NFO Sinus

FREQUENCY INVERTER FOR INTERFERENCE-FREE,
QUIET AND DEPENDABLE MOTOR CONTROL

Operating and Installation Manual

NFO Sinus 0.37 – 15 kW

Frequency Inverters

NFO DRIVES

Contents

Introduction

The frequency inverter described in this operating manual is used for frequency (Hz), speed (RPM) or torque control of three-phase induction motors. This manual tells you how to install and use the inverter.

Read the manual carefully before installing the inverter, to ensure you install it correctly and get the maximum performance out of it.

The inverter has a patented switch circuitry that ensures the motor receives a sinusoidal voltage at all times, under all operating conditions. This solves all problems related to conventional PWM based frequency inverters, e.g. electromagnetic interference, ball bearing damages, high earth current and high switching noise.

A 30mA rated RCD (earth leakage circuit breaker) can be used with this frequency inverter.

The inverter also uses the patent "Natural field orientation" which is a vector control method to give perfect speed control of induction motors all the way from zero to full speed.

1   Safety aspects

Always disconnect the inverter from the mains supply before working on any electrical or mechanical installation components.

Installation, maintenance and repairs must always be conducted by staff adequately trained and experienced for the purpose.

Modifying or replacing any components of the inverter or its accessories will render the inverter warranty null and void. Should the need for any modifications or replacements arise, always contact NFO Drives AB.

Components in the power section and some components in the signal section are connected to the mains supply when the inverter is powered**.**

⚠ **WARNING! Touching any components with the mains supply connected can be fatal!** Always disconnect the mains supply before opening the cover.

⚠ **WARNING!** Even when disconnected from the mains supply, the inverter may still contain lethal voltages due to its buffer capacitors. **Always wait at least five minutes** to make sure no voltage remains before working on the inverter.

⚠ **WARNING!** The heat sink of the inverter may get hot, depending on operating conditions. Do not touch.

⚠ For connection of mains supply, the inverter shall be permanently connected to fixed wiring including a circuit breaker which must be used to ensure all-pole disconnection under overvoltage III conditions.

⚠ The inverter shall always be connected to protective earth (P.E.) when the mains supply is connected.

⚠ If the motor temperature sensor (PTC/Klixon) functionality is used, the sensor and its wiring must supply adequate isolation and comply with installation requirements for the equipment in use.

⚠ The level of integrity offered by the drive control input functions – for example stop/start, forward/reverse and maximum speed, are not sufficient for use in safety-critical applications without independent channels of protection. All applications where malfunction could cause injury or loss of life must be subject to a risk assessment and further protection provided where needed.

2 Technical data

Table 1. Inverter ratings for 380-440V 3~ 50/60 Hz Type TN electrical supply network

Art. no. [NFO/DLV]	Rated output power	Rated output current [1]	Max output current [2]	Apparent output power [3]	Absolute losses [4] $P_{L,CDM(90,100)}$	Efficiency class [5],[6]	Standby power [7]	Size [mm]	Protection class [8]	Weight [kg]
2A3A3130D	0.37 kW	1.3 A	1.6 A	0.70 kVA	0.039 kW	IE2	14.5 W	413x280x80	IP54	7.0
2A3A3210D	0.75 kW	2.1 A	2.5 A	1.29 kVA	0.055 kW	IE2	14.5 W	413x280x80	IP54	7.0
2A3A3350D	1.5 kW	3.5 A	4.2 A	2.29 kVA	0.085 kW	IE2	14.5 W	413x280x80	IP54	7.0
2A3A3490D	2.2 kW	4.9 A	5.8 A	3.30 kVA	0.114 kW	IE2	14.5 W	413x280x80	IP54	7.0
2B3A3880D	4 kW	8.8 A	10.5 A	5.85 kVA	0.188 kW	IE2	13.8 W	413x280x150	IP54	10.8
2B3A3111D	5.5 kW	11.1 A	13.3 A	7.94 kVA	0.249 kW	IE2	13.8 W	413x280x150	IP54	10.8
2C3A3151D	7.5 kW	14.8 A	17.7 A	9.95 kVA	0.352 kW	IE2	13.8 W	413x280x215	IP54	14.0
2C1A3151D	7.5 kW	14.8 A	17.7 A	9.95 kVA	0.352 kW	IE2	16.1 W	413x280x203	IP20	14.0
2C1A3221D	11 kW	21.5 A	25.8 A	14.4 kVA	0.516 kW	IE2	16.1 W	413x280x203	IP20	14.0
2C1A3281D	15 kW	28.5 A	32.0 A	19.5 kVA	0.704 kW	IE2	16.1 W	413x280x203	IP20	14.0

Notes:

[1] Inverter's rated output current corresponds to an average motor rating for the particular size.

[2] The inverter application should not be dimensioned for higher continuous current than Rated output current. However, it can supply Max output current for infinite time, but it may be detrimental to its life span.

[3] Apparent output power $S_{r,equ}$ used for IE (International Efficiency) classification.

[4] Measured at a load point corresponding to 90% of rated frequency and 100% of rated output current.

[5] CDM (Complete Drive Module) efficiency class according to Commission Regulation (EU) 2019/1781 and IEC 61800-9-2:2017.

[6] Due to sinusoidal voltage output from the NFO inverter, the expected additional harmonic losses in the motor, which are present when using a PWM inverter, are now absent.

IEC 61800-9-2:2017: "When [three-phase induction motors] are operated on a CDM, additional harmonic losses $P_{LHL} = r_{LHL} \times P_{LTsin}$ are caused by the non-sinusoidal voltage supply". The increase of motor losses as a result of PWM operation (r_{LHL}) are estimated to 15% of the total losses. According to the reference model for a 2.2kW IE2 or IE3 induction motor, this corresponds to about 0,05 kW.

When determining the overall efficiency of the PDS (Power Drive System, i.e. inverter and motor together), it should be taken into account that motor losses are approximately 15% lower when using an inverter with sinusoidal voltage output, than it would be if using a conventional PWM inverter.

[7] No external control equipment connected to the 24V supply output, and cooling fan regulator at low speed.

[8] According to SS-EN 60529.

Table 2. Common data

Inverter output	
Output voltage waveform	Sinusodial
Output frequency	0 – 150 Hz
Control modes	
Frequency control	0 - 150 Hz, Vector control without slip compensation
Speed control	0 – 9000 rpm, Vector control with slip compensation
Torque control	1 – 400 % of motors nominal torque
Process control	PI with feedback, temperature sensor PT1000 for reading temperature at constant pressure control in the ventilation system [1], 24V supply to external sensors [1]
Control inputs	
Setpoints	0-10V, 2-10V, œ10V, 0-20mA, 4-20mA, œ20mA, potentiometer 10kΩ, 7 set frequencies selectable from terminal with positive or negative logic
Actual values	0-10V, 2-10V, œ10V
Local mode	Keyboard: Forward, Reverse, Stop
Acceleration time	0,2 – 500s
Retardation time	0,2 – 500s
Signal outputs	
Voltage [1]	0 – 10V
Frequency [1]	0 – 32kHz, open collector
Relay	Fault relay, operating relay, function relay [1]
Motor safety	
Thermistor input	PTC or Klixon
Power monitor	Switch off if motor load is over rated power for a long time
Ambient conditions	
Ambient temp	-10 to +40 °C
Storage temp.	-20 to +60 °C
Humidity	0 – 90%, non-condensing
Protection class	See Table 1, Inverter ratings
EMC certification	Approved for medical devices (EN 60601-1-2), residential, commercial and light-industrial environment (EN 61000-6-3) and industrial environment (EN 61000-6-2) without shielded cables or EMC filter etc.
Electrical safety	Low Voltage Directive EN 61800-5-1:2007, EN 61800-5-1/A1:2017. Motor terminal short circuit protection [2] according to IEC 60364-4-41:2005 / AMD1, clause 411. Short circuit protection functionality operates regardless of motor cable area, cable length, or other cable properties, and regardless of mains power supply impedance.
Climatic tests (IP54 models)	Dry heat test IEC 60068-2-2 Damp heat test IEC 60068-2-78 Vibration test IEC 60068-2-6

Notes:

[1] Available with additional I/O board only.

[2] If short circuit should occur, the inverter may get damaged. However, it will prevent damage of connected equipment, fire and other hazards.

3   Mechanical installation

⚠️ When unpacking the inverter, carefully inspect the product and make sure it has not been damaged during transportation. Inverter with cracks, dents or other visual damage shall not be installed.

