whereas holding registers hold a 2-byte word (i.e. 16 bits). All data addresses in Modbus messages are referenced to zero. The first occurrence of a data item is addressed as item number zero. For example: The coil known as ‘coil 1’ in a programmable controller is addressed as coil 0000 in the data address field of a Modbus message. Coil 127 decimal is addressed as coil 007EHEX (126 decimal).
Holding register 40001 is addressed as register 0000 in the data address field of the message. The function code field already specifies a ‘holding register’ operation. Therefore, the ‘4XXXX’ reference is implicit. Holding register 40108 is addressed as register 006BHEX (107 decimal).

Coil number	Description	Signal direction
1–16	Frequency converter control word	Master to slave
17–32	Frequency converter speed or set-point reference Range 0x0 – 0xFFFF (-200% ... ~200%)	Master to slave
33–48	Frequency converter status word (see *Table 9.10*)	Follower to slave
49–64	Open loop mode: Frequency converter output frequency Closed loop mode: Frequency converter feedback signal	Follower to slave
65	Parameter write control (master to slave)	Master to slave
	0 = Parameter changes are written to the RAM of the frequency converter	
	1 = Parameter changes are written to the RAM and EEPROM of the frequency converter.	
66–65536	Reserved	

Table 9.8 Coil Descriptions

Coil	0	1
01	Preset reference LSB	
02	Preset reference MSB	
03	DC brake	No DC brake
04	Coast stop	No coast stop
05	Quick stop	No quick stop
06	Freeze freq.	No freeze freq.
07	Ramp stop	Start
08	No reset	Reset
09	No jog	Jog
10	Ramp 1	Ramp 2
11	Data not valid	Data valid
12	Relay 1 off	Relay 1 on
13	Relay 2 off	Relay 2 on
14	Set up LSB	
15	Set up MSB	
16	No reversing	Reversing

Table 9.9 Frequency Converter Control Word (Drive Profile)

Coil	0	1
33	Control not ready	Control ready
34	Frequency converter not ready	Frequency converter ready
35	Coasting stop	Safety closed
36	No alarm	Alarm
37	Not used	Not used
38	Not used	Not used
39	Not used	Not used
40	No warning	Warning
41	Not at reference	At reference
42	Hand mode	Auto mode
43	Out of freq. range	In frequency range
44	Stopped	Running
45	Not used	Not used
46	No voltage warning	Voltage warning
47	Not in current limit	Current limit
48	No thermal warning	Thermal warning

Table 9.10 Frequency Converter Status Word (Drive Profile)

Register number	Description
00001–00006	Reserved
00007	Last error code from an Drive data object interface
00008	Reserved
00009	Parameter index*
00010–00990	000 parameter group (parameters 001 through 099)
01000–01990	100 parameter group (parameters 100 through 199)
02000–02990	200 parameter group (parameters 200 through 299)
03000–03990	300 parameter group (parameters 300 through 399)
04000–04990	400 parameter group (parameters 400 through 499)
...	...
49000–49990	4900 parameter group (parameters 4900 through 4999)
50000	Input data: Frequency converter control word register (CTW).
50010	Input data: Bus reference register (REF).
...	...
50200	Output data: Frequency converter status word register (STW).
50210	Output data: Frequency converter main actual value register (MAV).

Table 9.11 Holding Registers

** Used to specify the index number to be used when accessing an indexed parameter.*

9.2.4 How to Access Parameters

9.2.4.1 Parameter Handling

The PNU (Parameter Number) is translated from the register address contained in the Modbus read or write message. The parameter number is translated to Modbus as (10 x parameter number) DECIMAL.

All parameters are named with one or two letters, a "-" and a number for example, F-07. To access parameters, use *Table 9.12* because letters cannot be addressed. Example: F-07=7, E-01=101, DR-53=1253.

Letter	Number
F	0
E	1
C	2
P	3
H	4
K	5
AN	6
B	7
O	8
PB	9
SP	10
DR	12
ID	15
DN	22
PI	23
LC	24
EC	25
RS	26
EN	29

Table 9.12

9.2.4.2 Storage of Data

The Coil 65 decimal determines whether data written to the frequency converter are stored in EEPROM and RAM (coil 65=1) or only in RAM (coil 65=0).

9.2.4.3 IND

The array index is set in Holding Register 9 and used when accessing array parameters.

9.2.4.4 Text Blocks

Parameters stored as text strings are accessed in the same way as the other parameters. The maximum text block size is 20 characters. If a read request for a parameter is for more characters than the parameter stores, the response is truncated. If the read request for a parameter is for fewer characters than the parameter stores, the response is space filled.

9.2.4.5 Conversion Factor

The different attributes for each parameter can be seen in the section on factory settings. Since a parameter value can only be transferred as a whole number, a conversion factor must be used to transfer decimals.

Conversion index	Conversion factor
67	1/60 (time)
6	1000000
5	100000
4	10000
3	1000
2	100
1	10
0	1
-1	0.1
-2	0.01
-3	0.001
-4	0.0001
-5	0.00001
-6	0.000001
-7	0.0000001

Table 9.13 Conversion Table

9.2.4.6 Parameter Values

Standard data types
Standard data types are int16, int32, uint8, uint16, and uint32. They are stored as 4x registers (40001–4FFFF). The parameters are read using function 03HEX "Read Holding Registers." Parameters are written using the function 6HEX "Preset Single Register" for 1 register (16 bits), and the function 10 HEX "Preset Multiple Registers" for 2 registers (32 bits). Readable sizes range from 1 register (16 bits) up to 10 registers (20 characters).

Non-standard data types
Non-standard data types are text strings and are stored as 4x registers (40001–4FFFF). The parameters are read using function 03HEX "Read Holding Registers" and written using function 10HEX "Preset Multiple Registers." Readable sizes range from 1 register (2 characters) up to 10 registers (20 characters).

9.3 Drive Control Profile

9.3.1 Control Word According to Drive Profile (*parameter O-10 Control Word Profile* = Drive profile)

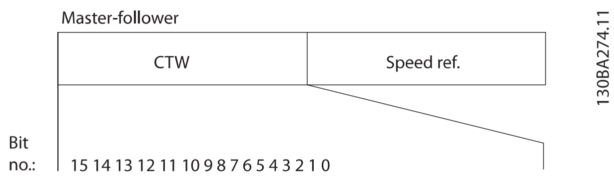

Illustration 9.2 Control Word

Bit	Bit value = 0	Bit value = 1
00	Reference value	External selection lsb
01	Reference value	External selection msb
02	DC brake	Ramp
03	Coasting	No coasting
04	Quick stop	Ramp
05	Hold output frequency	Use ramp
06	Ramp stop	Start
07	No function	Reset
08	No function	Jog
09	Ramp 1	Ramp 2
10	Data invalid	Data valid
11	No function	Relay 01 active
12	No function	Relay 02 active
13	Parameter set-up	Selection lsb
14	Parameter set-up	Selection msb
15	No function	Reverse

Table 9.14 Control Word Bits

Explanation of the control bits
Bits 00/01
Bits 00 and 01 are used to select between the 4 reference values, which are pre-programmed in *parameter C-05 Multi-step Frequency 1 - 8* according to *Table 9.15*.

Programmed ref. value	Parameter	Bit 01	Bit 00
1	*Parameter C-05 Multi-step Frequency 1 - 8* [0]	0	0
2	*Parameter C-05 Multi-step Frequency 1 - 8* [1]	0	1
3	*Parameter C-05 Multi-step Frequency 1 - 8* [2]	1	0
4	*Parameter C-05 Multi-step Frequency 1 - 8* [3]	1	1

Table 9.15 Reference Values

Bit 02, DC brake
Bit 02 = 0 leads to DC brake and stop. Set braking current and duration in *parameter B-01 DC Brake Current* and *parameter B-02 DC Braking Time*.
Bit 02 = 1 leads to ramping.

Bit 03, Coasting
Bit 03 = 0: The frequency converter immediately "lets go" of the motor (the output transistors are "shut off") and it coasts to a standstill.
Bit 03 = 1: The frequency converter starts the motor, if the other starting conditions are met.

Bit 04, Quick stop
Bit 04 = 0: Makes the motor speed decel to stop (set in *parameter C-23 Quick Stop Decel Time*).
Bit 04 = 1 leads to ramping.

Bit 05, Hold output frequency
Bit 05 = 0: The present output frequency (in Hz) freezes. Change the frozen output frequency only with the digital inputs (*parameter E-01 Terminal 18 Digital Input* to *parameter E-06 Terminal 33 Digital Input*) programmed to *Speed up* and *Slow down*.

NOTICE

If freeze output is active, the frequency converter can only be stopped by the following:

- **Bit 03 Coasting stop**
- **Bit 02 DC brake**
- **Digital input (*parameter E-01 Terminal 18 Digital Input* to *parameter E-06 Terminal 33 Digital Input*) programmed to *DC brake*, *Coasting stop*, or *Reset* and *coasting stop*.**

Bit 06, Ramp stop/start
Bit 06 = 0: Causes a stop and makes the motor speed decel to stop via the selected decel parameter.
Bit 06 = 1: Allows the frequency converter to start the motor, if the other starting conditions are met.

Bit 07, Reset
Bit 07 = 0: No reset.
Bit 07 = 1: Resets a trip. Reset is activated on the signal's leading edge, that is, when changing from logic '0' to logic '1'.

Bit 08, Jog
Bit 08 = 1: The output frequency is determined by *parameter C-21 Jog Speed [RPM]*.

Bit 09, Selection of ramp 1/2
Bit 09 = 0: Ramp 1 is active (*parameter F-07 Accel Time 1* to *parameter F-08 Decel Time 1*).
Bit 09 = 1: Ramp 2 (*parameter E-10 Accel Time 2* to *parameter E-11 Decel Time 2*) is active.

Bit 10, Data not valid/Data valid
Tells the frequency converter whether to use or ignore the control word.
Bit 10 = 0: The control word is ignored.
Bit 10 = 1: The control word is used. This function is relevant because the message always contains the control word, regardless of the message type. Turn off the control word, if it should not be used when updating or reading parameters.

Bit 11, Relay 01
Bit 11 = 0: Relay not activated.
Bit 11 = 1: Relay 01 activated if *control word bit 11* is selected in *parameter E-24 Function Relay*.

Bit 12, Relay 04
Bit 12 = 0: Relay 04 is not activated.
Bit 12 = 1: Relay 04 is activated if *control word bit 12* is selected in *parameter E-24 Function Relay*.

Bit 13/14, Set-up selection
Use bits 13 and 14 to select from the 4 menu set-ups according to *Table 9.16*.

Set-up	Bit 14	Bit 13
1	0	0
2	0	1
3	1	0
4	1	1

Table 9.16 4 Menu Set-ups

The function is only possible when *Multi set-ups*are selected in *parameter K-10 Active Set-up*.

Bit 15 Reverse
Bit 15 = 0: No reversing.
Bit 15 = 1: Reversing. In the default setting, reversing is set to digital in *parameter O-54 Reversing Select*. Bit 15 causes reversing only when Ser. communication, Logic or Logic and is selected.

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9.3.2 Status Word According to Drive Profile (STW) (*parameter O-10 Control Word Profile* = Drive profile)

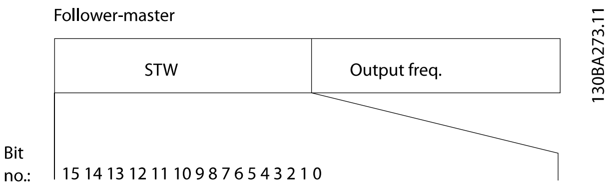

Illustration 9.3 Status Word

Bit	Bit = 0	Bit = 1
00	Control not ready	Control ready
01	Drive not ready	Drive ready
02	Coasting	Enable
03	No error	Trip
04	No error	Error (no trip)
05	Reserved	-
06	No error	Triplock
07	No warning	Warning
08	Speed ≠ reference	Speed = reference
09	Local operation	Bus control
10	Out of frequency limit	Frequency limit OK
11	No operation	In operation
12	Drive OK	Stopped, auto start
13	Voltage OK	Voltage exceeded
14	Torque OK	Torque exceeded
15	Timer OK	Timer exceeded

Table 9.17 Status Word Bits

Explanation of the Status Bits

Bit 00, Control not ready/ready
Bit 00 = 0: The frequency converter trips.
Bit 00 = 1: The frequency converter controls are ready but the power component does not necessarily receive any power supply (if there is 24 V external supply to controls).

Bit 01, Drive ready
Bit 01 = 1: The frequency converter is ready for operation but the coasting command is active via the digital inputs or via serial communication.

Bit 02, Coasting stop
Bit 02 = 0: The frequency converter releases the motor.
Bit 02 = 1: The frequency converter starts the motor with a start command.

Bit 03, No error/trip
Bit 03 = 0: The frequency converter is not in fault mode.
Bit 03 = 1: The frequency converter trips. To re-establish operation, enter [Reset].

Bit 04, No error/error (no trip)
Bit 04 = 0: The frequency converter is not in fault mode.
Bit 04 = 1: The frequency converter shows an error but does not trip.

Bit 05, Not used
Bit 05 is not used in the status word.

Bit 06, No error/triplock
Bit 06 = 0: The frequency converter is not in fault mode.
Bit 06 = 1: The frequency converter is tripped and locked.

Bit 07, No warning/warning
Bit 07 = 0: There are no warnings.
Bit 07 = 1: A warning has occurred.

Bit 08, Speed≠ reference/speed = reference
Bit 08 = 0: The motor is running, but the present speed is different from the preset speed reference. It might for example, be the case when the speed accels/decels during start/stop.
Bit 08 = 1: The motor speed matches the preset speed reference.

Bit 09, Local operation/bus control
Bit 09 = 0: [Stop/Reset] is activated on the control unit or *local control* in *parameter F-02 Operation Method* is selected. Control via serial communication is not possible.
Bit 09 = 1 It is possible to control the frequency converter via the network/serial communication.

Bit 10, Out of frequency limit
Bit 10 = 0: The output frequency has reached the value in *parameter F-18 Motor Speed Low Limit [RPM]* or *parameter F-17 Motor Speed High Limit [RPM]*.
Bit 10 = 1: The output frequency is within the defined limits.

Bit 11, No operation/in operation
Bit 11 = 0: The motor is not running.
Bit 11 = 1: The frequency converter has a start signal or the output frequency is greater than 0 Hz.

Bit 12, Drive OK/stopped, autostart
Bit 12 = 0: There is no temporary overtemperature on the inverter.
Bit 12 = 1: The inverter stops because of overtemperature, but the unit does not trip and resumes operation once the overtemperature stops.

Bit 13, Voltage OK/limit exceeded
Bit 13 = 0: There are no voltage warnings.
Bit 13 = 1: The DC voltage in the frequency converter's DC link is too low or too high.

Bit 14, Torque OK/limit exceeded
Bit 14 = 0: The motor current is lower than the torque limit selected in *parameter F-43 Current Limit*.
Bit 14 = 1: The torque limit in *parameter F-43 Current Limit* is exceeded.

Bit 15, Timer OK/limit exceeded
Bit 15 = 0: The timers for motor thermal protection and thermal protection are not exceeded 100%.
Bit 15 = 1: One of the timers exceeds 100%.

All bits in the STW are set to 0 if the connection between the InterBus option and the frequency converter is lost, or an internal communication problem has occurred.

9.3.3 Bus Speed Reference Value

Speed reference value is transmitted to the frequency converter in a relative value in %. The value is transmitted in the form of a 16-bit word. The integer value 16384 (4000 hex) corresponds to 100%. Negative figures are formatted using 2's complement. The actual output frequency (MAV) is scaled in the same way as the bus reference.

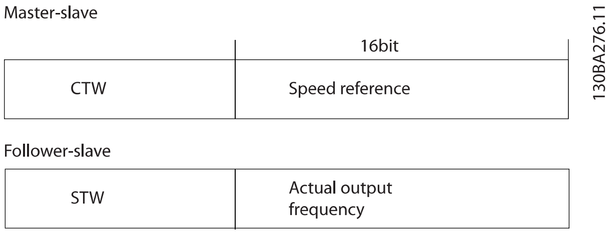

Illustration 9.4 Actual Output Frequency (MAV)

The reference and MAV are scaled as follows:

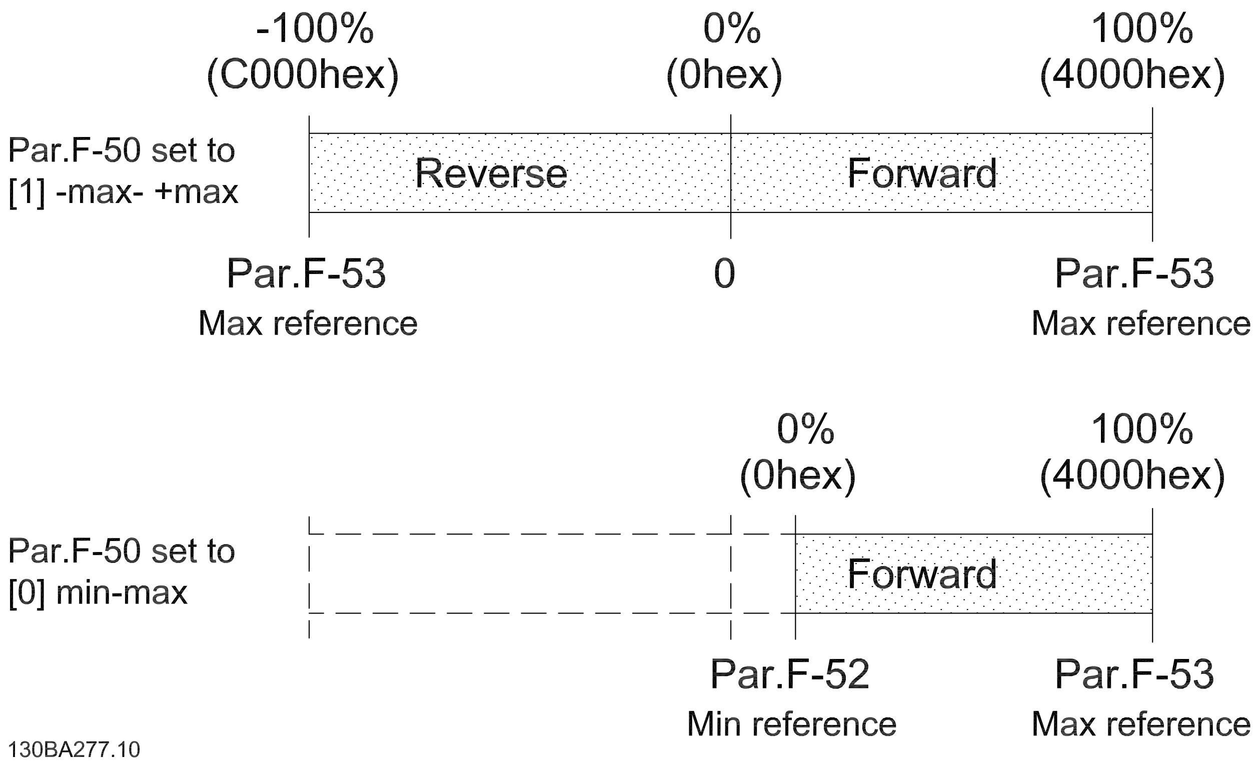

Illustration 9.5 Reference and MAV

10 Warnings and Alarms

10.1 System Monitoring

The frequency converter monitors the condition of its input power, output, and motor factors, and other system performance indicators. A warning or alarm does not necessarily indicate a problem internally in the frequency converter.