⚠️ The inverter must not be installed such that outlet air from another inverter or other equipment blows directly into the inverter air intake. A minimum of 80 mm clearance must be kept above and below the inverter, and a minimum of 20 mm vertical gap must be kept between inverters, to ensure sufficient air flow.

⚠️ All electrical connections are accessible when the lower front panel is removed. No other covers may be removed.

⚠️ During installation it is important that no foreign objects, such as cable strands or screws, fall into the inverter as a short circuit may occur. Drilling in chassis or cover plates is not allowed.

⚠️ After installation, make sure all grommets at the cable entries are mounted and the cover is closed and secured with its screws to avoid touching dangerous voltage.

3.1   Mounting

The inverter shall be mounted on a vertical surface using four mounting screws. Make sure that the top mounting screws are sufficiently strong to hold the entire weight of the inverter. All electrical connections are accessible when the lower front panel is removed. Drilling or modifying any part of the chassis is not allowed. The IP20 inverter is intended to be built into a cabinet with sufficient cooling / air flow. Installer must make sure that cabinet ventilation is sufficient. The IP54 inverter can be mounted stand-alone. Ambient air temperature must not exceed 40°C.
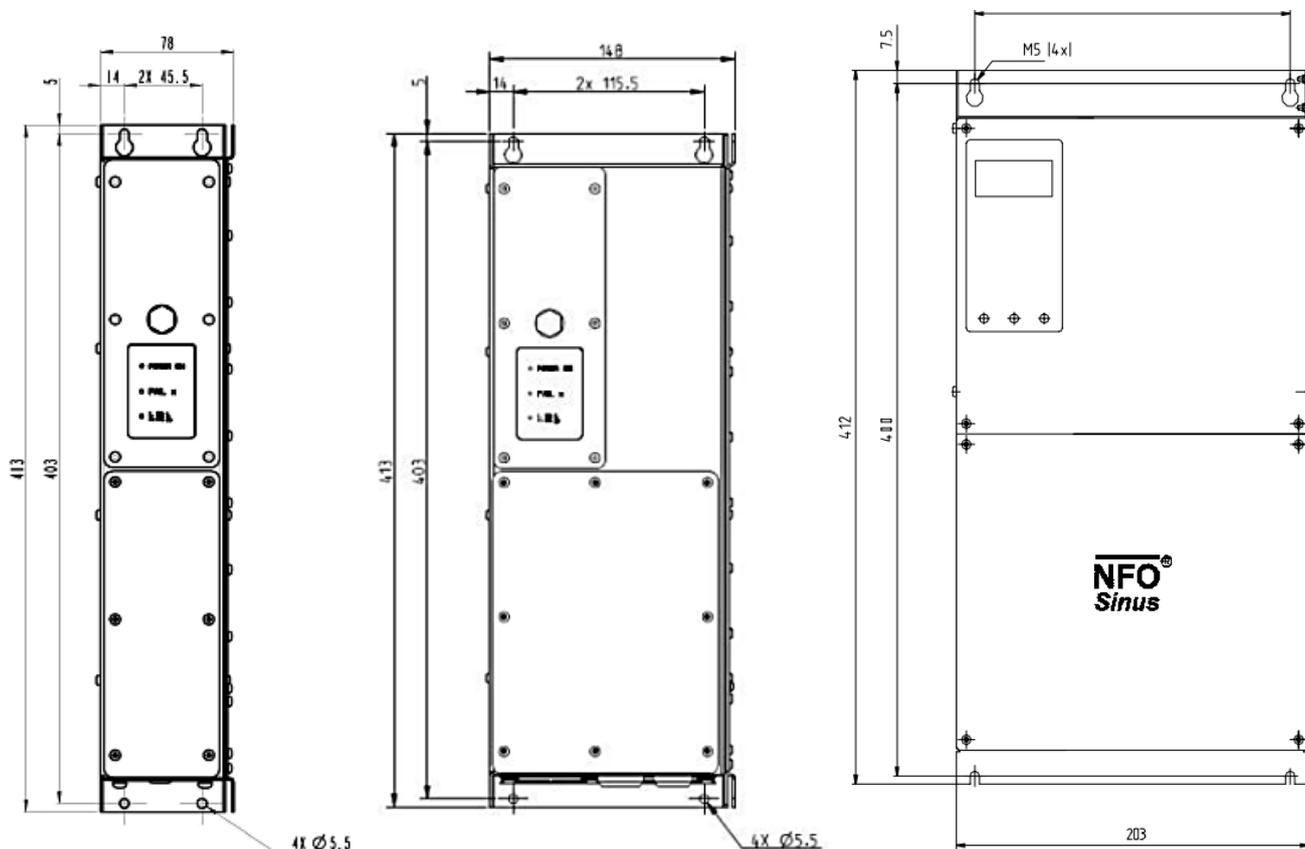
4   Electrical installation

All terminals are accessed by removing the lower front panel.

Please note that the inverter must not be run for more than a short period of with the front panel removed, as this affects the airflow through it.
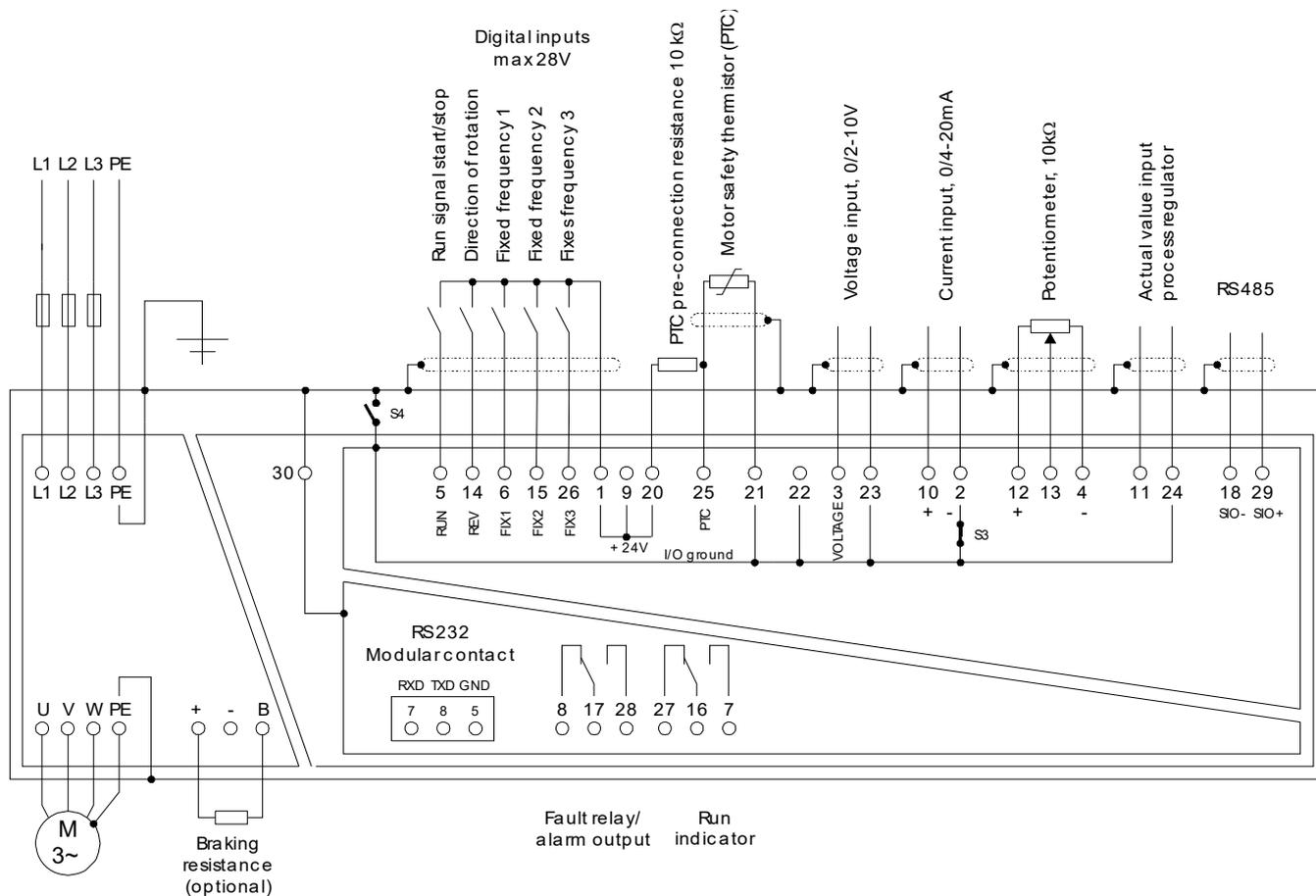
Fig.1. Typical configuration

⚠ Warning! If option Autostart is ON and there is a run signal to the inverter (terminal 5), the inverter will start the motor when power is applied.