Often, it indicates failure conditions from:

- Input voltage.
- Motor load.
- Motor temperature.
- External signals.
- Other areas monitored by internal logic.

Investigate as indicated in the alarm or warning.

10.2 Warning and Alarm Types

Warnings
A warning is issued when an alarm condition is impending or when an abnormal operating condition is present and may result in the frequency converter issuing an alarm. A warning clears by itself when the abnormal condition is removed.

Alarms
Trip
An alarm is issued when the frequency converter is tripped, that is, the frequency converter suspends operation to prevent frequency converter or system damage. The motor will coast to a stop. The frequency converter logic continues to operate and monitor the frequency converter status. After the fault condition is remedied, the frequency converter can be reset. It is then ready to start operation again.

A trip can be reset in any of 4 ways:

- Press [Reset] on the keypad
- Digital reset input command
- Serial communication reset input command
- Auto reset

Trip lock
An alarm that causes the frequency converter to trip lock requires that input power is cycled. The motor will coast to a stop. The frequency converter logic continues to operate and monitor the frequency converter status. Remove input power to the frequency converter and correct the cause of the fault, then restore power. This action puts the frequency converter into a trip condition as described above and may be reset in any of those 4 ways.

10

10.3 Warning and Alarm Displays

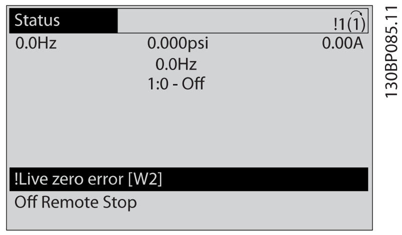

Illustration 10.1 Warning Display

An alarm or trip lock alarm flashes in the display along with the alarm number.

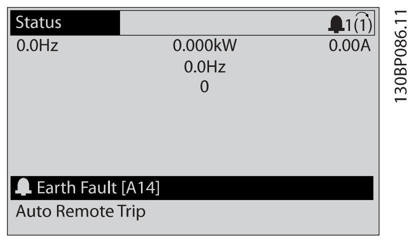

Illustration 10.2 Alarm Display

In addition to the text and alarm code in the keypad, there are 3 status indicator lights.

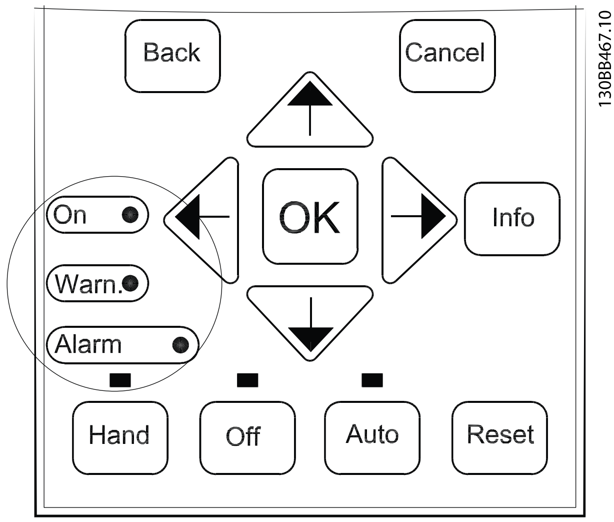

Illustration 10.3 Status Indicator Lights

	Warning LED	Alarm LED
Warning	On	Off
Alarm	Off	On (Flashing)
Trip lock	On	On (Flashing)

Table 10.1 Status Indicator Lights Explanations

10.3.1 Warnings/Alarm Messages

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

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

In the event of an alarm, the frequency converter trips. Reset the alarm to resume operation once the cause has been rectified.

Three ways to reset:

- Press [Reset].
- Via a digital input with the “Reset” function.
- Via serial communication/optional network.

NOTICE

After a manual reset pressing [Reset], press [Auto] to restart the motor.

If an alarm cannot be reset, the reason may be that its cause has not been rectified, or the alarm is trip-locked (see also *Table 10.2*).

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

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

If a warning or alarm is marked against a code in *Table 10.2*, this means that either a warning occurs before an alarm, or else that it is possible to specify whether a warning or an alarm should be shown for a given fault.

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

NOTICE

No missing motor phase detection (numbers 30–32) and no stall detection is active when *parameter P-20 Motor Construction* is set to *[1] PM non-salient SPM*.

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock	Parameter reference
1	10 Volts low	X			–
2	Live zero error	(X)	(X)		*Parameter AN-01 Live Zero Timeout Function*
3	No motor	(X)			*Parameter H-80 Function at Stop*
4	Mains phase loss	(X)	(X)	(X)	*Parameter SP-12 Function at Line Imbalance*
5	DC link voltage high	X			–
6	DC link voltage low	X			–
7	DC over-voltage	X	X		–
8	DC under voltage	X	X		–
9	Inverter overloaded	X	X		–
10	Motor Electronic OL over temperature	(X)	(X)		*Parameter F-10 Electronic Overload*
11	Motor thermistor over temperature	(X)	(X)		*Parameter F-10 Electronic Overload*
12	Torque limit	X	X		–
13	Over Current	X	X	X	–
14	Earth Fault	X	X		–
15	Hardware mismatch		X	X	–
16	Short Circuit		X	X	–
17	Control word time-out	(X)	(X)		*Parameter O-04 Control Word Timeout Function*
20	Temp. input error		X		–
21	Param Error			X	–
22	Hoist Mech. Brake	(X)	(X)		*Parameter group B-2#*
23	Internal Fans	X			–
24	External Fans	X			–
25	Brake resistor short-circuited	X			–
26	Brake resistor power limit	(X)	(X)		*Parameter B-13 Braking Thermal Overload*
27	Brake chopper short-circuited	X	X		–
28	Brake check	(X)	(X)		*Parameter B-15 Brake Check*
29	Heatsink temp	X	X	X	–
30	Motor phase U missing	(X)	(X)	(X)	*Parameter H-78 Missing Motor Phase Function*
31	Motor phase V missing	(X)	(X)	(X)	*Parameter H-78 Missing Motor Phase Function*
32	Motor phase W missing	(X)	(X)	(X)	*Parameter H-78 Missing Motor Phase Function*
33	Inrush Fault		X	X	–
34	Network communication fault	X	X		–
35	Option Fault			X	–
36	Mains failure	X	X		–
37	Phase imbalance		X		–
38	Internal Fault		X	X	–
39	Heatsink sensor		X	X	–
40	Overload of Digital Output Terminal 27	(X)			*Parameter E-00 Digital I/O Mode, parameter E-51 Terminal 27 Mode*

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock	Parameter reference
41	Overload of Digital Output Terminal 29	(X)			*Parameter E-00 Digital I/O Mode, parameter E-52 Terminal 29 Mode*
42	Ovrld X30/6-7	(X)			–
43	Ext. Supply (option)	X			–
45	Earth Fault 2	X	X		–
46	Pwr. card supply		X	X	–
47	24 V supply low	X	X	X	–
48	1.8 V supply low		X	X	–
49	Speed limit		X		*parameter H-36 Trip Speed Low [RPM]*
50	Auto Tune calibration failed		X		–
51	Auto Tune check U_{nom} and I_{nom}		X		–
52	Auto Tune low I_{nom}		X		–
53	Auto Tune motor too big		X		–
54	Auto Tune motor too small		X		–
55	Auto Tune parameter out of range		X		–
56	Auto Tune interrupted by user		X		–
57	Auto Tune time-out		X		–
58	Auto Tune internal fault	X	X		–
59	Current limit	X			–
60	External Interlock	X	X		–
61	Feedback Error	(X)	(X)		*Parameter H-20 Motor Feedback Loss Function*
62	Output Frequency at Maximum Limit	X			–
63	Mechanical Brake Low		(X)		*Parameter B-20 Release Brake Current*
64	Voltage Limit	X			–
65	Control Board Over-temperature	X	X	X	–
66	Heat sink Temperature Low	X			–
67	Option Module Configuration has Changed		X		–
68	Safe Stop	(X)	(X)[1)]		*Parameter E-07 Terminal 37 Safe Stop*
69	Pwr. Card Temp		X	X	–
70	Illegal Drive configuration			X	–
71	PTC 1 Safe Stop				–
72	Dangerous failure				–
73	Safe Stop Auto Restart	(X)	(X)		*Parameter E-07 Terminal 37 Safe Stop*
74	PTC Thermistor			X	–
75	Illegal Profile Sel.		X		–
76	Power Unit Setup	X			–
77	Reduced power mode	X			*Parameter SP-59 Actual Number of Inverter Units*
78	Tracking Error	(X)	(X)		*Parameter H-24 Tracking Error Function*
79	Illegal PS config		X	X	–
80	Drive Restored to Factory Settings		X		–
81	CSIV corrupt		X		–
82	CSIV parameter error		X		–
83	Illegal Option Combination			X	–

10

No.	Description	Warning	Alarm/Trip	Alarm/Trip Lock	Parameter reference
88	Option Detection			X	–
89	Mechanical Brake Sliding	X			–
90	Feedback Monitor	(X)	(X)		*Parameter EC-61 Feedback Signal Monitoring*
91	Analog input 54 wrong settings			X	S202
99	Locked rotor		X		–
101	Speed monitor		X		–
104	Mixing fans		X		–
122	Mot. rotat. unexp.		X		–
123	Motor mod. changed		X		–
220	Configuration File Version not supported	X			–
246	Pwr.card supply			X	–
250	New spare parts			X	–
251	New Type Code		X	X	–
253	X49/9 Overload	X			–
254	X49/11 Overload	X			–
255	X49/7 Overload	X			–
430	PWM Disabled		X		–

Table 10.2 Alarm/Warning Code List

(X) Dependent on parameter

1) Cannot be auto reset via parameter H-04 Auto-Reset (Times)

A trip is the action following an alarm. The trip coasts the motor and is reset by pressing [Reset] or by a digital input (parameter group E-1# [1]). The origin event that caused an alarm cannot damage the frequency converter or cause dangerous conditions. A trip lock is an action when an alarm occurs, which could damage the frequency converter or connected parts. A trip lock situation can only be reset by a power cycling.

Warning	Yellow
Alarm	Flashing red
Trip locked	Yellow and red

Table 10.3 LED Indication

Bit	Hex	Dec	Alarm Word	Alarm Word 2	Warning Word	Warning Word 2	Extended Status Word
Alarm Word Extended Status Word							
0	00000001	1	Brake Check (A28)	ServiceTrip, Read/Write	Brake Check (W28)	Reserved	Ramping
1	00000002	2	Pwr. Card Temp (A69)	ServiceTrip (reserved)	Pwr. Card Temp (W69)	Reserved	Auto Tune Running
2	00000004	4	Earth Fault (A14)	ServiceTrip, Typecode/ Sparepart	Earth Fault (W14)	Reserved	Start CW/CCW
3	00000008	8	Ctrl.Card Temp (A65)	ServiceTrip (reserved)	Ctrl.Card Temp (W65)	Reserved	Slow Down
4	00000010	16	Ctrl. Word TO (A17)	ServiceTrip (reserved)	Ctrl. Word TO (W17)		Catch Up
5	00000020	32	Over Current (A13)	Reserved	Over Current (W13)	Reserved	Feedback High
6	00000040	64	Torque Limit (A12)	Reserved	Torque Limit (W12)	Reserved	Feedback Low
7	00000080	128	Motor Th Over (A11)	Reserved	Motor Th Over (W11)	Reserved	Output Current High

Bit	Hex	Dec	Alarm Word	Alarm Word 2	Warning Word	Warning Word 2	Extended Status Word
Alarm Word Extended Status Word							
8	00000100	256	Motor Electronic OL Over (A10)	Reserved	Motor Electronic OL Over (W10)	Reserved	Output Current Low
9	00000200	512	Drive Overld. (A9)	Reserved	Drive Overld (W9)	Reserved	Output Freq High
10	00000400	1024	DC under Volt (A8)	Reserved	DC under Volt (W8)		Output Freq Low
11	00000800	2048	DC over Volt (A7)	Reserved	DC over Volt (W7)		Brake Check OK
12	00001000	4096	Short Circuit (A16)	Reserved	DC Voltage Low (W6)	Reserved	Braking Max
13	00002000	8192	Inrush Fault (A33)	Reserved	DC Voltage High (W5)		Braking
14	00004000	16384	Mains ph. Loss (A4)	Reserved	Mains ph. Loss (W4)		Out of Speed Range
15	00008000	32768	Auto Tune Not OK	Reserved	No Motor (W3)		OVC Active
16	00010000	65536	Live Zero Error (A2)	Reserved	Live Zero Error (W2)		AC Brake
17	00020000	131072	Internal Fault (A38)	KTY error	10V Low (W1)	KTY Warn	Password Timelock
18	00040000	262144	Brake Overload (A26)	Fans error	Brake Overload (W26)	Fans Warn	Password Protection
19	00080000	524288	U phase Loss (A30)	Reserved	Brake Resistor (W25)	Reserved	
20	00100000	1048576	V phase Loss (A31)	Reserved	Brake IGBT (W27)	Reserved	
21	00200000	2097152	W phase Loss (A32)	Reserved	Speed Limit (W49)	Reserved	
22	00400000	4194304	Network Fault (A34)	Reserved	Network Fault (W34)	Reserved	Unused
23	00800000	8388608	24 V Supply Low (A47)	Reserved	24V Supply Low (W47)	Reserved	Unused
24	01000000	16777216	Mains Failure (A36)	Reserved	Mains Failure (W36)	Reserved	Unused
25	02000000	33554432	1.8V Supply Low (A48)	Reserved	Current Limit (W59)	Reserved	Unused
26	04000000	67108864	Brake Resistor (A25)	Reserved	Low Temp (W66)	Reserved	Unused
27	08000000	134217728	Brake IGBT (A27)	Reserved	Voltage Limit (W64)	Reserved	Unused
28	10000000	268435456	Option Change (A67)	Reserved	Encoder loss (W90)	Reserved	Unused
29	20000000	536870912	Drive Restored to factory settings(A80)	Feedback Fault (A61, A90)	Feedback Fault (W61, W90)		Unused
30	40000000	1073741824	Safe Stop (A68)	Safe Stop (A71)	Safe Stop (W68)	Safe Stop (W71)	Unused
31	80000000	2147483648	Mech. brake low (A63)	Dangerous Failure (A72)	Extended Status Word		Unused

Table 10.4 Description of Alarm Word, Warning Word, and Extended Status Word

The alarm words, warning words and extended status words can be read out via serial bus or optional network for diagnostics. See also *parameter DR-94 Ext. Status Word*.

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10.4 Warning and Alarm Definitions

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

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

Troubleshooting

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

WARNING/ALARM 2, Live zero error
This warning or alarm only appears if programmed in *parameter AN-01 Live Zero Timeout Function*. The signal on 1 of the analog inputs is less than 50% of the minimum value programmed for that input. Broken wiring or a faulty device sending the signal can cause this condition.

Troubleshooting

- Check connections on all analog mains terminals.
  - Control card terminals 53 and 54 for signals, terminal 55 common.
  - OPCGPIO terminals 11 and 12 for signals, terminal 10 common.
  - OPCAIO terminals 1, 3, and 5 for signals, terminals 2, 4, and 6 common.
- Check that the frequency converter programming and switch settings match the analog signal type.
- Perform an input terminal signal test.

WARNING/ALARM 3, No motor
No motor is connected to the output of the frequency converter.

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

Troubleshooting

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

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

WARNING 6, DC link voltage low
The DC-link voltage (DC) is lower than the low voltage warning limit. The limit depends on the frequency converter voltage rating. The unit is still active.

WARNING/ALARM 7, DC overvoltage
If the DC-link voltage exceeds the limit, the frequency converter trips after a certain time.

Troubleshooting

- Extend the ramp time.
- Change the ramp type.
- Activate the functions in *parameter B-10 Brake Function*.
- Increase *parameter SP-26 Trip Delay at Drive Fault*.
- If the alarm/warning occurs during a power sag, use kinetic back-up (*parameter SP-10 Line failure*).

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

Troubleshooting

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

WARNING/ALARM 9, Inverter overload
The frequency converter has run with more than 100% overload for too long and is about to cut out. The counter for electronic thermal inverter protection issues a warning at 98% and trips at 100% with an alarm. The frequency converter cannot be reset until the counter is below 90%.

Troubleshooting

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

WARNING/ALARM 10, Motor overload temperature
According to the electronic thermal protection, the motor is too hot. Select whether the frequency converter issues a warning or an alarm when the counter is >90% if *parameter F-10 Electronic Overload* is set to warning options, or whether the frequency converter trips when the counter reaches 100% if *parameter F-10 Electronic Overload* is set to trip options. The fault occurs when the motor runs with more than 100% overload for too long.