⚠ An external brake-resistor must be fitted if the retardation time is less than 5 sec, see section 6.

⚠ Note! A motor safety switch can be mounted between the inverter (terminals U, V and W) and the motor, but it **must only be operated** (switched off or on) when the **motor is not running**.

⚠ Note! **Never install contactors or switches between the inverter** (terminals U, V and W) **and the motor** that intentionally or unintentionally may be used to disconnect the motor from inverter output.

⚠ **EMC standards is met without use of shielded motor cables, if the inverter is correctly installed. There is no limit to the length of the motor cable as the inverter always supplies a sinusoidal voltage to the motor. A slight voltage drop in the motor cables must be allowed for, which is accounted for during the autotuning. Use cable with a resistance in each phase that is significantly lower than the resistance in each motor phase winding (stator resistance).**

4.1 Signal terminal connection

Terminals 21, 22, 23 and 24 (I/O ground) can be connected galvanically to PE via jumper S4 (not supplied with installation). These terminals may vary in terms of potential by up to 100 V from PE if S4 is not fitted. The RS 232 contact is always connected galvanically to PE.

The negative power input (terminal 2) is connected to I/O ground (terminals 21 - 24) via jumper S3 (supplied fitted). Remove this jumper and the common-mode voltage at the power input (terminals 2 and 10) may vary by up to +/24V from I/O ground. This is used when a number of current controlled units are connected in series. When connecting a current signal in series, the I/O ground of the inverters may need to be connected to each other for correct operation.

The inverter can be configured for negative logic at the digital inputs (terminals 5, 6, 14, 15 and 26) by moving jumper S1 (see Fig. 3). The inputs are then made active by connecting them to the I/O ground (terminals 21 – 24), see Fig. 2 .
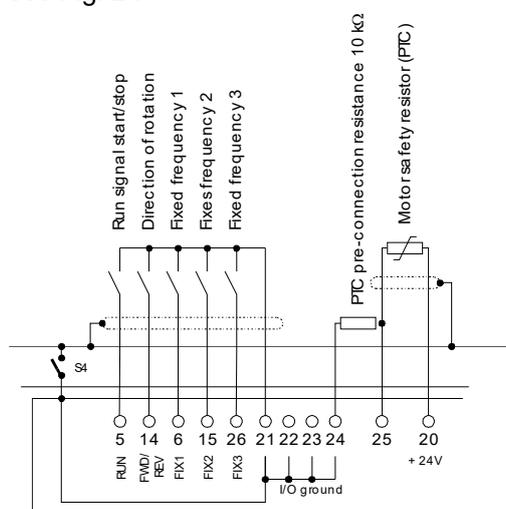
Fig. 2. Connection via negative logic (jumper S1 moved)
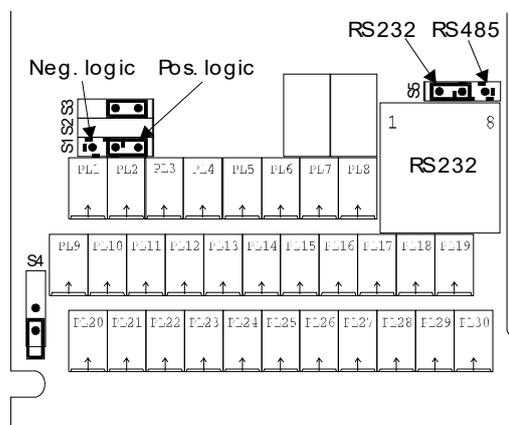
Fig. 3. Jumper locations (shown as supplied)

4.1.1 Wiring

All signal lines should be installed with shielded cables, with the cable shields being connected to the protective earth at one end. The reason for recommending shielding is that signal cables laid alongside power cables are prone to interference, so the inverter can be fed incorrect setpoints.

When running with a potentiometer, this should have a tolerance of better than 5% so the setpoint is not outside the permitted range. The inverter can be configured to give an alarm if the setpoint is out of limits using the *Ain Fail* fault.

4.1.2 Signal terminals and their use

Term.	Function	Description
1	+24V	+24V max 150mA regulated voltage to digital inputs or
9	+24V	external transmitters.
20	+24V	
21	COMMON	
22	COMMON	I/O ground
23	COMMON	
24	COMMON	
5	RUN	Run signal
14	REV	Direction of rotation.
6	FIX1	Select fixed frequency.
15	FIX2	Select fixed frequency.
26	FIX3	Select fixed frequency.
25	PTC	PTC motor protection, requires resistance at 10 kΩ connected to +24 V
12	PLUS POT	Potentiometer input 10 kΩ, positive limit.
13	POT	Potentiometer input 10 kΩ, central takeoff
4	MINUS POT	Potentiometer input 10 kΩ, negative limit
3	VOLTAGE	Voltage setpoint input.
10	CURRENT +	Current setpoint input, positive potential.
2	CURRENT -	Current setpoint input, negative potential.
28	ALARM N. Closed	
17	ALARM Common	Fault relay, potential-free contact max 1 A, 50 V DC.
8	ALARM N. Open	If fault condition and/or inverter powered off, terminals 17 and 28 close.
27	RUN Norm Closed	
16	RUN Common	Run indication, potential-free contact max 1 A, 50 V DC.
7	RUN Norm Open	Terminals 7 and 16 are closed when motor is running.
18	SIO-	RS 485, negative input
29	SIO+	RS 485, positive input
11	ACT_VOLTAGE	Process regulator actual value input (voltage).
30	PE	Protective earth
19		

Table 3. Signal terminals and their use

Digital inputs (terminals 5, 6, 14, 15, 25 and 26) under positive logic:

Maximum input voltage: 30V

Switch level: approx. 5.5V

Digital inputs (terminals 5, 6, 14, 15, 25 and 26) under negative logic:

Maximum input voltage: 30V

Switch level: approx. 18V
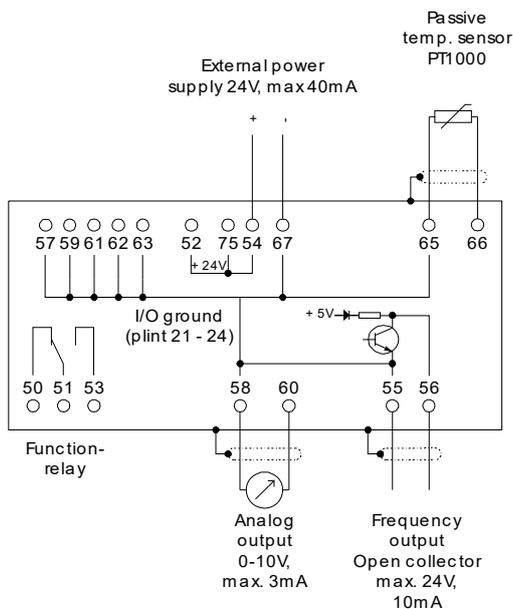
Fig. 4. Connecting expansion board

Term.	Function	Description
50	RELAY Norm. Closed	Function relay, potential-free contact max. 2 A, 50 V DC, 50 W. see section 5.13.1
51	RELAY Common	Function relay
52	+24V	+24V, max. 40mA (not the same power as terminals 1, 9 and 20)
53	RELAY Norm. Open	Function relay
54	+24V	
55	COMMON	Reference ground
56	FREQ OUT	Frequency output, max. 24V 10 mA, Open Collector, see section 5.13.3
57	COMMON	
58	COMMON	
59	COMMON	
60	VOLT OUT	Analog voltage output, max. 10V 3mA, see section 5.13.2
61	COMMON	
62	COMMON	
63	COMMON	
65	COMMON	
66	PT1000	Temperature sensor PT1000, process regulation, see section 5.11
67	COMMON	
75	+24V	

Table 4. Signal terminals and their use, I/O expansion board.

4.1.3 Connecting serial channel RS232

The inverter can be controlled via a type RS232 serial channel. Jumper S5 must then be installed on the left (installed as supplied) as shown in Fig. 3. Connection is made to the 8-pin modular contact, pins numbered 1 to 8 from left to right. Table 5 shows examples of how connection can be made to a serial port on a PC. An USB adapter can be used if a RS232 port is missing. There is a separate manual available describing the control protocols, see www.nfodrives.se.

Inverter modular contact	Description	9-p DSUB COM1 (PC)	25-p DSUB COM2 (PC)	Signal name
7	Data from inverter to higher-level system	2	3	RXD
8	Data from higher-level system to inverter	3	2	TXD
5	Signal ground	5	7	GND

Table 5. Connecting series channel RS232.

4.1.4 Connecting serial channel RS485

The inverter can also be controlled via an RS485 type serial channel. Jumper S5 must then be installed on the right as shown in Fig. 3. Connection is made to terminals 18 (SIO-) and 29 (SIO+). Any terminal resistance must be connected to the terminal separately.

4.2 Power terminal connection

4.2.1 Connectors and cables

Use cable type(-s) with operating temperature rating of at least 70°C. For models 0.37kW – 5.5 kW, the power terminals are screw terminals with a cross section of 0.5 – 4 mm^2 (up to 6 mm^2 for solid wire). The cable shall be stripped 12 – 14 mm before inserted in terminal.
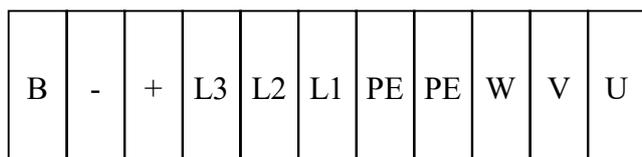
Fig. 5. Power terminal appearance, 0.37 – 5.5kW

The power terminals for the inverters 7,5 – 15kW are divided into two rows according to Fig. 6 below The terminals L3-L2-L1-PE-PE-W-V-U are of type "Push-Lock" with a cross section of 0.75 – 16mm^2. The cable shall be stripped 18 mm and pushed into the connector and then the lever is closed. Terminals +, - and B are screw terminals
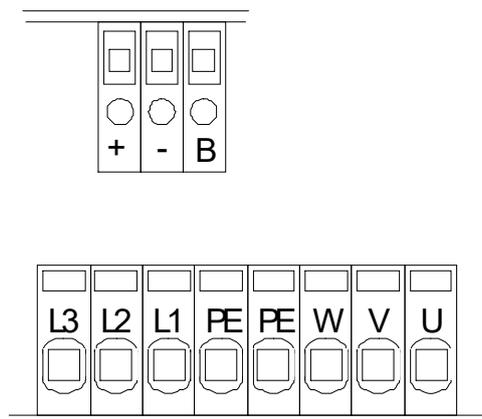
Fig. 6. Power terminal appearance, 7.5 - 15kW   **Fig. 7. The lever of the power terminals**
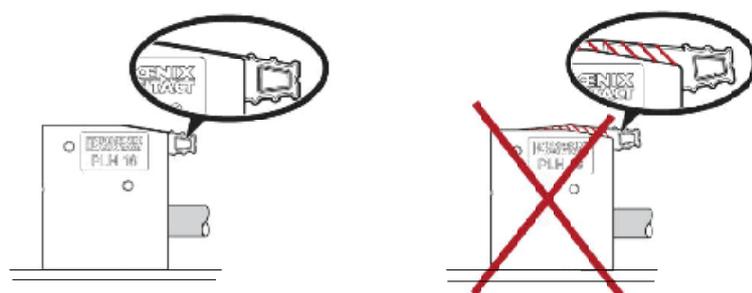
⚠ It is important that the lever is properly closed.

4.2.2 Power terminal use

Terminal	Function	Description
B	Braking resistance	Connection for external braking resistance (between B and +)
-	-	DC link voltage. Nominal voltage:
+	+	At three-phase feed 400 V: 565 V DC
L3		
L2	Mains supply, phases	Mains supply 380-440V 3~ 50/60 Hz
L1		
PE	Protective earth	Power supply protective earth
PE	Protective earth	Protective earth connection motor
W		
V	Motor connection	Motor connection
U		

Table 6. Power terminal usage

When installing two or more inverters together, with one or more of their motors running regeneratively, the inverters DC link terminals (+ and -) can be connected to each other (thus supplying energy to each other). Note! As there are component tolerances in the inverters, the link voltage may vary slightly between units, so an equalising resistor and ultra-fast fuse must be fitted to each line. Contact NFO Drives AB for correct dimensioning.

4.2.3 Connecting mains supply

The inverter terminals L1, L2, L3 and PE shall be connected to a type TN electrical supply network with a nominal voltage of 380 – 440V 3~ 50/60Hz. With the mains supply connected correctly and the motor running, the inverter draws less than 2 mA earth current in the PE connection. A 30mA RCD can be used with the inverter.

Recommended slow-blowing fuses for three-phase supply:

0.37 kW	0.75 kW	1.5 kW	2.2 kW	3 kW	4 kW	5.5 kW	7.5 kW	11 kW	15 kW	18.5 kW	22 kW
6A	6A	6A	10A	10A	16A	16A	25A	35A	35A	50A	63A

⚠ Turning on and off the mains supply too frequently can damage the inrush circuit of the inverter. Wait at least 1 min between each power up. **Don't use the mains supply for frequent on/off control of the motor!**

4.2.4 Connecting motor

Connect motor cables to terminals U, V, W and PE.

Nominal motor voltage for three-phase fed inverters is 400V. A motor with a nominal voltage of 400V–Y / 230V–D must be configured for Y-connection, and a motor with nominal voltage of 690V–Y / 400V–D must be configured for D-connection.

⚠ **Autotuning must always be performed before first motor start, see section 5.6**

⚠ Note! A motor safety switch can be mounted between the inverter (terminals U, V and W) and the motor, but it **must only be operated** (switched off or on) when the **motor is not running**.

⚠ Note! **Never install contactors or switches between the inverter** (terminals U, V and W) **and the motor** that intentionally or unintentionally may be used to disconnect the motor from inverter output.

5 Parameter settings and operation

5.1 General notes

The inverter can be used in four different control modes:

- Frequency regulation of an induction motor (motor speed is not compensated for load variations) with a fixed (digital) or analog setpoint, see section 5.7 for more details. The motor's electrical frequency is shown on the display. This operating mode is called *Freque* and is supplied installed.

- Speed regulation for an induction motor with speed calculation (motor speed compensated for load variations) with a fixed (digital) or analog setpoint, see section 5.9 for more details. The motor's estimated speed is shown in the display. This mode is called *Speed*

- Torque control for an induction motor with a fixed (digital) or analog setpoint, see section 5.10. This operating mode is called *Torque.*

- As a process regulator with feedback from a process controlled by an induction motor, see section 5.11. This mode is called *PI-reg.*

⚠ Autotuning must always be done before first motor start, see section 5.6, Autotuning and motor parameters.

5.2 Keyboard and display

The diagram and table below show the key functions.
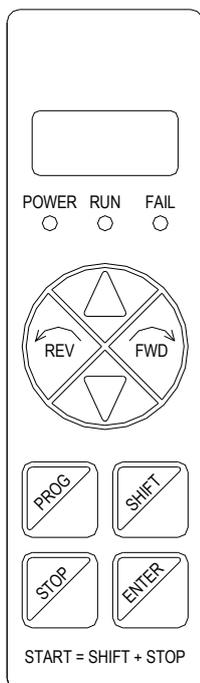
Button	Function
FWD	Local mode: start motor clockwise. Programming mode: scroll forward through parameters or parameter groups.
REV	Local mode: start motor counter-clockwise. Programming mode: scroll back through parameters or parameter groups.
PROG	Go to/exit programming mode. Go from parameters to parameter groups.
SHIFT	Increase increment by ⇑ and ⇓.
STOP	Stop motor and switch to local mode. Used together with SHIFT, starts motor.
ENTER	Set parameter as amended or go to parameter group.
⇑	Increase parameter when changing.
⇓	Decrease parameter when changing.

Fig. 8. Keyboard   **Table 7**. **Button functions**

The value of a given parameter can be increased or decreased by pressing ⇑ or ⇓. When adjusting parameters, these have set increments (how much they change by each time the button is pressed). To increase this increment,

press SHIFT and hold down. Both ⇑ and ⇓ and SHIFT + ⇑ and SHIFT + ⇓ are repetitive. Pressing any of these key combinations and holding them down increases the repetition frequency successively.

When any parameter is changed, a * appears on the right of the first line of the display. This means the parameter has not yet been saved in the inverter's memory. To save the value, press ENTER, then the * disappears.

5.3   Indicator lights

The indicator lights have the following meanings:

POWER   The inverter is powered

RUN   The motor is running

FAIL   Alarm is active

5.4   Operating modes

When starting and initiating the inverter, the software version number will appear for a few seconds. The inverter then goes to external mode and waits for the start command, the display reads *Ext Stby*. To give the start command, activate terminal 5 (RUN).