Troubleshooting

- Check for motor overheating.
- Check if the motor is mechanically overloaded.
- Check that the motor current set in *parameter P-03 Motor Current* is correct.

- Ensure that the motor data in *parameters* P-02, P-03, P-06, P-07, F-04, and F-05 are set correctly.
- If an external fan is in use, check that it is selected in *parameter F-11 Motor External Fan*.
- Running Auto tune in *parameter P-04 Auto Tune* tunes the frequency converter to the motor more accurately and reduces thermal loading.

WARNING/ALARM 11, Motor thermistor over temp
The thermistor may be disconnected. Select whether the frequency converter issues a warning or an alarm in *parameter F-10 Electronic Overload*.

Troubleshooting

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

WARNING/ALARM 12, Torque limit
The torque has exceeded the value in *parameter F-40 Torque Limiter (Driving)* or the value in *parameter F-41 Torque Limiter (Braking). Parameter SP-25 Trip Delay at Torque Limit* can change this warning from a warning-only condition to a warning followed by an alarm.

Troubleshooting

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

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

Troubleshooting

- Remove the power and check if the motor shaft can be turned.
- Check that the motor size matches the frequency converter.
- Check that the motor data is correct in *parameters* P-02, P-03, P-06, P-07, F-04, and F-05.

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

Troubleshooting

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

ALARM 15, Hardware mismatch
A fitted option is not operational with the present control board hardware or software.

Record the value of the following parameters and contact GE:

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

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

Troubleshooting

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

WARNING/ALARM 17, Control word timeout
There is no communication with the frequency converter. The warning is only active when *parameter O-04 Control Word Timeout Function* is not set to *[0] Off*.
If *parameter O-04 Control Word Timeout Function* is set to *[2] Stop* and *[26] Trip*, a warning appears and the frequency converter ramps down until it trips and then shows an alarm.

Troubleshooting

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

WARNING/ALARM 20, Temp. input error
The temperature sensor is not connected.

WARNING/ALARM 21, Parameter error
The parameter is out of range. The parameter number is reported in the keypad.

Troubleshooting

- Set the affected parameter to a valid value.

WARNING/ALARM 22, Hoist mechanical brake
The value of this warning/alarm shows the type of warning/alarm.
0 = The torque reference was not reached before timeout (*parameter B-27 Torque Ramp Time*).
1 = Expected brake feedback not received before timeout (*parameter B-23 Activate Brake Delay*, *parameter B-25 Brake Release Time*).

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

For frequency converters with DC fans, there is a feedback sensor mounted in the fan. If the fan is commanded to run and there is no feedback from the sensor, this alarm appears. For frequency converters with AC fans, the voltage to the fan is monitored.

Troubleshooting

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

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

For frequency converters with DC fans, there is a feedback sensor mounted in the fan. If the fan is commanded to run and there is no feedback from the sensor, this alarm appears. For frequency converters with AC fans, the voltage to the fan is monitored.

Troubleshooting

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

WARNING 25, Brake resistor short circuit
The brake resistor is monitored during operation. If a short circuit occurs, the brake function is disabled and the warning appears. The frequency converter is still operational, but without the brake function.

Troubleshooting

- Remove the power to the frequency converter and replace the brake resistor (refer to *parameter B-15 Brake Check*).

WARNING/ALARM 26, Brake resistor power limit
The power transmitted to the brake resistor is calculated as a mean value over the last 120 s of run time. The calculation is based on the DC-link voltage and the brake resistor value set in *parameter B-16 AC brake Max. Current*. The warning is active when the dissipated braking is >90% of the brake resistor power. If *[2] Trip* is selected in *parameter B-13 Braking Thermal Overload*, the frequency converter trips when the dissipated braking power reaches 100%.

⚠WARNING

If the brake transistor is short-circuited, there is a risk of substantial power being transmitted to the brake resistor.

WARNING/ALARM 27, Brake chopper fault
The brake transistor is monitored during operation, and if a short circuit occurs, the brake function is disabled, and a warning is issued. The frequency converter is still operational, but since the brake transistor has short-circuited, substantial power is transmitted to the brake resistor, even if it is inactive.

Troubleshooting

- Remove power to the frequency converter and remove the brake resistor.

High-power drives: This alarm/warning also occurs if the brake resistor overheat. Terminals 104–106 of FK102 are available as brake resistor temperature switch on the power card of high-power drives. Unless used as an input, a jumper must be placed between terminals 104 and 106 of FK102.

WARNING/ALARM 28, Brake check failed
The brake resistor is not connected or not working.

Troubleshooting

- Check *parameter B-15 Brake Check*.

ALARM 29, Heatsink temp

The maximum temperature of the heat sink is exceeded. The temperature fault is not reset until the temperature drops below a defined heat sink temperature. The trip and reset points are different based on the frequency converter power size.

Troubleshooting

Check for the following conditions.

- The ambient temperature is too high.
- The motor cables are too long.
- Incorrect airflow clearance above and below the frequency converter.
- Blocked airflow around the frequency converter.
- Damaged heat sink fan.
- Dirty heat sink.

ALARM 30, Motor phase U missing

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

Troubleshooting

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

ALARM 31, Motor phase V missing

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

Troubleshooting

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

ALARM 32, Motor phase W missing

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

Troubleshooting

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

ALARM 33, Inrush fault

Too many power-ups have occurred within a short time period.

Troubleshooting

- Let the unit cool to operating temperature.

WARNING/ALARM 34, Fieldbus communication fault

The network on the communication option card is not working.

WARNING/ALARM 35, Option faultOut of frequency range

An option alarm is received. The alarm is option-specific. The most likely cause is a power-up or a communication fault.

WARNING/ALARM 36, Mains failure

This warning/alarm is only active if the supply voltage to the frequency converter is lost and *parameter SP-10 Line failure* is not set to *[0] No Function*.

Troubleshooting

- Check the fuses to the frequency converter and mains supply to the unit.

ALARM 37, Phase imbalance

There is a current imbalance between the power units.

ALARM 38, Internal fault

When an internal fault occurs, a code number defined in *Table 10.5* is shown.

Troubleshooting

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

It may be necessary to contact GE Service or the supplier. Note the code number for further troubleshooting directions.

No.	Text
0	Serial port cannot be restore. Contact your GE supplier or GE Service Department.
256–258	Power EEPROM data is defective or too old.
512	Control board EEPROM data is defective or too old.
513	Communication timeout reading EEPROM data.
514	Communication timeout reading EEPROM data.
515	Application-oriented control cannot recognize the EEPROM data.
516	Cannot write to the EEPROM because a write command is on progress.
517	Write command is under timeout.
518	Failure in the EEPROM.
519	Missing or invalid barcode data in EEPROM.
783	Parameter value outside of min/max limits.
1024–1279	A CAN message that has to be sent could not be sent.
1281	Digital signal processor flash timeout.
1282	Power micro software version mismatch.
1283	Power EEPROM data version mismatch.
1284	Cannot read digital signal processor software version.
1299	Option SW in slot A is too old.
1300	Option SW in slot B is too old.
1315	Option SW in slot A is not supported (not allowed).
1316	Option SW in slot B is not supported (not allowed).
1379	Option A did not respond when calculating platform version.
1380	Option B did not respond when calculating platform version.
1536	An exception in the application-oriented control is registered. Debug information written in keypad.
1792	DSP watchdog is active. Debugging of power part data, motor-oriented control data not transferred correctly.
2049	Power data restarted.

No.	Text
2064–2072	H081x: Option in slot x has restarted.
2080–2088	H082x: Option in slot x has issued a powerup-wait.
2096–2104	H983x: Option in slot x has issued a legal powerup-wait.
2304	Could not read any data from power EEPROM.
2305	Missing SW version from power unit.
2314	Missing power unit data from power unit.
2315	Missing SW version from power unit.
2316	Missing lo_statepage from power unit.
2324	Power card configuration is determined to be incorrect at power-up.
2325	A power card has stopped communicating while main power is applied.
2326	Power card configuration is determined to be incorrect after the delay for power cards to register.
2327	Too many power card locations have been registered as present.
2330	Power size information between the power cards does not match.
2561	No communication from DSP to ATACD.
2562	No communication from ATACD to DSP (state running).
2816	Stack overflow control board module.
2817	Scheduler slow tasks.
2818	Fast tasks.
2819	Parameter thread.
2820	Keypad stack overflow.
2821	Serial port overflow.
2822	USB port overflow.
2836	cfListMempool too small.
3072–5122	Parameter value is outside its limits.
5123	Option in slot A: Hardware incompatible with control board hardware.
5124	Option in slot B: Hardware incompatible with control board hardware.
5376–6231	Out of memory.

Table 10.5 Internal Fault, Code Numbers

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

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

WARNING 40, Overload of digital output terminal 27
Check the load connected to terminal 27 or remove the short circuit connection. Check *parameter E-00 Digital I/O Mode* and *parameter E-51 Terminal 27 Mode*.

WARNING 41, Overload of digital output terminal 29
Check the load connected to terminal 29 or remove the short circuit connection. Also check *parameter E-00 Digital I/O Mode* and *parameter E-52 Terminal 29 Mode*.

WARNING 42, Overload of digital output on X30/6 or overload of digital output on X30/7
For terminal X30/6, check the load connected to terminal X30/6 or remove the short circuit connection. Also check *parameter E-56 Term X30/6 Digi Out (OPCGPIO)* (General Purpose I/O).

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

ALARM 43, Ext. supply
The Extended Relay Option is mounted without external 24 V DC. Either connect a 24 V DC external supply or specify that no external supply is used via *parameter 14-80 Option Supplied by External 24VDC*, *[0] No*. A change in *parameter 14-80 Option Supplied by External 24VDC* requires a power cycle.

ALARM 45, Earth fault 2
Ground fault.

Troubleshooting

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

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

There are 3 supplies generated by the switch mode supply (SMPS) on the power card:

- 24 V.
- 5 V.
- ±18 V.

When powered with 3-phase mains voltage, all 3 supplies are monitored.

Troubleshooting

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

WARNING 47, 24 V supply low
The supply on the power card is out of range.

There are 3 supplies generated by the switch mode supply (SMPS) on the power card:

- 24 V.
- 5 V.
- ±18 V.

Troubleshooting

- Check for a defective power card.

WARNING 48, 1.8 V supply low
The 1.8 V DC supply used on the control card is outside of the allowable limits. The supply is measured on the control card.

Troubleshooting

- Check for a defective control card.
- If an option card is present, check for overvoltage.

WARNING 49, Speed limit
The warning is shown when the speed is outside of the specified range in F-18 and F-17. When the speed is below the specified limit in *parameter H-36 Trip Speed Low [RPM]* (except when starting or stopping), the frequency converter trips.

ALARM 50, Auto tune calibration failed
Contact the GE supplier or GE service department.

ALARM 51, Auto tune check U_{nom} and I_{nom}
The settings for motor voltage, motor current, and motor power are wrong.

Troubleshooting

- Check the settings in *parameters* P-02, P-03, P-06, P-07, F-04, and F-05.

ALARM 52, Auto tune low I_{nom}
The motor current is too low.

Troubleshooting

- Check the settings in *parameter P-03 Motor Current*.

ALARM 53, Auto tune motor too big
The motor is too large for the Auto tune to operate.

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

ALARM 55, Auto tune parameter out of range
Auto tune cannot run because the parameter values of the motor are outside of the acceptable range.

ALARM 56, Auto tune interrupted by user
The AMA is manually interrupted.

ALARM 57, Auto tune internal fault
Continue to restart the Auto tune, until the Auto tune is carried out.

NOTICE

Repeated runs may heat the motor to a level where the resistance R_s and R_r are increased. Usually, however, this behavior is not critical.

ALARM 58, Internal fault
Contact the GE supplier.

WARNING 59, Current limit
The current is higher than the value in *parameter F-43 Current Limit*. Ensure that motor data in *parameters* P-02, P-03, P-06, P-07, F-04, and F-05 is set correctly. Increase the current limit if necessary. Ensure that the system can operate safely at a higher limit.

WARNING 60, External interlock
A digital input signal indicates a fault condition external to the frequency converter. An external interlock has commanded the frequency converter to trip. Clear the external fault condition. To resume normal operation, apply 24 V DC to the terminal programmed for external interlock, and reset the frequency converter.

WARNING/ALARM 61, Tracking error
An error has occurred has been detected between the calculated motor speed and the speed measurement from the feedback device. The function warning/alarm/disable is set in *parameter H-20 Motor Feedback Loss Function*. Accepted error setting in *parameter H-21 Motor Feedback Speed Error* and the allowed time the error occur setting in *parameter H-22 Motor Feedback Loss Timeout*. During a commissioning procedure, the function could be effective.

WARNING 62, Output frequency at maximum limit
The output frequency has reached the value set in *parameter F-03 Max Output Frequency 1*. Check the application for possible causes. Possibly increase the output frequency limit. Be sure that the system can operate safely at a higher output frequency. The warning clears when the output drops below the maximum limit.

ALARM 63, Mechanical brake low
The actual motor current has not exceeded the release brake current within the start delay time window.

WARNING 64, Voltage limit
The combination of load and speed requires a motor voltage higher than what can be provided due to the actual DC-link voltage.

WARNING/ALARM 65, Control card over temperature
The cut-out temperature of the control card is 85 °C.

Troubleshooting

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

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

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

ALARM 68, Safe Stop activated
Safe Torque Off (STO) has been activated. To resume normal operation, apply 24 V DC to terminal 37, then send a reset signal (via bus, digital I/O, or by pressing [Reset]).

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

Troubleshooting

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

ALARM 70, Illegal drive configuration
The control card and power card are incompatible. To check compatibility, contact the GE supplier with the model number from the unit nameplate and the part numbers of the cards.

ALARM 71, PTC 1 safe stop
STO has been activated from external source. Normal operation can be resumed when 24 V DC is applied to terminal # 37. When that happens, send a reset signal (via bus or digital I/O, or press [Reset]).

ALARM 72, Dangerous failure

STO with trip lock. An unexpected combination of STO commands has occurred:

- OPCPTC enables X44/10, but STO is not enabled.
- OPCPTC is the only device using STO (specified through selection *[4] PTC 1 Alarm* or *[5] PTC 1 Warning* in *parameter E-07 Terminal 37 Safe Stop*), STO is activated, and X44/10 is not activated.

WARNING 73, Safe stop auto restart
STO activated. With automatic restart enabled, the motor can start when the fault is cleared.

ALARM 74, PTC Thermistor
Alarm related to PTC Thermistor Card OPCPTC. The PTC is not working.

ALARM 75, Illegal profile sel.
Do not write the parameter value while the motor runs. Stop the motor before writing the MCO profile to *parameter O-10 Control Word Profile*.

WARNING 76, Power Unit Setup
The required number of power units does not match the detected number of active power units.

Troubleshooting

- Confirm that the spare part and its power card are the correct part number.

WARNING 77, Reduced power mode
The frequency converter is operating in reduced power mode (less than the allowed number of inverter sections). This warning is generated on power cycle when the frequency converter is set to run with fewer inverters and remains on.

ALARM 78, Tracking error
The difference between setpoint value and actual value exceeds the value in *parameter H-25 Tracking Error*.

Troubleshooting

- Disable the function or select an alarm/warning in *parameter H-24 Tracking Error Function*.
- Investigate the mechanics around the load and motor, check feedback connections from motor encoder to frequency converter.
- Select motor feedback function in *parameter H-20 Motor Feedback Loss Function*.
- Adjust tracking error band in *parameter H-25 Tracking Error* and *parameter H-27 Tracking Error Ramping*.

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

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

ALARM 81, CSIV corrupt
CSIV file has syntax errors.

ALARM 82, CSIV parameter error
CSIV failed to initialize a parameter.

ALARM 83, Illegal option combination
The mounted options are incompatible.

ALARM 88, Option detection
A change in the option layout is detected.
Parameter H-01 Option Detection is set to *[0] Frozen configuration* and the option layout has been changed.

- To apply the change, enable option layout changes in *parameter H-01 Option Detection*.
- Alternatively, restore the correct option configuration.

WARNING 89, Mechanical brake sliding
The hoist brake monitor detects a motor speed exceeding 10 RPM.

ALARM 90, Feedback monitor
Check the connection to encoder/resolver option and, if necessary, replace OPCENC or OPCRES.

ALARM 91, Analog input 54 wrong settings
Set switch S202 in position OFF (voltage input) when a KTY sensor is connected to analog input terminal 54.

ALARM 99, Locked rotor
Rotor is blocked.

WARNING/ALARM 101, Speed monitor
The motor speed monitor value is outside range. See *parameter H-30 Motor Speed Monitor Function*.

WARNING/ALARM 104, Mixing fan fault
The fan is not operating. The fan monitor checks that the fan is spinning at power-up or whenever the mixing fan is turned on. The mixing-fan fault can be configured as a warning or an alarm trip in *parameter SP-53 Fan Monitor*.

Troubleshooting

- Cycle power to the frequency converter to determine if the warning/alarm returns.

WARNING/ALARM 122, Mot. rotat. unexp.
The frequency converter performs a function that requires the motor to be at standstill, for example DC hold for PM motors.

WARNING 123, Motor Mod. Changed
The motor selected in *parameter 1-11 Motor Model* is not correct. Check the motor model.

WARNING 220, Configuration file version not supported
The frequency converter does not support the current configuration file version. Customization is aborted.

ALARM 246, Power card supply
This alarm is only for enclosure size F 6x unit size frequency converters. It is equivalent to *alarm 46, Power card supply*.

The report value in the alarm log indicates which power module generated the alarm:

1 = Inverter module to the far left.

2 = Middle inverter module in 62 or 64 frequency converter.

2 = Right inverter module in 61 or 63 frequency converter.

3 = Right inverter module in 62 or 64 frequency converter.

5 = Rectifier module.

WARNING 249, Rect. low temperature
The temperature of the rectifier heat sink is lower than expected.

Troubleshooting

- Check the temperature sensor.

WARNING 250, New spare part
The power or switch mode supply has been exchanged. Restore the frequency converter type code in the EEPROM. Select the correct type code in *parameter SP-23 Typecode Setting* according to the label on the frequency converter. Remember to select Save to EEPROM at the end.