⚠ The inverter will start automatically after supply power is applied, if terminal 5 (RUN) is active, and parameter *AutoStart=ON* (default setting).

You can switch to local mode at any time by pressing STOP, which shuts off power to the motor.

To switch from any mode to programming mode or vice versa, press PROG. If switching to programming mode from external or serial channel mode, motor control is maintained as in those modes.

5.4.1 Local mode

When motor is running, you can switch to local mode (stop motor) by pressing STOP at any time.

In local mode, the display reads *Stop* and a frequency. The displayed frequency can be adjusted by pressing ⇑ or ⇓ and saved in the inverter's memory. Pressing FWD or REV accelerates the motor clockwise or counter-clockwise, the display reads *Acc*. *Final fr.* appears once the frequency has been reached. When the button is released, the motor starts deceleration if parameter *stMode* is set to *Brake*, the display shows *Ret*. If *stMode* is set to *Release*, the motor will coast to stop. If the inverter is run at frequency 0.0, the display will show *St still* provided the motor is stopped. This way of running the motor is only designed to be used during commission.

The motor can also be started by pressing SHIFT + FWD or SHIFT + REV, in which case it will continue to run even once the keys are released. Once again, you can increase or reduce the frequency by pressing ⇑, ⇓, SHIFT + ⇑ or SHIFT + ⇓. To stop the motor, press STOP or FWD.

To switch to external mode, press SHIFT + STOP. You can also switch if parameter *AutoStart=ON* and terminal 5 (RUN) goes from active to inactive or is active and goes inactive.

To switch to programming mode, press PROG.

To switch from local mode to serial channel mode, use command from serial channel.

5.4.2 Programming mode

This mode is used to change and read off parameters from the inverter. The inverter parameters are divided into parameter groups, as shown in Table 8.

To access parameter groups, press PROG. To scroll forwards or backwards between parameter groups, use FWD and REV. To access parameters within a group, press ENTER. To go back to parameter groups, press PROG. To exit programming mode, press PROG again.

Pressing SHIFT + PROG at a parameter exits programming mode immediately. Pressing SHIFT + PROG again takes you directly back to the last parameter.

To scroll forwards or backwards through parameters in a group, use FWD and REV. The first line of the display shows the current parameter's name and the second line its current value.

If terminal 5 (RUN) is active, the inverter can be started by pressing SHIFT + STOP or stopped by pressing STOP, in which case the inverter will remain in programming mode.

A 'R' (Read only) appears in the top right-hand corner of the display if the parameter concerned is read-only. This may be because the parameter shows a status value or cannot be varied because the motor is running.

If switching to programming mode from external or serial channel mode, motor control remains in that mode; but parameters cannot be modified when the motor is running

5.4.3 External mode

When running in external mode, top row of the display shows inverter status, and second row its actual frequency. If the inverter status shows *Ext Stby*, this indicates the inverter is ready to run and is awaiting a run signal. *Ext Run* is showed when the inverter is running.

The source for the setpoint is determined by the parameter *OpMode* for the selected operating mode. Selecting *OpMode: Terminal* enables the setpoint source to be selected from the terminal signals. If using analog setpoints, the signal type is selected using parameter *AinSet* from the *Control* parameter group. Setpoint sources can be changed at all times.

Analog F means run clockwise at the lowest setpoint at min and the highest setpoint at max run.

Analog R likewise, but counter-clockwise.

Fix-1 F means run clockwise with setpoint from corresponding fixed value parameter for the control mode concerned,

Fix-1 R likewise but running counter-clockwise, and so on.

Fixed value parameters can be changed on the run, in which case the new setpoint applies immediately.

To switch to local mode (motor released), press STOP.

To switch to programming mode, press PROG.

Function	REV (14)	FIX1 (6)	FIX2 (15)	FIX3 (26)	RUN (5)
Analog F	0	0	0	0	1
Analog R	1	0	0	0	1
Fix-1 F	0	1	0	0	1
Fix-2 F	0	0	1	0	1
Fix-3 F	0	1	1	0	1
Fix-4 F	0	0	0	1	1
Fix-5 F	0	1	0	1	1
Fix-6 F	0	0	1	1	1
Fix-7 F	0	1	1	1	1
Fix-1 R	1	1	0	0	1
Fix-2 R	1	0	1	0	1
Fix-3 R	1	1	1	0	1
Fix-4 R	1	0	0	1	1
Fix-5 R	1	1	0	1	1
Fix-6 R	1	0	1	1	1
Fix-7 R	1	1	1	1	1

Table 8. Digital input settings at signal terminals 5, 6, 14, 15 and 26.

Parameter AinSet setting	Analog value	Input (terminal)
0-10V	Voltage 0-10V	3
2-10V	Voltage 2-10V	3
+/-10V	Voltage +/- 10V	3
0-20mA	Current 0-20mA	10 and 2
4-20mA	Current 4-20mA	10 and 2
+/-20mA	Current +/- 20mA	10 and 2
Pot 10k	Potentiometer 10kΩ	12, 13 and 4

Table 9. Settings for analog setpoint inputs at signal terminals

5.4.4 Serial channel/Field bus mode

As standard there are two different communication protocols available, NFO Classic and Modbus RTU/ASCII. Both communicate via RS232/RS485. As option there are add on modules for other field busses, please contact NFO Drives AB.

Switching to field bus mode is done by giving a command via the bus. To return to local mode, use bus command or press STOP. Some busses change automatically to field bus mode; this requires disconnection of the bus communication to return to local mode (disconnect the cable from the RS232 contact in the inverter).

Parameters for field bus control are placed in the parameter group *Serial*. The parameter *BusType* indicates which type of bus/protocol is used. A separate manual describing field bus control is available at www.nfodrives.se.

For setup and control of the inverter via Modbus or NFO, a Windows program "NFO Sinus Manager" is available. It can be downloaded from www.nfodrives.se.

5.5   Parameter specifications

Parameters are divided into parameter groups, as shown in the table below:

Motor	Control	Freque	Speed	Torque	PI Reg	Output	Serial	Status	Error
P-Nom	Mode	OpMode	OpMode	OpMode	OpMode	ReMode	BusType	U-rms	E-logg
U-Nom	Accel	F-fix1	C-fix1	T-fix1	R-fix1	ReFreq	Address	I-rms	RstDly
f-Nom	Retard	F-fix2	C-fix2	T-fix2	R-fix2	V-Out	SiBaud	P-out	TrTime
N-Nom	RunDly	F-fix3	C-fix3	T-fix3	R-fix3	V-Max	SiProt	PF	AC Fail
I-Nom	DC-Brk	F-fix4	C-fix4	T-fix4	R-fix4	F-Out	SioTot	DClink	Temp Hi
cos φ	AinSet	F-fix5	C-fix5	T-fix5	R-fix5	F-Max	AutoReset	FrqSet	PTC Temp
Tuning	AutoStart	F-fix6	C-fix6	T-fix6	R-fix6		AutoStop	FrqAct	OverLoad
R-stat	EnergySave	F-fix7	C-fix7	T-fix7	R-fix7			SpdSet	Ain Fail
R-rot	StMode	Fr-Min	Sp-Min	Tq-Min	Setmin			SpdAct	DC Low
L-main	Kp-spd	Fr-Max	Sp-Max	Tq-Max	Setmax			TrqSet	DC High
Sigma	Ti-spd			Max-fr	Actmin			TrqAct	GND Fail
I-magn	FSleep				Actmax			RegSet	IMagnLow
I-limt	Byp-fr				T-Min			RegAct	Short C
	Byp-bw				T-Max			AinP11	Cur Low
	IbstTm				RegAmp			AinP10	Cur High
	IbstLv				RegKp			AinP03	Run Fail
					RegTi			AinP13	
					Min-fr			PT1000	
					Max-fr			M-Temp	
					Unit			OpTime	
					AinAct			RnTime	
								BrTime	

Table 10. Parameter groups and parameters.

Only the parameter groups for the run mode selected are displayed, i.e. either *Freque, Speed, Torque* or *PI reg*.

The table below shows all inverter parameters, divided into parameter groups.

Type = Init means parameters can only be changed via initialising in local mode.

Type = Init/Run means parameters can be changed in any mode.

Type = Read means parameters are read-only.

Name	Description	Section	Default value	Range	Type [1]
		Motor			
P-Nom	Nominal motor output	5.6		0.01 – 100kW	Init
U-Nom	Nominal motor voltage	5.6		1 – 1000V	Init
f-Nom	Nominal motor frequency	5.6	**Table 12**	1 – 500Hz	Init
N-Nom	Nominal motor speed	5.6		5 – f-Nom * 60rpm	Init
I-Nom	Nominal motor current	5.6		**Table 12**	Init
cos φ	Motor cos φ	5.6		0.01 – 1.00	Init
Tuning	Autotuning command	5.6			Init
R-stat	Motor stator resistance	5.6			Init
R-rot	Motor rotor resistance	5.6			Init
L-main	Motor main inductance	5.6			Init
Sigma	Motor leak inductance	5.6		0,001-1,000	Init
I-magn	Magnetisation current setpoint (RMS)	5.6		0 – min (I-nom, I-limt)	Init
I-limt	Maximum motor current (RMS)	5.6			Init/Run
		Control			
Mode	Control mode *Freque* = speed control with frequency estimation *Speed* = rpm control with speed estimation *Torque* = torque control *PI-reg* = process control mode	5.7.1 5.8 5.9 5.10 5.11	*Speed*	*Freque* *Speed* *Torque* *PI-reg*	Init
Accel	Acceleration time from 0 to f-Nom Hz	5.7.2	30.0 s [2]	0.2 - 500.0 s	Init/Run
Retard	Retardation time from f-Nom to 0 Hz	5.7.2	30.0 s [2]	0.2 - 500.0 s	Init/Run
RunDly	Start delay Delay in seconds from when power is applied until motor can start.		0 s	0 – 3600 s	Init/Run
DC-Brk	Motor DC braking before startup. Time in seconds for which motor is braked before startup.	5.7.5	0 s	0 – 3600 s	Init/Run
AinSet	Type of setpoint at analog input (terminals 3, 10 or 13)		*0-10V*	*0-10V* *2-10V* *+/-10V* *0-20mA* *4-20mA* *+/-20mA* *Pot 10k*	
AutoStart	Autostart mode *OFF* = Inverter awaiting flank on RUN after power applied. *ON* = motor starts as soon as power is applied if RUN is active. ⚠ WARNING: if there is a run signal to the inverter, it will start when power is applied.	5.7.6	*ON*	*OFF* *ON*	Init/Run

Energy Save	Energy save function *OFF* = Function is disabled. *ON* = Inverter optimizing energy consumption of the motor.	5.7.8	*OFF*	*OFF* *ON*	Init/Run
StMode	Stop mode *Brake* = motor brakes as *Retard*. *Release* = motor coast to stop.	5.7.7	*Brake*	*Brake* *Release*	Init/Run
Kp-spd	Amplifier constant speed regulator	5.7.11	0,20[2]	0,01 – 10,00	Init/Run
Ti-spd	Integration time speed regulator	5.7.11	1,00[2]	0 – 10,00 s	Init/Run
FSleep	Frequency limit when motor is disengaged	5.7.9	0.0 Hz	0.0-150.0 Hz	Init/Run
Byp-fr	Bypass frequency	5.7.10	0.0 Hz	0.0-150.0 Hz	Init/Run
Byp-bw	Bypass frequency bandwidth	5.7.10	0.0 Hz	0.0-150.0 Hz	Init/Run
IbstTm	Time with extended current limit from start	5.7.12	0 s	0-100 s	Init/Run
IbstLv	Extended current limit level from start	5.7.12	0 %	0-100%	Init/Run
Freque					
OpMode	Setpoint source, frequency	5.8.1	*Terminal*		Init/Run
F-fix1	Fixed frequency 1	5.8.2	10.0 Hz	0.0-150.0 Hz	Init/Run
F-fix2	Fixed frequency 2	5.8.2	20.0 Hz	0.0-150.0 Hz	Init/Run
F-fix3	Fixed frequency 3	5.8.2	30.0 Hz	0.0-150.0 Hz	Init/Run
F-fix4	Fixed frequency 4	5.8.2	40.0 Hz	0.0-150.0 Hz	Init/Run
F-fix5	Fixed frequency 5	5.8.2	50.0 Hz	0.0-150.0 Hz	Init/Run
F-fix6	Fixed frequency 6	5.8.2	60.0 Hz	0.0-150.0 Hz	Init/Run
F-fix7	Fixed frequency 7	5.8.2	70.0 Hz	0.0-150.0 Hz	Init/Run
Fr-Min	Lowest frequency when running with analog setpoint.	5.8.3	0.0 Hz	0.0-150.0 Hz	Init/Run
Fr-Max	Highest frequency when running with analog setpoint.	5.8.3	50.0 Hz	0.0-150.0 Hz	Init/Run
Speed					
OpMode	Setpoint source, speed	5.9.1	*Terminal*		Init/Run
C-fix1	Fixed speed 1	5.9.2	300 rpm	0-9000 rpm	Init/Run
C-fix2	Fixed speed 2	5.9.2	600 rpm	0-9000 rpm	Init/Run
C-fix3	Fixed speed 3	5.9.2	900 rpm	0-9000 rpm	Init/Run
C-fix4	Fixed speed 4	5.9.2	1200 rpm	0-9000 rpm	Init/Run
C-fix5	Fixed speed 5	5.9.2	1500 rpm	0-9000 rpm	Init/Run
C-fix6	Fixed speed 6	5.9.2	1800 rpm	0-9000 rpm	Init/Run
C-fix7	Fixed speed 7	5.9.2	2100 rpm	0-9000 rpm	Init/Run
Sp-Min	Lowest speed when running with analog setpoint.	5.9.3	0 rpm	0-9000 rpm	Init/Run
Sp-Max	Highest speed when running with analog setpoint.	5.9.3	1500 rpm	0-9000 rpm	Init/Run
Torque					
OpMode	Setpoint source, torque	5.10.1	*Terminal*		Init/Run
T-fix1	Fixed torque 1	5.10.2	10.0 %	1 – 400 %	Init/Run
T-fix2	Fixed torque 2	5.10.2	20.0 %	1 – 400 %	Init/Run
T-fix3	Fixed torque 3	5.10.2	30.0 %	1 – 400 %	Init/Run
T-fix4	Fixed torque 4	5.10.2	40.0 %	1 – 400 %	Init/Run
T-fix5	Fixed torque 5	5.10.2	50.0 %	1 – 400 %	Init/Run
T-fix6	Fixed torque 6	5.10.2	60.0 %	1 – 400 %	Init/Run
T-fix7	Fixed torque 7	5.10.2	70.0 %	1 – 400 %	Init/Run
Tq-Min	Lowest torque when running with analog setpoint	5.10.3	10.0 %	1 – 400 %	Init/Run

Tq-Max	Highest torque when running with analog setpoint	5.10.3	100.0 %	1 – 400 %	Init/Run
Max-fr	Maximum frequency under torque control.	5.10	50 Hz	0.0 – 150.0 Hz	Init/Run
PI Reg					
OpMode	Setpoint source, regulator	5.11.1	*Terminal*		Init/Run
R-fix1	Fixed setpoint 1	5.11.2	40.0	-2000.0 - 2000.0	Init/Run
R-fix2	Fixed setpoint 2	5.11.2	80.0	-2000.0 - 2000.0	Init/Run
R-fix3	Fixed setpoint 3	5.11.2	120.0	-2000.0 - 2000.0	Init/Run
R-fix4	Fixed setpoint 4	5.11.2	160.0	-2000.0 - 2000.0	Init/Run
R-fix5	Fixed setpoint 5	5.11.2	200.0	-2000.0 - 2000.0	Init/Run
R-fix6	Fixed setpoint 6	5.11.2	240.0	-2000.0 - 2000.0	Init/Run
R-fix7	Fixed setpoint 7	5.11.2	280.0	-2000.0 - 2000.0	Init/Run
Setmin	Value at min. input signal from setpoint input	5.11.3	0.0	-2000.0 - 2000.0	Init/Run
Setmax	Value at max. input signal from setpoint input	5.11.3	300.0	-2000.0 - 2000.0	Init/Run
Actmin	Value at min. input signal from actual value input	5.11	0.0	-2000.0 - 2000.0	Init/Run
Actmax	Value at max. input signal from actual value input	5.11	300.0	-2000.0 - 2000.0	Init/Run
T-Min	Min. temperature	5.11.3	-20 °C	-100 – 100 °C	Init/Run
T-Max	Max. temperature	5.11.3	20 °C	-100 – 100 °C	Init/Run
RegAmp	Amplifies process regulator	5.11.4	1	1 or -1	Init/Run
RegKp	Proportional component process regulator	5.11.4	0.00	0.00 – 1.00	Init/Run
RegTi	Integrator component process regulator	5.11.4	30.0 s	1.0 – 200.0 s	Init/Run
Min-fr	Min. frequency from regulator	5.11	0.0 Hz	0.0 – 150.0 Hz	Init/Run
Max-fr	Max. frequency from regulator	5.11	50.0 Hz	0.0 – 150.0 Hz	Init/Run
Unit	Regulator units	5.11	Pa		Init/Run
AinAct	Scaling of actual value input	5.11	0-10V		Init/Run
Output					
ReMode	Function relay function *Disable* = Function disabled *Running* = Motor running *Run Fwd* = Motor running forwards *Run Rev* = Motor running reverse *Run Setp* = Motor frequency has reached setpoint *Run Freq* = Motor frequency $> ReFreq$	5.13.1	*Running*	*Disable Running Run Fwd Run Rev Run Setp Run Freq*	Init/Run
ReFreq	Changeover frequency in *ReMode = Run Freq*	5.13.1	50.0 Hz	0,0 – 150.0 Hz	Init/Run
V-Out	Analog power output *Disable* = Function disabled *Freque* = Current electrical frequency *Speed* = Current rotor speed *Torque* = Current torque	5.13.2	*Disable*	*Disable Freque Speed Torque*	Init/Run