WARNING 251, New typecode
The power card or other components are replaced and the type code has changed.

WARNING 253, Digital output X49/9 overload
Digital output X49/9 is overloaded.

WARNING 254, Digital output X49/11 overload
Digital output X49/11 is overloaded.

WARNING 255, Digital output X49/7 overload
Digital output X49/7 is overloaded.

ALARM 430, PWM Disabled
The PWM on the power card is disabled.

11 Basic Troubleshooting

11.1 Start Up and Operation

Symptom	Possible cause	Test	Solution
Display dark/no function	Missing input power.	See *Table 3.1*.	Check the input power source.
	Missing or open fuses, or circuit breaker tripped.	See *Open fuses* and *Tripped circuit breaker* in this table for possible causes.	Follow the recommendations provided.
	No power to the keypad.	Check the keypad cable for proper connection or damage.	Replace the faulty keypad or connection cable.
	Shortcut on control voltage (terminal 12 or 50) or at control terminals.	Check the 24 V control voltage supply for terminals 12/13 to 20–39 or 20–39 V or 10 V supply for terminals 50–55.	Wire the terminals properly.
	.		.
	Wrong contrast setting.		Press [Status] + [▲]/[▼] to adjust the contrast
	Display (keypad) is defective.	Test using a different keypad.	Replace the faulty keypad or connection cable.
	Internal voltage supply fault or SMPS is defective.		Contact supplier.
Intermittent display	Overloaded power supply (SMPS) due to improper control wiring or a fault within the frequency converter.	To rule out a problem in the control wiring, disconnect all control wiring by removing the terminal blocks.	If the display stays lit, then the problem is in the control wiring. Check the wiring for shorts or incorrect connections. If the display continues to cut out, follow the procedure for display dark.
Motor not running	Service switch open or missing motor connection.	Check if the motor is connected and the connection is not interrupted (by a service switch or other device).	Connect the motor and check the service switch.
	No mains power with 24 V DC option card.	If the display is functioning but no output, check that mains power is applied to the frequency converter.	Apply mains power to run the unit.
	keypad Stop.	Check if [Off] has been pressed.	Press [Auto] or [Hand] (depending on operation mode) to run the motor.
	Missing start signal (Standby).	Check *parameter E-01 Terminal 18 Digital Input* for correct setting for terminal 18 (use default setting).	Apply a valid start signal to start the motor.
	Motor coast signal active (Coasting).	Check if a coast inv command is programmed for the terminal in parameter group E-0# Digital Inputs.	Apply 24 V on terminal or program this terminal to *[0] No operation*.
	Wrong reference signal source.	Check reference signal: Local, remote, or bus reference? Preset reference active? Terminal connection correct? Scaling of terminals correct? Reference signal available?	Program correct settings. Check *parameter F-02 Operation Method*. Set preset reference active in parameter *parameter C-05 Multi-step Frequency 1 - 8*. Check for correct wiring. Check scaling of terminals. Check reference signal.

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Symptom	Possible cause	Test	Solution
Motor running in wrong direction	Motor rotation limit.	Check that *parameter H-08 Reverse Lock* is programmed correctly.	Program correct settings.
	Active reversing signal.	Check if a reversing command is programmed for the terminal in parameter group *E-0# Digital inputs*.	Deactivate reversing signal.
	Wrong motor phase connection.		
Motor is not reaching maximum speed	Frequency limits set wrong.	Check output limits in: • *Parameter F-17 Motor Speed High Limit [RPM]*. • *Parameter F-15 Motor Speed High Limit [Hz]*. • *Parameter F-03 Max Output Frequency 1*.	Program correct limits.
	Reference input signal not scaled correctly.	Check reference input signal scaling in AN-## Reference limits in parameter group F-5#.	Program correct settings.
Motor speed unstable	Possible incorrect parameter settings.	Check the settings of all motor parameters, including all motor compensation settings. For closed-loop operation, check PID settings.	Check settings in parameter group AN-##. For closed loop operation, check settings in parameter group CL-0#.
Motor runs rough	Possible overmagnetization.	Check for incorrect motor settings in all motor parameters.	Check motor settings in parameter groups P-0# *Motor Data*, P-3# *Adv Motor Data*, and H-5# *Load Indep. Setting.*
Motor does not brake	Possible incorrect settings in the brake parameters. Possible too short decel times.	Check brake parameters. Check decel time settings.	Check parameter group *B-0# DC Brake* and *F-5# Extended Reference*.
Open power fuses or circuit breaker trip	Phase-to-phase short circuit.	Motor or panel has a short phase-to-phase. Check motor and panel phase for short circuits.	Eliminate any short circuits detected.
	Motor overload.	Motor is overloaded for the application.	Perform start-up test and verify that the motor current is within specifications. If motor current is exceeding nameplate full load current, motor may run only with reduced load. Review the specifications for the application.
	Loose connections.	Perform pre-startup check for loose connections.	Tighten loose connections.
Mains current imbalance greater than 3%	Problem with mains power (See *Alarm 4 Mains phase loss* description).	Rotate input power leads into the frequency converter 1 position: A to B, B to C, C to A.	If imbalanced leg follows the wire, it is a power problem. Check mains power supply.
	Problem with the frequency converter.	Rotate input power leads into the frequency converter 1 position: A to B, B to C, C to A.	If imbalance leg stays on same input terminal, it is a problem with the unit. Contact the supplier.
Motor current imbalance greater than 3%	Problem with motor or motor wiring.	Rotate output motor cables 1 position: U to V, V to W, W to U.	If imbalanced leg follows the wire, the problem is in the motor or motor wiring. Check motor and motor wiring.
	Problem with the frequency converters.	Rotate output motor cables 1 position: U to V, V to W, W to U.	If imbalance leg stays on same output terminal, it is a problem with the unit. Contact the supplier.

Symptom	Possible cause	Test	Solution
Acoustic noise or vibration (for example a fan blade is making noise or vibrations at certain frequencies)	Resonances, for example in the motor/fan system.	Bypass critical frequencies by using parameters in parameter group C-0#.	Check if noise and/or vibration have been reduced to an acceptable limit.
		Turn off overmodulation in *parameter F-38 Overmodulation*.	
		Change switching pattern and frequency in parameter group F-3#.	
		Increase resonance damping in *parameter H-64 Resonance Dampening*.	

Table 11.1 Troubleshooting

12 Terminal and Applicable Wire

12.1 Cables

Power [kW (hp)]				Enclosure	Mains		Motor		Load share		Brake		Ground*
200–240 V [kW (hp)]	380–500 V [kW (hp)]	525–600 V [kW (hp)]	525–690 V [kW (hp)]		Tightening torque [Nm (in-lbs)]	Wire size [mm²(AWG)]	Tightening torque [Nm (in-lbs)]	Wire size [mm²(AWG)]	Tightening torque [Nm (in-lbs)]	Wire size [mm²(AWG)]	Tightening torque [Nm (in-lbs)]	Wire size [mm²(AWG)]	Tightening torque [Nm (in-lbs)]
0.25–2.2 (1/3–3)	0.37–4 (1/2–59)	0.75–4 (1–59)	–	IP20	1.8 (16)	4 (10)	1.8 (16)	4 (10)	1.8 (16)	4 (10)	1.8 (16)	4 (10)	3 (27)
3.7 (5)	5.5–7.5 (7.5–10)	5.5–7.5 (7.5–10)	–	IP20									
0.25–3.7 (1/3–5)	0.37–7.5 (1/2–10)	0.75–7.5 (1–10)	–	IP55 or IP66									
5.5–7.5 (7.5–10)	11–15 (15–20)	11–15 (15–20)	–	IP20		16 (6)		16 (6)		16 (6)		16 (6)	
5.5–7.5 (7.5–10)	11–15 (15–20)	11–15 (15–20)	–	IP55 or IP66					1.5 (14)		1.5 (14)		
11–15 (15–20)	18.5–30 (25–40)	18.5–30 (25–40)	–	IP20	4.5 (40)	35 (2)	4.5 (40)	35 (2)	4.5 (40)	35 (2)	4.5 (40)	35 (2)	
11 (15)	18.5–22 (25–30)	18.5–22 (25–30)	11–22 (15–30)	IP55 or IP66					3.7 (33)		3.7 (33)		
18.5–22 (25–30)	37–45 (50–60)	37–45 (50–60)	–	IP20	10 (89)	50 (1)	10 (89)	50 (1)	10 (89)	50 (1)	10 (89)	50 (1)	
(15–22) (20–30)	30–45 (40–60)	30–45 (40–60)	–	IP55 or IP66		90 (3/0)		90 (3/0)		90 (3/0)		90 (3/0)	
30–37 (40–50)	55–75 (75–100)	55–75 (75–100)	–	IP20	14 (124)	150 (300)	14 (124)	150 (300)	14 (124)	95 (4/0)	14 (124)	95 (4/0)	
30–37 (40–50)	55–75 (75–100)	55–75 (75–100)	30–75 (40–100)	IP55 or IP66		120 (4/0)		120 (4/0)		120 (4/0)		120 (4/0)	
–	90–132 (125–200)	–	90–132 (125–200)	All	19 (168)	2x95 (2x3/0)	19 (168)	2x95 (2x3/0)	19 (75)	2x95 (2x3/0)	8.5 (75)	2x95 (2x3/0)	8.5 (7.5)
–	160–250 (250–350)	–	160–315 (250–400)	All		2x185 (2x350)		2x185 (2x350)		2x185 (2x350)		2x185 (2x350)	19 (168)
–	315–400 (350–550)	–	355–560 (500–750)	All		4x240 (4x500)		4x240 (4x500)	19 (168)	4x240 (4x500)			
–	450–630 (600–900)	–	630–800 (900–1150)	All		8x240 (8x500)		8x150 (8x300)		4x120 (4x250)		4x185 (4x350)	
–	710–800 (1000–1200)	–	900–1200 (1250–1600)	All				12x150 (12x300)				6x185 (6x350)	

* Maximum cable size according to national code

Table 12.1 Cables

12

13 Specifications

13.1 Electrical Data

13.1.1 Mains Supply 200–240 V

Type designation	**0.34 hp**	**0.5 hp**	**0.75 hp**	**1.0 hp**	**1.5 hp**	**2.0 hp**	**3.0 hp**	**5.0 hp**
Typical shaft output [kW]	0.25	0.37	0.55	0.75	1.1	1.5	2.2	3.7
Enclosure protection rating IP20, IP21	12	12	12	12	12	12	12	13
Enclosure protection rating IP55, IP66	14/15	14/15	14/15	14/15	14/15	14/15	14/15	15
Output current								
Continuous (200–240 V) [A]	1.8	2.4	3.5	4.6	6.6	7.5	10.6	16.7
Intermittent (200–240 V) [A]	2.9	3.8	5.6	7.4	10.6	12.0	17.0	26.7
Continuous kVA (208 V) [kVA]	0.65	0.86	1.26	1.66	2.38	2.70	3.82	6.00
Maximum input current								
Continuous (200–240 V) [A]	1.6	2.2	3.2	4.1	5.9	6.8	9.5	15.0
Intermittent (200–240 V) [A]	2.6	3.5	5.1	6.6	9.4	10.9	15.2	24.0
Additional specifications								
Maximum cable cross-section[2)] for mains, motor, brake, and load sharing [mm^2] ([AWG])	4,4,4 (12,12,12) (minimum 0.2 (24))							
Maximum cable cross-section[2)] for disconnect [mm^2] ([AWG])	6,4,4 (10,12,12)							
Estimated power loss at rated maximum load [W][3)]	21	29	42	54	63	82	116	185
Efficiency	0.94	0.94	0.95	0.95	0.96	0.96	0.96	0.96

Table 13.1 Mains Supply 200–240 V, 0.34–5.0 hp

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Type designation	7.5 hp		10 hp		15 hp	
Heavy duty/Ligth duty[1)]	HO	NO	HO	NO	HO	NO
Typical shaft output [kW]	5.5	7.5	7.5	11	11	15
Unit Size IP20	23		23		24	
Enclosure protection rating IP21, IP55, IP66	21		21		22	
Output current						
Continuous (200–240 V) [A]	24.2	30.8	30.8	46.2	46.2	59.4
Intermittent (60 s overload) (200–240 V) [A]	38.7	33.9	49.3	50.8	73.9	65.3
Continuous kVA (208 V) [kVA]	8.7	11.1	11.1	16.6	16.6	21.4
Maximum input current						
Continuous (200–240 V) [A]	22.0	28.0	28.0	42.0	42.0	54.0
Intermittent (60 s overload) (200–240 V) [A]	35.2	30.8	44.8	46.2	67.2	59.4
Additional specifications						
IP20 maximum cable cross-section[2)] for mains, brake, motor, and load sharing [mm^2] ([AWG])	10,10,- (8,8,-)		10,10,- (8,8,-)		35,-,- (2,-,-)	
IP21, IP55, IP66 maximum cable cross-section[2)] for mains, brake, and load sharing [mm^2] ([AWG])	16,10,16 (6,8,6)		16,10,16 (6,8,6)		35,-,- (2,-,-)	
IP21. IP55, IP66 maximum cable cross-section[2)] for motor [mm^2] ([AWG])	10,10,- (8,8,-)		10,10,- (8,8,-)		35,25,25 (2,4,4)	
Estimated power loss at rated maximum load [W][3)]	239	310	371	514	463	602
Efficiency	0.96		0.96		0.96	

Table 13.2 Mains Supply 200–240 V, 7.5–11 hp

Type designation	20 hp		25 hp		30 hp		40 hp		50 hp	
Heavy duty/Ligth duty[1)]	HO	NO	HO	NO	HO	NO	HO	NO	HO	NO
Typical shaft output [kW[	15	18.5	18.5	22	22	30	30	37	37	45
Unit size IP20	24		33		33		44		44	
Unit size IP21, IP55, IP66	31		31		31		32		32	
Output current										
Continuous (200–240 V) [A]	59.4	74.8	74.8	88.0	88.0	115	115	143	143	170
Intermittent (60 s overload) (200–240 V) [A]	89.1	82.3	112	96.8	132	127	173	157	215	187
Continuous kVA (208 V [kVA]	21.4	26.9	26.9	31.7	31.7	41.4	41.4	51.5	51.5	61.2
Maximum input current										
Continuous (200–240 V) [A]	54.0	68.0	68.0	80.0	80.0	104	104	130	130	154
Intermittent (60 s overload) (200–240 V) [A]	81.0	74.8	102	88.0	120	114	156	143	195	169
Additional specifications										
IP20 maximum cable cross-section for mains, brake, motor, and load sharing [mm^2] ([AWG])	35 (2)		50 (1)		50 (1)		150 (300 MCM)		150 (300 MCM)	
IP21, IP55, IP66 maximum cable cross-section for mains and motor [mm^2] ([AWG])	50 (1)		50 (1)		50 (1)		150 (300 MCM)		150 (300 MCM)	
IP21, IP55, IP66 maximum cable cross-section for brake and load sharing [mm^2] ([AWG])	50 (1)		50 (1)		50 (1)		95 (3/0)		95 (3/0)	
Estimated power loss at rated maximum load [W][3)]	624	737	740	845	874	1140	1143	1353	1400	1636
Efficiency	0.96		0.97		0.97		0.97		0.97	

Table 13.3 Mains Supply 200–240 V, 20–50 hp

13.1.2 Mains Supply 380–500 V

Type designation	0.5 hp	0.75 hp	1.0 hp	1.5 hp	2.0 hp	3.0 hp	4.0 hp	5.0 hp	7.5 hp	10 hp
Typical shaft output [kW]	0.37	0.55	0.75	1.1	1.5	2.2	3.0	4.0	5.5	7.5
Enclosure protection rating IP20, IP21	12	12	12	12	12	12	12	12	13	13
Enclosure protection rating IP55, IP66	14/15	14/15	14/15	14/15	14/15	14/15	14/15	14/15	15	15
Output current										
Continuous (380–440 V) [A]	1.3	1.8	2.4	3.0	4.1	5.6	7.2	10	13	16
Intermittent (380–440 V) [A]	2.1	2.9	3.8	4.8	6.6	9.0	11.5	16	20.8	25.6
Continuous (441–500 V) [A]	1.2	1.6	2.1	2.7	3.4	4.8	6.3	8.2	11	14.5
Intermittent (441–500 V) [A]	1.9	2.6	3.4	4.3	5.4	7.7	10.1	13.1	17.6	23.2
Continuous kVA (400 V) [kVA]	0.9	1.3	1.7	2.1	2.8	3.9	5.0	6.9	9.0	11
Continuous kVA (460 V) [kVA]	0.9	1.3	1.7	2.4	2.7	3.8	5.0	6.5	8.8	11.6
Maximum input current										
Continuous (380–440 V) [A]	1.2	1.6	2.2	2.7	3.7	5.0	6.5	9.0	11.7	14.4
Intermittent (380–440 V) [A]	1.9	2.6	3.5	4.3	5.9	8.0	10.4	14.4	18.7	23
Continuous (441–500 V) [A]	1.0	1.4	1.9	2.7	3.1	4.3	5.7	7.4	9.9	13
Intermittent (441–500 V) [A]	1.6	2.2	3.0	4.3	5.0	6.9	9.1	11.8	15.8	20.8
Additional specifications										
IP20, IP21 maximum cable cross-section2) for mains, motor, brake, and load sharing [mm^2] ([AWG])	4,4,4 (12,12,12) (minimum 0.2(24))									
IP55, IP66 maximum cable cross-section2) for mains, motor, brake, and load sharing [mm^2] ([AWG])	4,4,4 (12,12,12)									
Maximum cable cross-section2) for disconnect [mm^2] ([AWG])	6,4,4 (10,12,12)									
Estimated power loss at rated maximum load [W3)	35	42	46	58	62	88	116	124	187	255
Efficiency	0.93	0.95	0.96	0.96	0.97	0.97	0.97	0.97	0.97	0.97