V-Max	Scale factor for analog power output	5.13.2	*10.00V*	0 - 10.00 V	Init/Run
F-Out	Analog frequency output *Disable* = Function disabled *Freque* = Current electrical frequency *Speed* = Current rotor speed *Torque* = Current torque	5.13.3	*Disable*	*Disable* *Freque* *Speed* *Torque*	Init/Run
F-Max	Scale factor for analog frequency output	5.13.3	*32000 Hz*	0 - 32000 Hz	Init/Run
Serial					
BusType					Init/Run
Address	Serial channel information See separate manual				Init/Run
SiBaud					Init/Run
SiProt					Init/Run
SioTot					Init/Run
AutoReset					Init/Run
AutoStop					Init/Run
Status					
U-rms	Motor voltage (RMS)		V		Read
I-rms	Motor current (RMS)		A		Read
P-out	Active power output		W		Read
PF	Output power factor				Read
DClink	DC Link voltage		V		Read
FrqSet	Actual frequency setpoint (*Freque* mode)		Hz		Read
FrqAct	Electrical frequency (*Freque* mode)		Hz		Read
SpdSet	Actual speed setpoint (*Speed* mode)		rpm		Read
SpdAct	Rotor speed (estimated actual value, *Speed* mode)		rpm		Read
TrqSet	Torque setpoint (as % of nominal motor torque)		%		Read
TrqAct	Current torque (as % of nominal motor torque)		%		Read
RegSet	Process regulator setpoint		As per parameter *Unit*		Read
RegAct	Process regulator actual value		As per parameter *Unit*		Read
AinP11	Analogue value terminal 11		V		Read
AinP10	Analogue value terminal 10		mA		Read
AinP03	Analogue value terminal 3		V		Read
AinP13	Analogue value terminal 13		%		Read
PT1000	Temperature PT1000 temp. sensor	5.11.3	°C		Read
M-temp	Estimated relative motor temp.		%		Read
Optime	Total time inverter has been powered		0.1 hours		Read
Runtime	Total time motor has been running		0.1 hours		Read
BrTime	Total time brake chopper has been activated		1 Sec		Read
Error					
E-logg	Fault log	5.15.1			Read
RstDly	Restart delay time after self-resetting error condition	5.15	10 sec	0 – 3600 sec	Init/Run
TrTime	Error counter reset time. (fault free operation)	5.15	600 sec	0 – 3600 sec	Init/Run
AC Fail	Phase error	5.15.2			
Temp Hi	Cooling flange overheating	5.15.2			

PTCTemp	Motor overheating.	5.15.2			
OverLoad	Power monitor				
Ain Fail	Analog setpoint input signal out of range	5.15.2			
DC Low	Voltage in DC link too low	5.15.2			
DC High	Voltage in DC link too high	5.15.2			
GND Fail	Fault in motor or motor wiring	5.15.2			
Short C					
IMagnLow					
Cur Low					
Cur High					
Cur Limt	Current limit reached	5.15.2			
Run Fail	Rotor locked, start failure	5.15.2			

Table 11. Parameters available, sorted by parameter group

Notes:

[1]   Type = Init   parameters can only be changed via initialising in local mode.
      Type = Init/Run   parameters can be changed in any mode.
      Type = Read   parameters are read-only.

[2]   Other combinations of default values for Acceleration, Deceleration, Kp-speed and Ti-speed are available.

5.6   Autotuning and motor parameters

There are three alternatives for autotuning the motor parameters: Full tuning, Basic tuning or Calculated tuning. Full tuning is preferred whenever possible, see section 5.6.4 below.

Before running autotuning, the nominal motor data has to be entered, which consists of parameters *P-nom, U-Nom, f-Nom, N-Nom, I-Nom* and *cos φ*. These are shown on the motor plate and must be entered according to the connection used; i.e. Y (star) or D (delta), including any possible 50 / 60Hz option for the motor. The basic nominal data settings as supplied are shown in Table 12.

To achieve optimal motor control, the inverter must have a correct set of parameters *R-stat, R-rot, L-main, Sigma, I-magn* and *I-limit*. The autotuning functionality measures and calculates these motor parameters, taking into account the cables, etc. between inverter and motor, and ensures best possible control of the motor. Autotuning shall **always** be performed, even if a standard motor is used.

When the nominal motor parameters are entered and saved, run the *Tuning* command. Tuning is initiated by selecting *Tuning* and *Tuning Full* from the user interface. Motor parameters are then measured and after completion saved in the inverter for their respective parameter. The tuning operation can take up to 1 minute to complete depending on motor size.

The autotuning functions sets *I-limit* to 120 % of the motor's nominal current or the maximum of the inverter.

5.6.1 Full tuning

To perform autotuning:

1. Check that motor is not running.
2. Go to parameter-group *Motor* and enter parameters *P-nom U-Nom, f-Nom, N-Nom, I-Nom* and *cos φ* for the connection the motor is to be used (Y or D).
3. Select the *Tuning* command and press ⇑.

4. When asked *Tuning Full?* press ENTER (any other button will not execute the command).

5. Wait until parameters have been evaluated, the screen will show *Tuning Ready*.

6. Continue setting other inverter parameters.

If a fault occurs during autotuning, two different error messages may appear, *Tuning Fail M* or *Tuning Fail P*. *Tuning Fail M* indicates that measuring of the motor parameters failed, while *Tuning Fail P* indicates that one or more parameter(s) is outside the allowable limit for the inverter. If the auto tuning process results in an error, the cause of error must be identified and corrected before the motor can be start.

Faults may be due to:

- Motor not connected correctly (short or open circuit in wiring).
- Motor fault (short or open circuit).
- Motor incorrectly connected (Y-connected instead of D-connected or vice versa).
- The inverter is under or over dimensioned for the connected motor (the inverter's motor parameter ranges allow one size greater and two sizes smaller standard motors than inverters nominal parameters).

Note! All tuning should be performed with a cold motor, i.e. the motor should have the normal ambient temperature where it will be used. If tuned with warm motor, operating issues may occur when starting with a cold motor.

When tuning completed, return to external mode by pressing SHIFT + STOP.

5.6.2 Basic tuning

A simplified form of calculating parameters can be carried out by pressing ⇑ again in point 3 as above. The display then shows *Basic?* This calculation procedure only measures the motor stator resistance and then uses stator resistance as the basis for calculating the other motor parameters.

5.6.3 Calculated tuning

If the stator resistance for the motor is known, the other motor parameters can be calculated. You can do this by entering the known value of *R*-stat in point 2 above, and thereafter press ⇑ three times in point 3. The display will now read *Tuning Calc?* press ENTER to run calculations.

This calculation method may not give exactly the same motor parameters as full (*Full Tuning*), but the same as simplified (*Basic*) if the stator resistance is measured to the same value. With full autotuning, all motor parameters are measured by the inverter, while during basic and calculated tuning remaining motor parameters are calculated based on *R-stat* and the nominal motor data.

5.6.4 Selection of tuning method

The aim should be to use full autotuning (*Full*) wherever possible. This is because, with full autotuning, all motor parameters are measured. Using Basic or Calculated tuning, all motor parameters are calculated based on the *R-stat* (measured or manually entered) and the nominal motor data parameters.