Table 13.4 Mains Supply 380–500 V, 0.37–10 hp

Type designation	15 hp		20 hp		25 hp		30 hp	
Heavy duty/Ligth duty[1]	HD	LD	HD	LD	HD	LD	HD	LD
Typical shaft output [kW]	11	15	15	18.5	18.5	22	22	30
Typical shaft output [hp] at 460 V	15	20	20	25	25	30	30	40
Unit Size IP20	23		23		24		24	
Unit Size IP21, IP55, IP66	21		21		22		22	
Output current								
Continuous (380–440 V) [A]	24	32	32	37.5	37.5	44	44	61
Intermittent (60 s overload) (380–440 V) [A]	38.4	35.2	51.2	41.3	60	48.4	70.4	67.1
Continuous (441–500 V) [A]	21	27	27	34	34	40	40	52
Intermittent (60 s overload) (441–500 V) [A]	33.6	29.7	43.2	37.4	54.4	44	64	57.2
Continuous kVA (400 V) [kVA]	16.6	22.2	22.2	26	26	30.5	30.5	42.3
Continuous kVA (460 V) [kVA]	–	21.5	–	27.1	–	31.9	–	41.4
Maximum input current								
Continuous (380–440 V) [A]	22	29	29	34	34	40	40	55
Intermittent (60 s overload) (380–440 V) [A]	35.2	31.9	46.4	37.4	54.4	44	64	60.5
Continuous (441–500 V) [A]	19	25	25	31	31	36	36	47
Intermittent (60 s overload) (441–500 V) [A]	30.4	27.5	40	34.1	49.6	39.6	57.6	51.7
Additional specifications								
IP21, IP55, IP66 maximum cable cross-section[2] for mains, brake, and load sharing [mm^2] ([AWG])	16, 10, 16 (6, 8, 6)		16, 10, 16 (6, 8, 6)		35,-,-(2,-,-)		35,-,-(2,-,-)	
IP21, IP55, IP66 maximum cable cross-section[2] for motor [mm^2] ([AWG])	10, 10,- (8, 8,-)		10, 10,- (8, 8,-)		35, 25, 25 (2, 4, 4)		35, 25, 25 (2, 4, 4)	
IP20 maximum cable cross-section[2] for mains, brake, motor, and load sharing [mm^2] ([AWG])	10, 10,- (8, 8,-)		10, 10,- (8, 8,-)		35,-,-(2,-,-)		35,-,-(2,-,-)	
Estimated power loss at rated maximum load [W][3]	291	392	379	465	444	525	547	739
Efficiency	0.98		0.98		0.98		0.98	

Table 13.5 Mains Supply 380–500 V, 15–30 hp

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Type designation	40 hp		50 hp		60 hp		75 hp		100 hp	
Heavy duty/Ligth duty[1)]	HD	LD	HD	LD	HD	LD	HD	LD	HD	LD
Typical shaft output [kW]	30	37	37	45	45	55	55	75	75	90
Unit Size IP20	24		33		33		34		34	
Unit Size IP21, IP55, IP66	31		31		31		32		32	
Output current										
Continuous (380–440 V) [A]	61	73	73	90	90	106	106	147	147	177
Intermittent (60 s overload) (380–440 V) [A]	91.5	80.3	110	99	135	117	159	162	221	195
Continuous (441–500 V) [A]	52	65	65	80	80	105	105	130	130	160
Intermittent (60 s overload) (441–500 V) [A]	78	71.5	97.5	88	120	116	158	143	195	176
Continuous kVA (400 V) [kVA]	42.3	50.6	50.6	62.4	62.4	73.4	73.4	102	102	123
Continuous kVA (460 V) [kVA]	–	51.8	–	63.7	–	83.7	–	104	–	128
Maximum input current										
Continuous (380–440 V) [A]	55	66	66	82	82	96	96	133	133	161
Intermittent (60 s overload) (380–440 V) [A]	82.5	72.6	99	90.2	123	106	144	146	200	177
Continuous (441–500 V) [A]	47	59	59	73	73	95	95	118	118	145
Intermittent (60 s overload) (441–500 V) [A]	70.5	64.9	88.5	80.3	110	105	143	130	177	160
Additional specifications										
IP20 maximum cable cross-section for mains and motor [mm^2] ([AWG])	35 (2)		50 (1)		50 (1)		150 (300 MCM)		150 (300 MCM)	
IP20 maximum cable cross-section for brake and load sharing [mm^2] ([AWG])	35 (2)		50 (1)		50 (1)		95 (4/0)		95 (4/0)	
IP21, IP55, IP66 maximum cable cross-section for mains and motor [mm^2] ([AWG])	50 (1)		50 (1)		50 (1)		150 (300 MCM)		150 (300 MCM)	
IP21, IP55, IP66 maximum cable cross-section for brake and load sharing [mm^2] ([AWG])	50 (1)		50 (1)		50 (1)		95 (3/0)		95 (3/0)	
Estimated power loss at rated maximum load [W][3)]	570	698	697	843	891	1083	1022	1384	1232	1474
Efficiency	0.98		0.98		0.98		0.98		0.99	

Table 13.6 Mains Supply 380–500 V , 40–100 hp

AF-650 GP	125 hp		150 hp		175 hp		250 hp		300 hp		350 hp	
Heavy duty/Ligth duty*	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**
Typical shaft output at 400 V [kW]	90	110	110	132	132	160	160	200	200	250	250	315
Typical shaft output at 460 V [hp]	125	150	150	200	200	250	250	300	300	350	350	450
Typical shaft ouptut at 500 V [kW]	110	132	132	160	160	200	200	250	250	315	315	355
Enclosure IP20	43h		43h		43h		44h		44h		44h	
Enclosure IP21, IP54	41h		41h		41h		42h		42h		42h	
Output current												
Continuous (at 400 V) [A]	177	212	212	260	260	315	315	395	395	480	480	588
Intermittent (60 s overload) (at 400 V)[A]	266	233	318	286	390	347	473	435	593	528	720	647
Continuous (at 460/500 V) [A]	160	190	190	240	240	302	302	361	361	443	443	535
Intermittent (60 s overload) (at 460/500 V) [kVA]	240	209	285	264	360	332	453	397	542	487	665	588
Continuous kVA (at 400 V) [kVA]	123	147	147	180	180	218	218	274	274	333	333	407
Continuous kVA (at 460 V) [kVA]	127	151	151	191	191	241	241	288	288	353	353	426
Continuous kVA (at 500 V) [kVA]	139	165	165	208	208	262	262	313	313	384	384	463
Maximum input current												
Continuous (at 400 V) [A]	171	204	204	251	251	304	304	381	381	463	463	567
Continuous (at 460/500 V) [A]	154	183	183	231	231	291	291	348	348	427	427	516
Max. cable size: mains, motor, brake and load share [mm^2 (AWG)]1)2)	2x95 (2x3/0)						2x185 (2x350 mcm)					
Max. external mains fuses [A]3)	315		350		400		550		630		800	
Estimated power loss at 400 V [W]4) 5)	2031	2559	2289	2954	2923	3770	3093	4116	4039	5137	5005	6674
Estimated power loss at 460 V [W]4) 5)	1828	2261	2051	2724	2089	3628	2872	3569	3575	4566	4458	5714
Weight, enclosure IP20, IP21, IP54 [kg/(lb)]6)	62 (135)						125 (275)					
Efficiency5)	0.98											
Output frequency	0-590 Hz											
Heatsink overtemp trip [° C/(° F)]	110 (230)											
Control card ambient trip [° C/(° F)]	75 (167)						80 (176)					
*High overload=150% current for 60 s, Normal overload=110% current for 60 s												

Table 13.7 Technical Specifications, Unit Size 4xh 380–500 V

1) American Wire Gauge.

2) Wiring terminals on N132, N160, and N315 frequency converters cannot receive cables one size larger.

3) For fuse ratings, see chapter 13.3 Fuse Specifications.

4) Typical power loss is at normal conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions.) These values are based on a typical motor efficiency (IE/IE3 border line). Lower efficiency motors add to the power loss in the frequency converter. Applies for dimensioning of frequency converter cooling. If the switching frequency is higher than the default setting, the power losses may increase. Keypad and typical control card power consumptions are included. Options and customer load can add up to 30 W to the losses, though usually a fully loaded control card and options for slots A and B each add only 4 W.

5) Measured using 5 m (16.4 ft) screened motor cables at rated load and rated frequency.

Efficiency measured at nominal current. For energy efficiency class, see chapter 13.2 General Technical DataEnvironment.

6) Additional frame size weights are as follows: 45h - 166 (255) / 46h - 129 (285) / 47h - 200 (440) / 48h - 225 (496). Weights are in kg (lbs).

AF-650 GP	450 hp		500 hp		550 hp	
Heavy duty/Light duty*	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**
Typical shaft output at 400 V [kW]	315	355	355	400	400	450
Typical shaft output at 460 V [hp]	450	500	500	600	550	600
Typical shaft output at 500 V [kW]	355	400	400	500	500	530
IP21/NEMA 1 Drive Type	51		51		51	
IP54/NEMA 12 drive type	51		51		51	
IP00 Open Chassis Drive Type	52		52		52	
Output current						
Continuous (at 400 V) [A]	600	658	658	745	695	800
Intermittent (60 s overload) (at 400 V) [A]	900	724	987	820	1043	880
Continuous (at 460/500 V) [A]	540	590	590	678	678	730
Intermittent (60 s overload) (at 460/500 V) [A]	810	649	885	746	1017	803
Continuous kVA (at 400 V) [kVA]	416	456	456	516	482	554
Continuous kVA (at 460 V) [kVA]	430	470	470	540	540	582
Continuous kVA (at 500 V) [kVA]	468	511	511	587	587	632
Maximum input current						
Continuous (at 400 V) [A]	590	647	647	733	684	787
Continuous (at 460/500 V) [A]	531	580	580	667	667	718
Max. cable size, mains, motor and load share [mm^2 (AWG)] [1)2)]	4x240 (4x500 mcm)		4x240 (4x500 mcm)		4x240 (4x500 mcm)	
Max. cable size, brake [mm^2 (AWG)[1)]	2x185 (2x350 mcm)		2x185 (2x350 mcm)		2x185 (2x350 mcm)	
Max. external mains fuses [A][3)]	900		900		900	
Estimated power loss at 400 V [W][4) 5)]	6794	7532	7498	8677	7976	9473
Estimated power loss at 460 V [W] [4)5)]	6118	6724	6672	7819	7814	8527
Weight, Unit Size IP21, IP54 [kg/(lb)]	270 (595)		272 (600)		313 (690)	
Weight, Unit Size IP00 [kg/(lb)]	234 (516)		236 (520)		277 (611)	
Efficiency[5)]	0.98					
Output frequency	0-590 Hz					
Heatsink overtemp. trip [° C/(° F)]	110 (230)					
Control card ambient trip [° C/(° F)]	85 (185)					
* Heavy Duty=160% torque during 60 s, Light Duty=110% torque during 60 s.						

Table 13.8 Technical Specifications, Unit Size 5x 380–500 V

1) American Wire Gauge.
2) Wiring terminals on N132, N160, and P315 frequency converters cannot receive cables one size larger.
3) For fuse ratings, see chapter 13.3 Fuse Specifications.
4) Typical power loss is at normal conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions.) These values are based on a typical motor efficiency (IE/IE3 border line). Lower efficiency motors add to the power loss in the frequency converter. Applies for dimensioning of frequency converter cooling. If the switching frequency is higher than the default setting, the power losses may increase. Keypad and typical control card power consumptions are included.Options and customer load can add up to 30 W to the losses, though usually a fully loaded control card and options for slots A and B each add only 4 W.
5) Measured using 5 m (16.4 ft) screened motor cables at rated load and rated frequency.
Efficiency measured at nominal current. For energy efficiency class, see chapter 13.2 General Technical DataEnvironment.

AF-650 GP	600 hp		650 hp		750 hp		900 hp		1000 hp		1200 hp	
Heavy duty/Light duty*	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**	**HD**	**LD**
Typical shaft output at 400 V [kW]	450	500	500	560	560	630	630	710	710	800	800	1000
Typical shaft output at 460 V [hp]	600	650	650	750	750	900	900	1000	1000	1200	1200	1350
Typical shaft output at 500 V [kW]	530	560	560	630	630	710	710	800	800	1000	1000	1100
IP21/NEMA 1 and IP54/NEMA 12 drive types without/with options cabinet	61/ 63		61/ 63		61/ 63		61/ 63		62/ 64		62/ 64	
Output current												
Continuous (at 400 V) [A]	800	880	880	990	990	1120	1120	1260	1260	1460	1460	1720
Intermittent (60 s overload) (at 400 V) [A]	1200	968	1320	1089	1485	1232	1680	1386	1890	1606	2190	1892
Continuous (at 460/500 V) [A]	730	780	780	890	890	1050	1050	1160	1160	1380	1380	1530
Intermittent (60 s overload) (at 460/500 V) [A]	1095	858	1170	979	1335	1155	1575	1276	1740	1518	2070	1683
Continuous kVA (at 400 V) [kVA]	554	610	610	686	686	776	776	873	873	1012	1012	1192
Continuous kVA (at 460 V) [kVA]	582	621	621	709	709	837	837	924	924	1100	1100	1219
Continuous kVA (at 500 V) [kVA]	632	675	675	771	771	909	909	1005	1005	1195	1195	1325
Maximum input current												
Continuous (at 400 V) [A]	779	857	857	964	964	1090	1090	1227	1227	1422	1422	1675
Continuous (at 460/500 V) [A]	711	759	759	867	867	1022	1022	1129	1129	1344	1344	1490
Max. cable size,motor [mm² (AWG)[1)]]	8x150 (8x300 mcm)								12x150 (12x300 mcm)			
Max. cable size,mains 61/62 [mm² (AWG)[1)]]	8x240 (8x500 mcm)											
Max. cable size,mains 63/64 [mm² (AWG)[1)]]	8x456 (8x900 mcm)											
Max. cable size, loadsharing [mm² (AWG)[1)]]	4x120 (4x250 mcm)											
Max. cable size, brake [mm² (AWG)[1)]	4x185 (4x350 mcm)								6x185 (6x350 mcm)			
Max. external mains fuses [A][2)]	1600				2000				2500			
Estimated power loss at 400 V [W][3)4)]	9031	10162	10146	11822	10649	12512	12490	14674	14244	17293	15466	19278
Estimated power loss at 460 V [W] [3) 4)]	8212	8876	8860	10424	9414	11595	11581	13213	13005	16229	14556	16624
63/64 maximum added losses A1 RFI, CB or Disconnect, & contactor 63/64	893	963	951	1054	978	1093	1092	1230	2067	2280	2236	2541
Maximum panel options losses	400											
Weight, unit size IP21, IP54 [kg]	1017/1318								1260/1561			
Weight, rectifier module [kg/(lb)]	102 (225)		102 (225)		102 (225)		102 (225)		136 (300)		136 (300)	
Weight, inverter module [kg/(lb)]	102 (225)		102 (225)		102 (225)		136 (300)		102 (225)		102 (225)	
Efficiency[4)]	0.98											
Output frequency	0-590 Hz											
Heatsink overtemp. trip [° C/(° F)]	110 (230)											
Control card ambient trip [° C/(° F)]	85 (185)											
* Heavy duty=160% torque during 60 s, Light duty=110% torque during 60 s.												

Table 13.9 Technical Specifications, Unit Size 6x, 380–500 V

1) American Wire Gauge.

2) For fuse ratings, see chapter 13.3 Fuse Specifications.

3) Typical power loss is at normal conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions.) These values are based on a typical motor efficiency (IE/IE3 border line). Lower efficiency motors add to the power loss in the frequency converter. Applies for dimensioning of frequency converter cooling. If the switching frequency is higher than the default setting, the power losses may *increase. Keypad and typical control card power consumptions are included. Options and customer load can add up to 30 W to the losses, though usually a fully loaded control card and options for slots A and B each add only 4 W.*

4) Measured using 5 m (16.4 ft) screened motor cables at rated load and rated frequency.

Efficiency measured at nominal current. For energy efficiency class, see chapter 13.2 General Technical DataEnvironment.

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13.1.3 Mains Supply 525–600 V

Type designation	1 hp	1.5 hp	2.0 hp	3.0 hp	4.0 hp	5.0 hp	7.5 hp	10 hp
Typical shaft output [kW]	0.75	1.1	1.5	2.2	3	4	5.5	7.5
Enclosure protection rating IP20, IP21	A3	A3	A3	A3	A3	A3	A3	A3
Enclosure protection rating IP55	A5	A5	A5	A5	A5	A5	A5	A5
Output current								
Continuous (525–550 V) [A]	1.8	2.6	2.9	4.1	5.2	6.4	9.5	11.5
Intermittent (525–550 V) [A]	2.9	4.2	4.6	6.6	8.3	10.2	15.2	18.4
Continuous (551–600 V) [A]	1.7	2.4	2.7	3.9	4.9	6.1	9.0	11.0
Intermittent (551–600 V) [A]	2.7	3.8	4.3	6.2	7.8	9.8	14.4	17.6
Continuous kVA (525 V) [kVA]	1.7	2.5	2.8	3.9	5.0	6.1	9.0	11.0
Continuous kVA (575 V) [kVA]	1.7	2.4	2.7	3.9	4.9	6.1	9.0	11.0
Maximum input current								
Continuous (525–600 V) [A]	1.7	2.4	2.7	4.1	5.2	5.8	8.6	10.4
Intermittent (525–600 V) [A]	2.7	3.8	4.3	6.6	8.3	9.3	13.8	16.6
Additional specifications								
Maximum cable cross-section[2)] for mains, motor, brake, and load sharing [mm^2] ([AWG])	4,4,4 (12,12,12) (minimum 0.2 (24))							
Maximum cable cross-section[2)] for disconnect [mm^2] ([AWG])	6,4,4 (10,12,12)							
Estimated power loss at rated maximum load [W][3)]	35	50	65	92	122	145	195	261
Efficiency	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97

Table 13.10 Mains Supply 525–600 V (AF-650 GP only), 1–10 hp

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Type designation	15 hp		20 hp		25 hp		30 hp		40 hp	
Heavy duty/Light duty[1)]	HD	LD	HD	LD	HD	LD	HD	LD	HD	LD
Typical shaft output [kW]	11	15	15	18.5	18.5	22	22	30	30	37
Typical shaft output [hp] at 575 V	15	20	20	25	25	30	30	40	40	50
Unit Size IP20	23		23		24		24		24	
Unit SizeIP21, IP55, IP66	21		21		22		22		31	
Output current										
Continuous (525–550 V) [A]	19	23	23	28	28	36	36	43	43	54
Intermittent (525–550 V) [A]	30	25	37	31	45	40	58	47	65	59
Continuous (551–600 V) [A]	18	22	22	27	27	34	34	41	41	52
Intermittent (551–600 V) [A]	29	24	35	30	43	37	54	45	62	57
Continuous kVA (550 V) [kVA]	18.1	21.9	21.9	26.7	26.7	34.3	34.3	41.0	41.0	51.4
Continuous kVA (575 V) [kVA]	17.9	21.9	21.9	26.9	26.9	33.9	33.9	40.8	40.8	51.8
Maximum input current										
Continuous at 550 V [A]	17.2	20.9	20.9	25.4	25.4	32.7	32.7	39	39	49
Intermittent at 550 V [A]	28	23	33	28	41	36	52	43	59	54
Continuous at 575 V [A]	16	20	20	24	24	31	31	37	37	47
Intermittent at 575 V [A]	26	22	32	27	39	34	50	41	56	52
Additional specifications										
IP20 maximum cable cross-section[2)] for mains, brake, motor, and load sharing [mm^2] ([AWG])	10, 10,- (8, 8,-)		10, 10,- (8, 8,-)		35,-,-(2,-,-)		35,-,-(2,-,-)		35,-,-(2,-,-)	
IP21, IP55, IP66 maximum cable cross-section[2)] for mains, brake, and load sharing [mm^2] ([AWG])	16, 10, 10 (6, 8, 8)		16, 10, 10 (6, 8, 8)		35,-,-(2,-,-)		35,-,-(2,-,-)		50,-,- (1,-,-)	
IP21, IP55, IP66 maximum cable cross-section[2)] for motor [mm^2] ([AWG])	10, 10,- (8, 8,-)		10, 10,- (8, 8,-)		35, 25, 25 (2, 4, 4)		35, 25, 25 (2, 4, 4)		50,-,- (1,-,-)	
Estimated power loss at rated maximum load [W][3)]	220	300	300	370	370	440	440	600	600	740
Efficiency	0.98		0.98		0.98		0.98		0.98	

Table 13.11 Mains Supply 525–600 V , 15–40 hp

Type designation	50 hp		60 hp		75 hp		100 hp	
Heavy duty/Light duty[1)]	HD	LD	HD	LD	HD	LD	HD	LD
Typical shaft output [kW]	37	45	45	55	55	75	75	90
Typical shaft output [hp] at 575 V	50	60	60	74	75	100	100	120
Unit Size IP20	33	33	33		34		34	
Unit Size IP21, IP55, IP66	31	31	31		32		32	
Output current								
Continuous (525–550 V) [A]	54	65	65	87	87	105	105	137
Intermittent (525–550 V) [A]	81	72	98	96	131	116	158	151
Continuous (551–600 V) [A]	52	62	62	83	83	100	100	131
Intermittent (551–600 V) [A]	78	68	93	91	125	110	150	144
Continuous kVA (550 V) [kVA]	51.4	61.9	61.9	82.9	82.9	100.0	100.0	130.5
Continuous kVA (575 V) [kVA]	51.8	61.7	61.7	82.7	82.7	99.6	99.6	130.5
Maximum input current								
Continuous at 550 V [A]	49	59	59	78.9	78.9	95.3	95.3	124.3
Intermittent at 550 V [A]	74	65	89	87	118	105	143	137
Continuous at 575 V [A]	47	56	56	75	75	91	91	119
Intermittent at 575 V [A]	70	62	85	83	113	100	137	131
Additional specifications								
IP20 maximum cable cross-section for mains and motor [mm^2] ([AWG])	50 (1)				150 (300 MCM)			
IP20 maximum cable cross-section for brake and load sharing [mm^2] ([AWG])	50 (1)				95 (4/0)			
IP21, IP55, IP66 maximum cable cross-section for mains and motor [mm^2] ([AWG])	50 (1)				150 (300 MCM)			
IP21, IP55, IP66 maximum cable cross-section for brake and load sharing [mm^2] ([AWG])	50 (1)				95 (4/0)			
Estimated power loss at rated maximum load [W][3)]	740	900	900	1100	1100	1500	1500	1800
Efficiency	0.98		0.98		0.98		0.98	

Table 13.12 Mains Supply 525–600 V, 50–100 hp

For fuse ratings, see chapter 13.3 Fuse Specifications.

1) Heavy duty (HD)=150% or 160% torque for a duration of 60 s. Light duty (LD)=110% torque for a duration of 60 s.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

3) Applies for dimensioning of frequency converter cooling. If the switching frequency is higher than the default setting, the power losses may increase. keypad and typical control card power consumptions are included.

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13.1.4 Mains Supply 525–690 V

Type designation	1.5 hp	2.0 hp	2.2 hp	4.0 hp	5.0 hp	7.5 hp	10 hp
Heavy Duty/Light Duty[1)]	HO/NO	HO/NO	HO/NO	HO/NO	HO/NO	HO/NO	HO/NO
Typical shaft output [kW/(hp)]	1.1 (1.5)	1.5 (2.0)	2.2 (3.0)	3.0 (4.0)	4.0 (5.0)	5.5 (7.5)	7.5 (10)
Enclosure protection rating IP20	13	13	13	13	13	13	13
Output current							
Continuous (525–550 V) [A]	2.1	2.7	3.9	4.9	6.1	9.0	11.0
Intermittent (525–550 V) [A]	3.4	4.3	6.2	7.8	9.8	14.4	17.6
Continuous (551–690 V) [A]	1.6	2.2	3.2	4.5	5.5	7.5	10.0
Intermittent (551–690 V) [A]	2.6	3.5	5.1	7.2	8.8	12.0	16.0
Continuous kVA 525 V	1.9	2.5	3.5	4.5	5.5	8.2	10.0
Continuous kVA 690 V	1.9	2.6	3.8	5.4	6.6	9.0	12.0
Maximum input current							
Continuous (525–550 V) [A]	1.9	2.4	3.5	4.4	5.5	8.1	9.9
Intermittent (525–550 V) [A]	3.0	3.9	5.6	7.0	8.8	12.9	15.8
Continuous (551–690 V) [A]	1.4	2.0	2.9	4.0	4.9	6.7	9.0
Intermittent (551–690 V) [A]	2.3	3.2	4.6	6.5	7.9	10.8	14.4
Additional specifications							
Maximum cable cross-section[2)] for mains, motor, brake, and load sharing [mm^2] ([AWG])	4, 4, 4 (12, 12, 12) (minimum 0.2 (24)						
Maximum cable cross-section[2)] for disconnect [mm^2] ([AWG])	6, 4, 4 (10, 12, 12)						
Estimated power loss at rated maximum load (W)[3)]	44	60	88	120	160	220	300
Efficiency	0.96	0.96	0.96	0.96	0.96	0.96	0.96

Table 13.13 Mains Supply 525–690 V IP20/Protected Chassis, 1.5–10 hp

Type designation	15 hp		20 hp		25 hp		30 hp	
Heavy Duty/Light Duty[1)]	HD	LD	HD	LD	HD	LD	HD	LD
Typical shaft output at 550 V [kW/(hp)]	7.5 (10)	11 (15)	11 (15)	15 (20)	15 (20)	18.5 (25)	18.5 (25)	22 (30)
Typical shaft output at 690 V [kW/(hp)]	11 (15)	15 (20)	15 (20)	18.5 (25)	18.5 (25)	22 (30)	22 (30)	30 (40)
Enclosure protection rating IP20	24		24		24		24	
Enclosure protection rating IP21, IP55	22		22		22		22	
Output current								
Continuous (525–550 V) [A]	14.0	19.0	19.0	23.0	23.0	28.0	28.0	36.0
Intermittent (60 s overload) (525–550 V) [A]	22.4	20.9	30.4	25.3	36.8	30.8	44.8	39.6
Continuous (551–690 V) [A]	13.0	18.0	18.0	22.0	22.0	27.0	27.0	34.0
Intermittent (60 s overload) (551–690 V) [A]	20.8	19.8	28.8	24.2	35.2	29.7	43.2	37.4
Continuous kVA (at 550 V) [kVA]	13.3	18.1	18.1	21.9	21.9	26.7	26.7	34.3
Continuous kVA (at 690 V) [kVA]	15.5	21.5	21.5	26.3	26.3	32.3	32.3	40.6
Maximum input current								
Continuous (at 550 V) (A)	15.0	19.5	19.5	24.0	24.0	29.0	29.0	36.0
Intermittent (60 s overload) (at 550 V) (A)	23.2	21.5	31.2	26.4	38.4	31.9	46.4	39.6
Continuous (at 690 V) (A)	14.5	19.5	19.5	24.0	24.0	29.0	29.0	36.0
Intermittent (60 s overload) (at 690 V) (A)	23.2	21.5	31.2	26.4	38.4	31.9	46.4	39.6
Additional specifications								
Maximum cable cross-section[2)] for mains/motor, load share, and brake [mm^2] ([AWG])	35, 25, 25 (2, 4, 4)							
Estimated power loss at rated maximum load (W)[3)]	150	220	220	300	300	370	370	440
Efficiency	0.98		0.98		0.98		0.98	

Table 13.14 Mains Supply 525–690 V IP20/IP21/IP55 - Chassis/NEMA 1/NEMA 12, 15–30 hp

Type designation	40 hp		50 hp		60 hp		75 hp		100 hp	
Heavy Duty/Light Duty[1)]	HD	LD	HD	LD	HD	LD	HD	LD	HD	LD
Typical shaft output at 550 V [kW/(hp)]	22 (30)	30 (40)	30 (40)	37 (50)	37 (50)	45 (60)	45 (60)	55 (75)	55 (75)	75 (100)
Typical shaft output at 690 V [kW/(hp)]	30 (40)	37 (50)	37 (50)	45 (60)	45 (60)	55 (75)	55 (75)	75 (100)	75 (100)	90 (125)
Enclosure protection rating IP20	24		33		33		43H		43H	
Enclosure protection rating IP21, IP55	32		32		32		32		32	
Output current										
Continuous (525–550 V) [A]	36.0	43.0	43.0	54.0	54.0	65.0	65.0	87.0	87.0	105
Intermittent (60 s overload) (525–550 V) [A]	54.0	47.3	64.5	59.4	81.0	71.5	97.5	95.7	130.5	115.5
Continuous (551–690 V) [A]	34.0	41.0	41.0	52.0	52.0	62.0	62.0	83.0	83.0	100
Intermittent (60 s overload) (551–690 V) [A]	51.0	45.1	61.5	57.2	78.0	68.2	93.0	91.3	124.5	110
continuous kVA (at 550 V) [kVA]	34.3	41.0	41.0	51.4	51.4	61.9	61.9	82.9	82.9	100
continuous kVA (at 690 V) [kVA]	40.6	49.0	49.0	62.1	62.1	74.1	74.1	99.2	99.2	119.5
Maximum input current										
Continuous (at 550 V) [A]	36.0	49.0	49.0	59.0	59.0	71.0	71.0	87.0	87.0	99.0
Intermittent (60 s overload) (at 550 V) [A]	54.0	53.9	72.0	64.9	87.0	78.1	105.0	95.7	129	108.9
Continuous (at 690 V) [A]	36.0	48.0	48.0	58.0	58.0	70.0	70.0	86.0	–	–
Intermittent (60 s overload) (at 690 V) [A]	54.0	52.8	72.0	63.8	87.0	77.0	105	94.6	–	–
Additional specifications										
Maximum cable cross-section for mains and motor [mm^2] ([AWG])	150 (300 MCM)									
Maximum cable cross-section for load share and brake [mm^2] ([AWG])	95 (3/0)									
Estimated power loss at rated maximum load [W][3)]	600	740	740	900	900	1100	1100	1500	1500	1800
Efficiency	0.98		0.98		0.98		0.98		0.98	

Table 13.15 Mains Supply 525–690 V IP20/IP21/IP55 – Chassis/NEMA1/NEMA 12 40–100 hp

For fuse ratings, see chapter 13.3 Fuse Specifications.

1) Heavy duty (HD)=150% or 160% torque for a duration of 60 s. Light duty (LD)=110% torque for a duration of 60 s.

2) The 3 values for the maximum cable cross-section are for single core, flexible wire, and flexible wire with sleeve, respectively.

3) Applies for dimensioning of frequency converter cooling. If the switching frequency is higher than the default setting, the power losses may increase. keypad and typical control card power consumptions are included.

13.2 General Technical Data

Mains supply

Supply voltage	200–240 V ±
Supply voltage	380–500 V ±10%
Supply voltage	525–600 V ±10%
Supply voltage	525–690 V ±10%

Mains voltage low/mains drop-out:
During low mains voltage or a mains drop-out, the AF-650 GP drive continues until the DC-link voltage drops below the minimum stop level, which corresponds typically to 15% below the frequency converter's lowest rated supply voltage. Power-up and full torque cannot be expected at mains voltage lower than 10% below the frequency converter's lowest rated supply voltage.

Supply frequency	50/60 Hz ±5%
Maximum imbalance temporary between mains phases	3.0% of rated supply voltage
True Power Factor (λ)	≥ 0.9 nominal at rated load
Displacement Power Factor (cos ϕ)	near unity (> 0.98)
Switching on input supply L1, L2, L3 (power-ups) ≤ 7.5 kW (10 hp)	maximum 2 times/minute
Switching on input supply L1, L2, L3 (power-ups) 11–75kW/15–100 hp	maximum 1 time/minute
Switching on input supply L1, L2, L3 (power-ups) ≥ 90 kW (125 hp)	maximum 1 time/2 min.
Environment according to EN60664-1	overvoltage category III/pollution degree 2

The unit is suitable for use on a circuit capable of delivering not more than 100 kAIC RMS symmetrical Amperes, 240/500/600/690 V maximum.

Motor output (U, V, W[1)])

Output voltage	0–100% of supply voltage
Output frequency	0–590 Hz
Switching on output	Unlimited
Ramp times	0.01–3600 s

Torque characteristics

Starting torque (constant torque)	maximum 150% for 60 s[1)] once in 10 minutes
Starting/overload torque (variable torque)	maximum 110% for 60 s[1)] once in 10 minutes
Torque rise time in Flux Vector Vector Control (for 5 kHz fsw)	1 ms
Torque rise time in Advanced Vector Control (independent of fsw)	10 ms

1) Percentage relates to the nominal torque.
2) The torque response time depends on application and load but as a rule, the torque step from 0 to reference is 4–5 x torque rise time.

Digital inputs

Programmable digital inputs	4 (6)[1)]
Terminal number	18, 19, 27[1)], 29[1)], 32, 33
Logic	PNP or NPN
Voltage level	0–24 V DC
Voltage level, logic 0 PNP	<5 V DC
Voltage level, logic 1 PNP	>10 V DC
Voltage level, logic 0 NPN[2)]	>19 V DC
Voltage level, logic 1 NPN[2)]	<14 V DC
Maximum voltage on input	28 V DC
Pulse frequency range	0–110 kHz
(Duty cycle) minimum pulse width	4.5 ms
Input resistance, R_i	approximately 4 kΩ

STO terminal 37[2)] (terminal 37 is fixed PNP logic)

Voltage level	0–24 V DC
Voltage level, logic 0 PNP	<4 V DC
Voltage level, logic 1 PNP	>20 V DC
Maximum voltage on input	28 V DC

Typical input current at 24 V	50 mA rms
Typical input current at 20 V	60 mA rms
Input capacitance	400 nF

All digital inputs are galvanically isolated from the supply voltage (PELV) and other high voltage terminals.

1) Terminals 27 and 29 can also be programmed as output.

2) See for further information about terminal 37 and STO.

Analog inputs

Number of analog inputs	2
Terminal number	53, 54
Modes	Voltage or current
Mode select	Switch S201 and switch S202
Voltage mode	Switch S201/switch S202 = OFF (U)
Voltage level	-10 V to +10 V (scaleable)
Input resistance, R_i	approximately 10 kΩ
Maximum voltage	±20 V
Current mode	Switch S201/switch S202 = ON (I)
Current level	0/4 to 20 mA (scaleable)
Input resistance, R_i	approximately 200 Ω
Maximum current	30 mA
Resolution for analog inputs	10 bit (+ sign)
Accuracy of analog inputs	Maximum error 0.5% of full scale
Bandwidth	100 Hz

The analog inputs are galvanically isolated from the supply voltage (PELV) and other high voltage terminals.

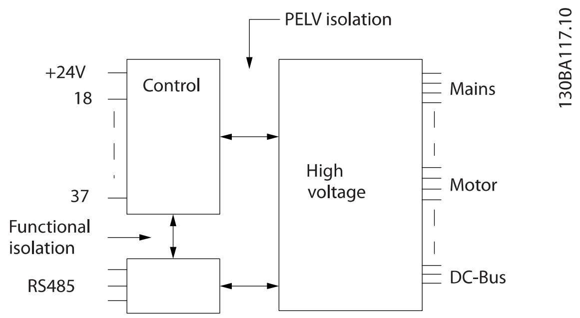

Illustration 13.1 PELV Isolation

Pulse/encoder inputs

Programmable pulse/encoder inputs	2/1
Terminal number pulse/encoder	29, 33[1)]/32[2)], 33[2)]
Maximum frequency at terminal 29, 32, 33	110 kHz (push-pull driven)
Maximum frequency at terminal 29, 32, 33	5 kHz (open collector)
Minimum frequency at terminal 29, 32, 33	4 Hz
Voltage level	See section *5-1* Digital Inputs* in the *programming guide*.
Maximum voltage on input	28 V DC
Input resistance, R_i	Approximately 4 kΩ
Pulse input accuracy (0.1–1 kHz)	Maximum error: 0.1% of full scale
Encoder input accuracy (1–11 kHz)	Maximum error: 0.05% of full scale

The pulse and encoder inputs (terminals 29, 32, 33) are galvanically isolated from the supply voltage (PELV) and other high voltage terminals.

1) Pulse inputs are 29 and 33.

2) Encoder inputs: 32=A, 33=B.

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Digital output

Programmable digital/pulse outputs	2
Terminal number	27, 29[1)]
Voltage level at digital/frequency output	0–24 V
Maximum output current (sink or source)	40 mA
Maximum load at frequency output	1 kΩ
Maximum capacitive load at frequency output	10 nF
Minimum output frequency at frequency output	0 Hz
Maximum output frequency at frequency output	32 kHz
Accuracy of frequency output	Maximum error: 0.1% of full scale
Resolution of frequency outputs	12 bit

1) Terminal 27 and 29 can also be programmed as input.
The digital output is galvanically isolated from the supply voltage (PELV) and other high voltage terminals.

Analog output

Number of programmable analog outputs	1
Terminal number	42
Current range at analog output	0/4 to 20 mA
Maximum load GND - analog output less than	500 Ω
Accuracy on analog output	Maximum error: 0.5% of full scale
Resolution on analog output	12 bit

The analog output is galvanically isolated from the supply voltage (PELV) and other high voltage terminals.

Control card, 24 V DC output

Terminal number	12, 13
Output voltage	24 V +1, -3 V
Maximum load	200 mA

The 24 V DC supply is galvanically isolated from the supply voltage (PELV), but has the same potential as the analog and digital inputs and outputs.

Control card, 10 V DC output

Terminal number	±50
Output voltage	10.5 V ±0.5 V
Maximum load	15 mA

The 10 V DC supply is galvanically isolated from the supply voltage (PELV) and other high voltage terminals.

Control card, RS485 serial communication

Terminal number	68 (P, TX+, RX+), 69 (N, TX-, RX-)
Terminal number 61	Common for terminals 68 and 69

The RS485 serial communication circuit is functionally separated from other central circuits and galvanically isolated from the supply voltage (PELV).

Control card, USB serial communication

USB standard	1.1 (Full speed)
USB plug	USB type B plug

Connection to PC is carried out via a standard host/device USB cable.
The USB connection is galvanically isolated from the supply voltage (PELV) and other high voltage terminals.
The USB ground connection is not galvanically isolated from protective earth. Use only an isolated laptop as PC connection to the USB connector on the frequency converter.

Relay outputs

Programmable relay outputs	2 Form C
Relay 01 terminal number	1–3 (break), 1–2 (make)
Maximum terminal load (AC-1)[1)] on 1–3 (NC), 1–2 (NO) (resistive load)	240 V AC, 2 A
Maximum terminal load (AC-15)[1)] (inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Maximum terminal load (DC-1)[1)] on 1–2 (NO), 1–3 (NC) (resistive load)	60 V DC, 1 A
Maximum terminal load (DC-13)[1)] (inductive load)	24 V DC, 0.1 A
Relay 02 terminal number	4–6 (break), 4–5 (make)

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Maximum terminal load (AC-1)[1)] on 4–5 (NO) (resistive load)[2)3)] overvoltage cat. II	400 V AC, 2 A
Maximum terminal load (AC-15)[1)] on 4–5 (NO) (inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Maximum terminal load (DC-1)[1)] on 4–5 (NO) (resistive load)	80 V DC, 2 A
Maximum terminal load (DC-13)[1)] on 4–5 (NO) (inductive load)	24 V DC, 0.1 A
Maximum terminal load (AC-1)[1)] on 4–6 (NC) (resistive load)	240 V AC, 2 A
Maximum terminal load (AC-15)[1)] on 4–6 (NC) (inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Maximum terminal load (DC-1)[1)] on 4–6 (NC) (resistive load)	50 V DC, 2 A
Maximum terminal load (DC-13)[1)] on 4–6 (NC) (inductive load)	24 V DC, 0.1 A
Minimum terminal load on 1–3 (NC), 1–2 (NO), 4–6 (NC), 4–5 (NO)	24 V DC 10 mA, 24 V AC 20 mA
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2

1) IEC 60947 part 4 and 5

The relay contacts are galvanically isolated from the rest of the circuit by reinforced isolation (PELV).

2) Overvoltage Category II.

3) UL applications 300 V AC2A.

Cable lengths and cross-sections for control cables[1)]

Maximum motor cable length, shielded	150 m
Maximum motor cable length, unscreened	300 m
Maximum cross-section to control terminals, flexible/rigid wire without cable end sleeves	2.5 mm^2/14 AWG
Maximum cross-section to control terminals, with ferrules without plastic sleeves	2.5 mm^2/14 AWG
Maximum cross-section to control terminals, with ferrules with plastic sleeves	1 mm^2/18 AWG
Minimum cross-section to control terminals	0.25 mm^2/24 AWG

1) For power cables, see chapter 12 Terminal and Applicable Wirechapter 13.1 Electrical Data.

Control card performance

Scan interval	1 ms

Control characteristics

Resolution of output frequency at 0–590 Hz	±0.003 Hz
Repeat accuracy of precise start/stop (terminals 18, 19)	≤±0.1 ms
System response time (terminals 18, 19, 27, 29, 32, 33)	≤2 ms
Speed control range (open loop)	1:100 of synchronous speed
Speed control range (closed loop)	1:1000 of synchronous speed
Speed accuracy (open loop)	30–4000 RPM: error ±8 RPM
Speed accuracy (closed loop), depending on resolution of feedback device	0–6000 RPM: error ±0.15 RPM
Torque control accuracy (speed feedback)	maximum error ±5% of rated torque

All control characteristics are based on a 4-pole asynchronous motor.

Environment

Enclosure	IP20 Open Chassis, Nema 1 with field installed kit, Nema 12, and Nema 4X
Vibration test	1.0 g (75 kW/100 hp and below)/0.7 g (above 75 kW/100 hp)
Maximum relative humidity	5–93% (IEC 721-3-3; Class 3K3 (non-condensing) during operation
Aggressive environment (IEC 60068-2-43) H_2S test	class Kd
Ambient temperature	Maximum 50 °C
Minimum ambient temperature during full-scale operation	0 °C
Minimum ambient temperature at reduced performance	-10 °C
Temperature during storage/transport	-25 to +65/70 °C
Maximum altitude above sea level without derating	1000 m

Derating for high altitude, see chapter 7.5 Derating.

EMC standards, Emission	EN 61800-3, EN 61000-6-3/4, EN 55011
EMC standards, Immunity	EN 61800-3, EN 61000-6-1/2, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6

See section on special conditions in chapter 7.2 Immunity Requirements.

13.3 Fuse Specifications

It is recommended to use fuses and/or circuit breakers on the supply side as protection if there is component break-down inside the frequency converter (first fault).

NOTICE

Using fuses and/or circuit breakers on the supply side is mandatory to ensure compliance with IEC 60364 for CE or NEC 2009 for UL.

WARNING

Protect personnel and property against the consequence of component break-down internally in the frequency converter.

Branch Circuit Protection
To protect the installation against electrical and fire hazard, all branch circuits in an installation, switch gear, machines, and so on, must be protected against short circuit and overcurrent according to national/international regulations.

NOTICE

The recommendations given do not cover branch circuit protection for UL.

Short-circuit protection
GE recommends using the fuses/circuit breakers mentioned below to protect service personnel and property if there is component break-down in the frequency converter.

Overcurrent protection
The frequency converter provides overload protection to limit threats to human life, property damage and to avoid fire hazard due to overheating of the cables in the installation. The frequency converter is equipped with an internal overcurrent protection (*parameter F-43 Current Limit*) that can be used for upstream overload protection (UL applications excluded). Moreover, fuses or circuit breakers can be used to provide the overcurrent protection in the installation. Overcurrent protection must always be carried out according to national regulations.

WARNING

If there is malfunction, not following the recommendation may result in personnel risk and damage to the frequency converter and other equipment.

The following tables list the recommended rated current. Recommended fuses are of the type gG for small to medium power sizes. For larger powers, aR fuses are recommended. Circuit breakers must be used provided they meet the national/international regulations and they limit the energy into the frequency converter to an equal or lower level than the compliant circuit breakers.
If fuses/circuit breakers according to recommendations are selected, possible damages on the frequency converter will mainly be limited to damages inside the unit.

13.3.1 Recommendations

WARNING

If there is malfunction, not following the recommendation may result in personnel risk and damage to the frequency converter and other equipment.

The tables in *chapter 13.3 Fuse Specifications* list the recommended rated current. Recommended fuses are of the type gG for small to medium power sizes. For larger powers, aR fuses are recommended. Circuit breakers must be used provided they meet the national/international regulations and they limit the energy into the frequency converter to an equal or lower level than the compliant circuit breakers.

If fuses/circuit breakers according to recommendations are selected, possible damage on the frequency converter is mainly limited to damages inside the unit.

13.3.2 CE Compliance

Fuses or circuit breakers are mandatory to comply with IEC 60364. GE recommend using a selection of the following.

The fuses below are suitable for use on a circuit capable of delivering 100000 Arms (symmetrical), 240 V, 500 V, 600 V, or 690 V depending on the frequency converter voltage rating. With the proper fusing, the frequency converter short circuit current rating (SCCR) is 100000 Arms.

AF-650 GP 3-phase [hp]	Recommended fuse size	Recommended max fuse	Recommended circuit breaker	Maximum trip level [A]
IP20/Open Chassis				
1/3	gG-16	gG-25	PKZM0-25	25
1/2				
1				
2				
3				
5	gG-20	gG-32		
7.5	gG-50	gG-63	PKZM4-50	50
10	gG-80	gG-125	NZMB1-A100	100
15				
20				
25	gG-125	gG-150	NZMB2-A200	150
30	aR-160	aR-160		
40	aR-200	aR-200	NZMB2-A250	250
50	aR-250	aR-250		

Table 13.16 200–240 V, Unit Sizes 1X, 2X, and 3X

AF-650 GP 3-phase [hp]	Recommended fuse size	Recommended maximum fuse	Recommended circuit breaker	Maximum trip level [A]
IP20/Open Chassis				
1/2	gG-16	gG-25	PKZM0-25	25
1				
2				
3				
5				
7.5	gG-20	gG-32		
10				
15	gG-50	gG-63	PKZM4-50	50
20				
25	gG-80	gG-125	NZMB1-A100	100
30				
40				
50	gG-125	gG-150	NZMB2-A200	150
60	aR-160	aR-160		
75	aR-250	aR-250	NZMB2-A250	250
100				
125	gG-300	gG-300	–	–
150	gG-350	gG-350		
200	gG-400	gG-400		
250	gG-500	gG-500		
300	gG-630	gG-630		
350	aR-700	aR-700		
450	aR-900	aR-900		
500				
550				
600	aR-1600	aR-1600		
650				
750	aR-2000	aR-2000		
900				
1000	aR-2500	aR-2500		
1200				

Table 13.17 380–500 V, Unit Sizes 1X, 2X, 3X, 4X, 4hX, 5X, and 6X

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AF-650 GP 3-phase [hp]	Recommended fuse size	Recommended maximum fuse	Recommended circuit breaker	Maximum trip level [A]
IP20/Open Chassis				
1	gG-10	gG-25	PKZM0-25	25
2				
3				
5				
7.5	gG-16	gG-32		
10				
15	gG-35	gG-63	PKZM4-50	50
20				
25	gG-63	gG-125	NZMB1-A100	100
30				
40				
50	gG-100	gG-150	NZMB2-A200	150
60				
75	aR-250	aR-250	NZMB2-A250	250
100				

Table 13.18 525–600 V, Unit Sizes 1X, 2X, and 3X

AF-650 GP 3-phase [hp]	Recommended fuse size	Recommended maximum fuse	Recommended circuit breaker	Maximum trip level [A]
IP21/Nema 1 and IP55/Nema 12 and IP66/Nema 4				
15	gG-25	gG-63	–	–
20	gG-32			
25				
30	gG-40			
40	gG-63	gG-80		
50		gG-100		
60	gG-80	gG-125		
75	gG-100	gG-160		
100	gG-125			
125	aR-250	aR-250		
150	aR-315	aR-315		
200	aR-350	aR-350		
250				
300	aR-400	aR-400		
350	aR-500	aR-500		
400	aR-550	aR-550		
500	aR-700	aR-700		
550				
650	aR-900	aR-900		
750				
900	aR-1600	aR-1600		
1000				
1150				
1250				
1350	aR-2000	aR-2000		

Table 13.19 525–690 V, Unit Sizes 2X, 3X, 4X, 4hX, 5X, and 6X

13.3.3 Fuse Specifications

AF-650 GP 3-phase [kW (hp)]	Recommended fuse size	Recommended maximum fuse
0.25 (1/3)	gG-16	gG-25
0.37 (1/2)		
0.75 (1)		
1.5 (2)		
2.2 (3)		
3.7 (5)	gG-20	gG-32
5.5 (7.5)	gG-50	gG-63
7.5 (10)	gG-80	gG-125
11 (15)		
15 (20)		
18.5 (25)	gG-125	gG-150
22 (30)	aR-160	aR-160
30 (40)	aR-200	aR-200
37 (50)	aR-250	aR-250

Table 13.20 200–240 V, IP20/Open Chassis

AF-650 GP 3-phase [kW (hp)]	Recommended fuse size	Recommended maximum fuse
0.25 (1/3)	gG-20	gG-32
0.37 (1/2)		
0.75 (1)		
1.5 (2)		
2.2 (3)		
3.7 (5)		
5.5 (7.5)	gG-63	gG-80
7.5 (10)		
11 (15)	gG-80	gG-100
15 (20)	gG-125	gG-160
18.5 (25)		
22 (30)	aR-160	aR-160
30 (40)	aR-200	aR-200
37 (50)	aR-250	aR-250

Table 13.21 200–240 V, IP55/Nema 12 and IP66/Nema 4X

AF-650 GP 3-phase [kW (hp)]	Recommended fuse size	Recommended maximum fuse
0.37 (1/2)	gG-16	gG-25
0.75 (1)		
1.5 (2)		
2.2 (3)		
3.7 (5)		
5.5 (7.5)	gG-20	gG-32
7.5 (10)		
11 (15)	gG-50	gG-63
15 (20)		
18.5 (25)	gG-80	gG-125
22 (30)		
30 (40)		
37 (50)	gG-125	gG-150
45 (60)	aR-160	aR-160
55 (75)	aR-250	aR-250
75 (100)		
90 (125)	aR-300	aR-300
110 (150)	aR-350	aR-350
132 (200)	aR-400	aR-400
160 (250)	aR-500	aR-500
200 (300)	aR-630	aR-630
250 (350)	aR-700	aR-700
315 (450)	aR-900	aR-900
355 (500)		
400 (550)		
450 (600)	aR-1600	aR-1600
500 (650)		
560 (750)	aR-2000	aR-2000
630 (900)		
710 (1000)	aR-2500	aR-2500
800 (1200)		

Table 13.22 380–500 V, IP20/Open Chassis

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AF-650 GP 3-phase [kW (hp)]	Recommended fuse size	Recommended maximum fuse
0.37 (1/2)	gG-20	gG-32
0.75 (1)		
1.5 (2)		
2.2 (3)		
3.7 (5)		
5.5 (7.5)		
7.5 (10)		
11 (15)	gG-50	gG-80
15 (20)		
18.5 (25)	gG-80	gG-100
22 (30)		
30 (40)	gG-125	gG-160
37 (50)		
45 (60)		
55 (75)	aR-250	aR-250
75 (100)		
90 (125)	aR-300	aR-300
110 (150)	aR-350	aR-350
132 (200)	aR-400	aR-400
160 (250)	aR-500	aR-500
200 (300)	aR-630	aR-630
250 (350)	aR-700	aR-700
315 (450)	aR-900	aR-900
355 (500)		
400 (550)		
450 (600)	aR-1600	aR-1600
500 (650)		
560 (750)	aR-2000	aR-2000
630 (900)		
710 (1000)	aR-2500	aR-2500
800 (1200)		

Table 13.23 380–500 V, IP55/Nema 12 and IP66/Nema 4X

AF-650 GP 3-phase [kW (hp)]	Recommended fuse size	Recommended maximum fuse
0.75 (1)	gG-10	gG-25
1.5 (2)		
2.2 (3)		
3.7 (5)		
5.5 (7.5)	gG-16	gG-32
7.5 (10)		
11 (15)	gG-35	gG-63
15 (20)		
18.5 (25)	gG-63	gG-125
22 (30)		
30 (40)		
37 (50)	gG-100	gG-150
45 (60)		
55 (75)	aR-250	aR-250
75 (100)		

Table 13.24 525–600 V, IP20/Open Chassis

AF-650 GP 3-phase [kW (hp)]	Recommended fuse size	Recommended maximum fuse
0.75 (1)	gG-16	gG-32
1.5 (2)		
2.2 (3)		
3.7 (5)		
5.5 (7.5)		
7.5 (10)		
11 (15)	gG-35	gG-80
15 (20)		
18.5 (25)	gG-50	gG-100
22 (30)		
30 (40)	gG-125	gG-160
37 (50)		
45 (60)		
55 (75)	aR-250	aR-250
75 (100)		

Table 13.25 525–600 V, IP55/Nema 12 and IP66/Nema 4X

AF-650 GP 3-phase [kW (hp)]	Recommended fuse size	Recommended maximum fuse
11 (15)	gG-25	gG-63
15 (20)	gG-32	
18.5 (25)		
22 (30)	gG-40	
30 (40)	gG-63	gG-80
37 (50)		gG-100
45 (60)	gG-80	gG-125
55 (75)	gG-100	gG-160
75 (100)	gG-125	
90 (125)	aR-250	aR-250
110 (150)	aR-315	aR-315
132 (200)	aR-350	aR-350
160 (250)		
200 (300)	aR-400	aR-400
250 (350)	aR-500	aR-500
315 (400)	aR-550	aR-550
355 (500)	aR-700	aR-700
400 (550)		
500 (650)	aR-900	aR-900
560 (750)		
630 (900)	aR-1600	aR-1600
710 (1000)		
800 (1150)		
900 (1250)		
1000 (1350)	aR-2000	aR-2000

Table 13.26 525–690 V, IP21/Nema 1 and IP55/Nema 12 and IP66/Nema 4X

13.3.4 NEC and UL Compliance

Fuses or Circuit Breakers are mandatory to comply with NEC 2009. We recommend using a selection of the following.

The fuses below are suitable for use on a circuit capable of delivering 100000 Arms (symmetrical), 240 V, or 500 V, or 600 V depending on the frequency converter voltage rating. With the proper fusing, the drive Short Circuit Current Rating (SCCR) is 100000 Arms.

	Recommended maximum fuse					
AF-650 GP Power	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**
[kW (hp)]	Type RK1 1)	Type J	Type T	Type CC	Type CC	Type CC
0.25–0.37 (1/3–1/2)	KTN-R-05	JKS-05	JJN-05	FNQ-R-5	KTK-R-5	LP-CC-5
0.75 (1)	KTN-R-10	JKS-10	JJN-10	FNQ-R-10	KTK-R-10	LP-CC-10
1.5 (2)	KTN-R-15	JKS-15	JJN-15	FNQ-R-15	KTK-R-15	LP-CC-15
2.2 (3)	KTN-R-20	JKS-20	JJN-20	FNQ-R-20	KTK-R-20	LP-CC-20
3.7 (5)	KTN-R-30	JKS-30	JJN-30	FNQ-R-30	KTK-R-30	LP-CC-30
5.5 (7.5)	KTN-R-50	KS-50	JJN-50	–	–	–
7.5 (10)	KTN-R-60	JKS-60	JJN-60	–	–	–
11 (15)	KTN-R-80	JKS-80	JJN-80	–	–	–
15–18.5 (20–25)	KTN-R-125	JKS-125	JJN-125	–	–	–
22 (30)	KTN-R-150	JKS-150	JJN-150	–	–	–
30 (40)	KTN-R-200	JKS-200	JJN-200	–	–	–
37 (50)	KTN-R-250	JKS-250	JJN-250	–	–	–

Table 13.27 200–240 V

	Recommended maximum fuse			
AF-650 GP Power	**SIBA**	**Littelfuse**	**Ferraz-Shawmut**	**Ferraz-Shawmut**
[kW (hp)]	Type RK1	Type RK1	Type CC	Type RK1 3)
0.25–0.37 (1/3–1/2)	5017906-005	KLN-R-05	ATM-R-05	A2K-05-R
0.75 (1)	5017906-010	KLN-R-10	ATM-R-10	A2K-10-R
1.5 (2)	5017906-016	KLN-R-15	ATM-R-15	A2K-15-R
2.2 (3)	5017906-020	KLN-R-20	ATM-R-20	A2K-20-R
3.7 (5)	5012406-032	KLN-R-30	ATM-R-30	A2K-30-R
5.5 (7.5)	5014006-050	KLN-R-50	–	A2K-50-R
7.5 (10)	5014006-063	KLN-R-60	–	A2K-60-R
11 (15)	5014006-080	KLN-R-80	–	A2K-80-R
15–18.5 (20–25)	2028220-125	KLN-R-125	–	A2K-125-R
22 (30)	2028220-150	KLN-R-150	–	A2K-150-R
30 (40)	2028220-200	KLN-R-200	–	A2K-200-R
37 (50)	2028220-250	KLN-R-250	–	A2K-250-R

Table 13.28 200–240 V

	Recommended maximum fuse			
AF-650 GP	**Bussmann**	**Littelfuse**	**Ferraz-Shawmut**	**Ferraz-Shawmut**
[kW (hp)]	Type JFHR2[2)]	JFHR2	JFHR2[4)]	J
0.25–0.37 (1/3–1/2)	FWX-5	–	–	HSJ-6
0.75 (1)	FWX-10	–	–	HSJ-10
1.5 (2)	FWX-15	–	–	HSJ-15
2.2 (3)	FWX-20	–	–	HSJ-20
3.7 (5)	FWX-30	–	–	HSJ-30
5.5 (7.5)	FWX-50	–	–	HSJ-50
7.5 (10)	FWX-60	–	–	HSJ-60
11 (15)	FWX-80	–	–	HSJ-80
15–18.5 (20–25)	FWX-125	–	–	HSJ-125
22 (30)	FWX-150	L25S-150	A25X-150	HSJ-150
30 (40)	FWX-200	L25S-200	A25X-200	HSJ-200
37 (50)	FWX-250	L25S-250	A25X-250	HSJ-250

Table 13.29 200–240 V

1) KTS-fuses from Bussmann may substitute KTN for 240 V frequency converters.

2) FWH-fuses from Bussmann may substitute FWX for 240 V frequency converters.

3) A6KR fuses from Ferraz Shawmut may substitute A2KR for 240 V frequency converters.

4) A50X fuses from Ferraz Shawmut may substitute A25X for 240 V frequency converters.

	Recommended maximum fuse					
AF-650 GP	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**
[kW (hp)]	Type RK1	Type J	Type T	Type CC	Type CC	Type CC
0.37–0.75 (1/2–1)	KTS-R-6	JKS-6	JJS-6	FNQ-R-6	KTK-R-6	LP-CC-6
1.5–2.2 (2–3)	KTS-R-10	JKS-10	JJS-10	FNQ-R-10	KTK-R-10	LP-CC-10
3.7 (5)	KTS-R-20	JKS-20	JJS-20	FNQ-R-20	KTK-R-20	LP-CC-20
5.5 (7.5)	KTS-R-25	JKS-25	JJS-25	FNQ-R-25	KTK-R-25	LP-CC-25
7.5 (10)	KTS-R-30	JKS-30	JJS-30	FNQ-R-30	KTK-R-30	LP-CC-30
11 (15)	KTS-R-40	JKS-40	JJS-40	–	–	–
15 (20)	KTS-R-50	JKS-50	JJS-50	–	–	–
18.5 (25)	KTS-R-60	JKS-60	JJS-60	–	–	–
22 (30)	KTS-R-80	JKS-80	JJS-80	–	–	–
30 (40)	KTS-R-100	JKS-100	JJS-100	–	–	–
37 (50)	KTS-R-125	JKS-125	JJS-125	–	–	–
45 (60)	KTS-R-150	JKS-150	JJS-150	–	–	–
55 (75)	KTS-R-200	JKS-200	JJS-200	–	–	–
75 (100)	KTS-R-250	JKS-250	JJS-250	–	–	–

Table 13.30 380–500 V

	Recommended maximum fuse			
AF-650 GP	**SIBA**	**Littelfuse**	**Ferraz-Shawmut**	**Ferraz-Shawmut**
[kW (hp)]	Type RK1	Type RK1	Type CC	Type RK1
0.37–0.75 (1/2–1)	5017906-006	KLS-R-6	ATM-R-6	A6K-6-R
1.5–2.2 (2–3)	5017906-010	KLS-R-10	ATM-R-10	A6K-10-R
3.7 (5)	5017906-020	KLS-R-20	ATM-R-20	A6K-20-R
5.5 (7.5)	5017906-025	KLS-R-25	ATM-R-25	A6K-25-R
7.5 (10)	5012406-032	KLS-R-30	ATM-R-30	A6K-30-R
11 (15)	5014006-040	KLS-R-40	–	A6K-40-R
15 (20)	5014006-050	KLS-R-50	–	A6K-50-R
18.5 (25)	5014006-063	KLS-R-60	–	A6K-60-R
22 (30)	2028220-100	KLS-R-80	–	A6K-80-R
30 (40)	2028220-125	KLS-R-100	–	A6K-100-R
37 (50)	2028220-125	KLS-R-125	–	A6K-125-R
45 (60)	2028220-160	KLS-R-150	–	A6K-150-R
55 (75)	2028220-200	KLS-R-200	–	A6K-200-R
75 (100)	2028220-250	KLS-R-250	–	A6K-250-R

Table 13.31 380–500 V

	Recommended maximum fuse			
AF-650 GP	**Bussmann**	**Ferraz Shawmut**	**Ferraz Shawmut**	**Littelfuse**
[kW (hp)]	JFHR2	J	JFHR2[1)]	JFHR2
0.37–0.75 (1/2–1)	FWH-6	HSJ-6	–	–
1.5–2.2 (2–3)	FWH-10	HSJ-10	–	–
3.7 (5)	FWH-20	HSJ-20	–	–
5.5 (7.5)	FWH-25	HSJ-25	–	–
7.5 (10)	FWH-30	HSJ-30	–	–
11 (15)	FWH-40	HSJ-40	–	–
15 (20)	FWH-50	HSJ-50	–	–
18.5 (25)	FWH-60	HSJ-60	–	–
22 (30)	FWH-80	HSJ-80	–	–
30 (40)	FWH-100	HSJ-100	–	–
37 (50)	FWH-125	HSJ-125	–	–
45 (60)	FWH-150	HSJ-150	–	–
55 (75)	FWH-200	HSJ-200	A50-P-225	L50-S-225
75 (100)	FWH-250	HSJ-250	A50-P-250	L50-S-250

Table 13.32 380–500 V

1) Ferraz Shawmut A50QS fuses may substitute for A50P fuses.

	Recommended maximum fuse					
AF-650 GP	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**	**Bussmann**
[kW (hp)]	Type RK1	Type J	Type T	Type CC	Type CC	Type CC
0.75 (1)	KTS-R-5	JKS-5	JJS-6	FNQ-R-5	KTK-R-5	LP-CC-5
1.5–2.2 (2–3)	KTS-R-10	JKS-10	JJS-10	FNQ-R-10	KTK-R-10	LP-CC-10
3.7 (5)	KTS-R20	JKS-20	JJS-20	FNQ-R-20	KTK-R-20	LP-CC-20
5.5 (7.5)	KTS-R-25	JKS-25	JJS-25	FNQ-R-25	KTK-R-25	LP-CC-25
7.5 (10)	KTS-R-30	JKS-30	JJS-30	FNQ-R-30	KTK-R-30	LP-CC-30
11 (15)	KTS-R-35	JKS-35	JJS-35	–	–	–
15 (20)	KTS-R-45	JKS-45	JJS-45	–	–	–
18.5 (25)	KTS-R-50	JKS-50	JJS-50	–	–	–
22 (30)	KTS-R-60	JKS-60	JJS-60	–	–	–
30 (40)	KTS-R-80	JKS-80	JJS-80	–	–	–
37 (50)	KTS-R-100	JKS-100	JJS-100	–	–	–
45 (60)	KTS-R-125	JKS-125	JJS-125	–	–	–
55 (75)	KTS-R-150	JKS-150	JJS-150	–	–	–
75 (100)	KTS-R-175	JKS-175	JJS-175	–	–	–

Table 13.33 525–600 V

	Recommended maximum fuse			
AF-650 GP	**SIBA**	**Littelfuse**	**Ferraz-Shawmut**	**Ferraz-Shawmut**
[kW (hp)]	Type RK1	Type RK1	Type RK1	J
0.75 (1)	5017906-005	KLS-R-005	A6K-5-R	HSJ-6
1.5–2.2 (2–3)	5017906-010	KLS-R-010	A6K-10-R	HSJ-10
3.7 (5)	5017906-020	KLS-R-020	A6K-20-R	HSJ-20
5.5 (7.5)	5017906-025	KLS-R-025	A6K-25-R	HSJ-25
7.5 (10)	5017906-030	KLS-R-030	A6K-30-R	HSJ-30
11 (15)	5014006-040	KLS-R-035	A6K-35-R	HSJ-35
15 (20)	5014006-050	KLS-R-045	A6K-45-R	HSJ-45
18.5 (25)	5014006-050	KLS-R-050	A6K-50-R	HSJ-50
22 (30)	5014006-063	KLS-R-060	A6K-60-R	HSJ-60
30 (40)	5014006-080	KLS-R-075	A6K-80-R	HSJ-80
37 (50)	5014006-100	KLS-R-100	A6K-100-R	HSJ-100
45 (60)	2028220-125	KLS-R-125	A6K-125-R	HSJ-125
55 (75)	2028220-150	KLS-R-150	A6K-150-R	HSJ-150
75 (100)	2028220-200	KLS-R-175	A6K-175-R	HSJ-175

Table 13.34 525–600 V

1) 170M fuses shown from Bussmann use the -/80 visual indicator. –TN/80 Type T, -/110 or TN/110 Type T indicator fuses of the same size and amperage may be substituted.

	Recommended maximum fuse							
AF-650 GP [kW (hp)]	Maximum pre-fuse	Bussmann E52273 RK1/JDDZ	Bussmann E4273 J/JDDZ	Bussmann E4273 T/JDDZ	SIBA E180276 RK1/JDDZ	Littelfuse E81895 RK1/JDDZ	Ferraz-Shawmut E163267/E2137 RK1/JDDZ	Ferraz-Shawmut E2137 J/HSJ
11 (15)	30 A	KTS-R-30	JKS-30	JKJS-30	5017906-030	KLS-R-030	A6K-30-R	HST-30
15–18.5 (20–25)	45 A	KTS-R-45	JKS-45	JJS-45	5014006-050	KLS-R-045	A6K-45-R	HST-45
22 (30)	60 A	KTS-R-60	JKS-60	JJS-60	5014006-063	KLS-R-060	A6K-60-R	HST-60
30 (40)	80 A	KTS-R-80	JKS-80	JJS-80	5014006-080	KLS-R-075	A6K-80-R	HST-80
37 (50)	90 A	KTS-R-90	JKS-90	JJS-90	5014006-100	KLS-R-090	A6K-90-R	HST-90
45 (60)	100 A	KTS-R-100	JKS-100	JJS-100	5014006-100	KLS-R-100	A6K-100-R	HST-100
55 (75)	125 A	KTS-R-125	JKS-125	JJS-125	2028220-125	KLS-150	A6K-125-R	HST-125
75 (100)	150 A	KTS-R-150	JKS-150	JJS-150	2028220-150	KLS-175	A6K-150-R	HST-150
* UL Compliance only 525–600 V								

Table 13.35 525–690 V*, 100 hp and below, Unit Sizes 2x and 3x

Recommended maximum fuse					
AF-650 GP	Bussmann PN	Alternate Bussmann PN	Siba PN	Littelfuse PN	Ferraz Shawmut PN
[kW (hp)]	Type JFHR2	Type T/JDDZ	Type JFHR2	Type JFHR2	
90 (125)	170M2619	JJS-300	20 610 31.315	L50-S-300	6.9URD31D08A0315
110 (150)	170M2620	JJS-350	20 610 31.350	L50-S-350	6.9URD31D08A0350
132 (200)	170M2621	JJS-400	20 610 31.400	L50-S-400	6.9URD31D08A0400
160 (250)	170M4015	JJS-500	20 610 31.550	L50-S-500	6.9URD31D08A0550
200 (300)	170M4016	JJS-600	20 610 31.630	L50-S-600	6.9URD31D08A0630
250 (350)	170M4017	–	20 610 31.800	–	6.9URD31D08A0700
315 (450)	170M6013	–	22 610 32.900	–	6.9URD33D08A0900
355 (500)	170M6013	–	22 610 32.900	–	6.9URD33D08A0900
400 (550)	170M6013	–	22 610 32.900	–	6.9URD33D08A0900
450 (600)	170M7081	–	–	–	–
500 (650)	170M7081	–	–	–	–
560 (750)	170M7082	–	–	–	–
630 (900)	170M7082	–	–	–	–
710 (1000)	170M7083	–	–	–	–
800 (1200)	170M7083	–	–	–	–

Table 13.36 380–500 V, above 125 hp

AF-650 GP	Bussmann PN	Rating	Alternate Siba PN
[kW (hp)]			
450 (600)	170M8611	1100A, 1000 V	20 781 32.1000
500 (650)	170M8611	1100A, 1000 V	20 781 32.1000
560 (750)	170M6467	1400A, 700 V	20 681 32.1400
630 (900)	170M6467	1400A, 700 V	20 681 32.1400
710 (1000)	170M8611	1100A, 1000 V	20 781 32.1000
800 (1200)	170M6467	1400A, 700 V	20 681 32.1400

Table 13.37 380–500 V, 600 hp and above

AF-650 GP	Bussmann PN	Siba PN	Ferraz Shawmut PN
[kW (hp)]		Type JFHR2	Type JFHR2
90 (125)	170M2616	20 610 31.315	6.9URD30D08A0315
110 (150)	170M2619	20 610 31.315	6,9URD31D08A0315
132 (200)	170M2619	20 610 31.315	6,9URD31D08A0315
160 (250)	170M4015	20 610 31.550	6,9URD32D08A0550
200 (300)	170M4015	20 610 31.550	6,9URD32D08A0550
250 (350)	170M4015	20 610 31.550	6.9URD32D08A0550
315 (400)	170M4015	20 610 31.550	6,9URD32D08A0550
335 (450)	170M4017	20 610 32.700	6.9URD31D08A0700
355 (500)	170M6013	22 610 32.900	6.9URD33D08A0900
415 (600)	170M6013	22 610 32.900	6.9URD33D08A0900
500/650	170M7081		
560 (750)	170M7081		
710 (950)	170M7081		
785 (1050)	170M7081		
800 (1150)	170M7082		
1000 (1350)	170M7083		

Table 13.38 525–690 V, above 125 hp

AF-650 GP	Bussmann PN	Rating	Alternate Siba PN
[kW (hp)]			
630 (900)	170M8611	1100 A, 1000 V	20 781 32.1000
710 (1000)	170M8611	1100 A, 1000 V	20 781 32.1000
800 (1150)	170M8611	1100 A, 1000 V	20 781 32.1000
900 (1250)	170M8611	1100 A, 1000 V	20 781 32.1000
1000 (1350)	170M8611	1100 A, 1000 V	20 781 32.1000
1200 (1600)	170M8611	1100 A, 1000 V	20 781 32.1000

Table 13.39 525–690 V, 900 hp and above

**170M fuses from Bussmann shown use the -/80 visual indicator, -TN/80 Type T, -/110 or TN/110 Type T indicator fuses of the same size and amperage may be substituted for external use*

***Any minimum 500 V UL listed fuse with associated current rating may be used to meet UL requirements.*

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

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