5.6.5 Default motor data

P-Nom	U-Nom	f-Nom	N-Nom	I-Nom	Range I-Nom	cos φ
0,37 kW	400V	50 Hz	1410 rpm	1,1 A	0,1 – 9,3	0,69
0,75 kW	400 V	50 Hz	1420 rpm	2,0 A	0,1 – 18,7	0,74
1,50 kW	400 V	50 Hz	1420 rpm	3,5 A	0,1 – 30,2	0,79
2,20 kW	400 V	50 Hz	1430 rpm	5,0 A	0,1 – 42,6	0,81
3,00 kW	400 V	50 Hz	1430 rpm	6,7 A	0,1 – 52,8	0,78
4,00 kW	400 V	50 Hz	1435 rpm	8,8 A	0,1 – 69,9	0,79
5,50 kW	400 V	50 Hz	1450 rpm	11,1 A	0,1 – 84,1	0,84
7,50 kW	400 V	50 Hz	1455 rpm	15,2 A	0,1 – 112,8	0,82
11 kW	400 V	50 Hz	1460 rpm	21,5 A	0,1 – 169,2	0,84
15 kW	400 V	50 Hz	1455 rpm	28,5 A	0,1 – 201,9	0,84

Table 12. Default nominal data values

3x400V	R-stat	R-rot	Range R-stat/R-rot	L-main	Range	Sigma	Range	I-magn	Range	I-limt	Range
0,37 kW	22,50 Ω	14,44 Ω	0,03 - 121,86	0,9840 H	min(3,2 , 310,31/f-Nom)	0,183	Table 10	0,68 A	Table 10	1,32 A	I-magn – 1,60A
0,75 kW	10,00 Ω	6,69 Ω	0,02 – 60,93	0,6205 H	min(3,2 , 115,16/f-Nom)	0,149	Table 10	1,08 A	Table 10	2,40 A	I-magn – 2,50A
1,50 kW	4,50 Ω	3,68 Ω	0,01 – 37,9	0,4163 H	min(3,2 , 96,51/f-Nom)	0,117	Table 10	1,63 A	Table 10	4,20 A	I-magn – 4,20A
2,20 kW	3,00 Ω	2,23 Ω	0,01 – 26,91	0,3096 H	min(3,2 , 68,53/f-Nom)	0,105	Table 10	2,20 A	Table 10	5,80 A	I-magn – 5,80A
3,00 kW	2,00 Ω	1,69 Ω	0,01 – 21,75	0,2200 H	min(3,2 , 55,39/f-Nom)	0,124	Table 10	3,11 A	Table 10	8,00 A	I-magn – 8,00A
4,00 kW	1,30 Ω	1,19 Ω	0,01 – 16,44	0,1767 H	min(3,2 , 41,86/f-Nom)	0,117	Table 10	3,89 A	Table 10	10,50 A	I-magn – 10,50A
5,50 kW	1,00 Ω	0,71 Ω	0,01 – 13,67	0,1617 H	min(3,2 , 38,41/f-Nom)	0,087	Table 10	4,27 A	Table 10	13,30 A	I-magn – 13,30A
7,5 kW	0,70 Ω	0,47 Ω	0,01 – 10,20	0,1121 H	min(3,2 , 25,97/f-Nom)	0,099	Table 10	6,16 A	Table 10	17,70 A	I-magn – 17,70A
11 kW	0,45 Ω	0,29 Ω	0,01 – 6,80	0,0856 H	min(3,2 , 17,32/f-Nom)	0,087	Table 10	8,11 A	Table 10	25,80 A	I-magn – 25,80A
15 kW	0,25 Ω	0,25 Ω	0,01 – 5,70	0,0677 H	min(3,2 , 14,51/f-Nom)	0,087	Table 10	10,32 A	Table 10	32,00 A	I-magn – 32,00A

Table 13. Default motor parameter values and permitted ranges

Tables above show the default value settings for nominal data and motor parameters for each inverter model. Please note that these parameters are for an equivalent star-connected (Y) motor and cannot be measured from the motor terminal.

5.6.6 Motors in parallel

Several motors can be connected in parallel. If so, they must be of the same size and shall be equally loaded. For correct tuning, sum up P-Nom and I-Nom for the motors before performing autotuning.

⚠ When running motors in parallel, separate motor protection should be mounted as they are not individually protected by the electronic motor overload protection or inverter current limit.

5.7 Setting control parameters

5.7.1 Control mode, parameter *Mode*

NFO Sinus can control induction motors in four different control modes: frequency without estimation (*Freque*), rpm with speed estimation (*Speed*), torque (*Torque*) and process regulation (*PI Reg*).

With the *Mode* parameter set to *Freque*, the frequency is controlled in accordance with the frequency setpoint entered. The inverter does not compensate the frequency for load variations. The torque available is governed by the parameter *I-limt*, which is normally set at 120% of the connected motor's current at nominal output. Other settings see section 5.8.

With the *Mode* parameter set to *Speed*, the motor speed is regulated in line with the setpoint entered. The inverter calculates the rpm and regulates this to keep it as close to the setpoint as possible. This means the inverter compensates for load variations. The torque available is governed by parameter *I*-lim, which is normally set at 120% of the connected motor's current at nominal output. Other settings see section 5.9.

With the *Mode* parameter set to *Torque*, the motor torque is regulated in line with the setpoint which is stated as a % of the motor's nominal torque. At low loads, the motor rpm is limited in accordance with parameter *Max-fr*. Other settings see section 5.10.

With the *Mode* parameter set to *PI-reg*, the motor is controlled such that an externally feedback signal (actual value) matches the inverter's setpoint. The motor frequency is regulated within a range defined by parameters *Min-fr* and Max-*fr*. Other settings see section 5.11.

5.7.2 Acceleration and retardation ramp, parameters *Accel* and *Retard*

Parameters *Accel* and *Retard* indicate how fast the motor is allowed to change speed. The units here are in seconds, and the value indicates the time it takes for the rotor frequency to change as much as the motor's nominal frequency (*f-Nom*). The parameter values are calculated using the formulas below:

t_{Accel} = *f-Nom* * Acc time desired / frequency change
t_{Retard} = *f-Nom* * Ret time desired / frequency change

Example: a motor has a nominal frequency of 50Hz, and is to accelerate from 0 to 80 Hz in 2 sec and brake from 80 to 5 Hz in 9 sec.
t_{Accel} = 50 * 2 / 80 = 1.25 s
t_{Retard} = 50 * 9 / 75 = 6.00 s

Remember:

- In generative operation, the inverter cannot brake harder than it can handle the motor's surplus energy. If the brake chopper is used, this will handle the surplus, but setting the retardation time too low may mean the brake chopper circuit becomes overloaded.

- The inverter cannot accelerate faster than its maximum torque allows. Setting the acceleration time too low leads to the inverter limiting current which gives an extended acceleration time.

⚠ **External braking resistance must be fitted if the retardation time is less than 5 sec. Avoid setting retardation ramp (parameter *Deceleration*) any shorter than necessary.**

5.7.3 Run delay, parameter *RunDly*

If the inverter fails to start the motor when power is applied to the inverter (alarm *Run Fail* is shown). The parameter *RunDly* can be set so that the inverter delays starting the motor after a short time power failure (interrupt). This can occur when operating with large inertial torque, such as a fan rotor. Set parameter to the time it takes for the motor to stop running at the maximum possible operating frequency.

5.7.4 Analog input type, parameter *AinSet*

Selects input type and range for the analog setpoint input (terminal 3, 10 or 13) whenever analog setpoint is selected in parameter *Op Mode* for actual control mode *power failure*. Possible settings {0-10V, 2-10V, +/-10V, 0-20mA, 4-20mA, +/-20mA, Potentiometer 10k. Terminal 3(23) is voltage, input, terminal 10 (2) is current input and terminal 13 (12,4) is potentiometer as described in Fig.1 above.

5.7.5 Motor brake, parameter DC-Brk

When starting a rotary load (such as a fan rotor with natural draught), it may happen that the inverter cannot get control the motor, and indicates a *Run Fail* alarm. To handle such starts, the inverter is equipped with a DC brake function. This function slows the motor down with the help of a DC current for a set period of time, after which the motor will then start. The parameter *DC-Brk* is set to the time needed to stop the motor when it is rotating at its fastest. The size of the brake current is adjusted to the motor's nominal current.

5.7.6 Autostart, parameter *AutoStart*

With *AutoStart* parameter =*ON*, the motor will start as soon as power is applied, provided the digital input signal RUN at the terminal (DIN1) is active. This parameter also controls whether the inverter will attempt to restart after a fault, see section 5.15.

With *AutoStart* parameter =*OFF* (default setting), when power is applied the inverter will wait for a transition on the digital input signal RUN at the terminal (DIN1). When the signal goes from inactive to active, the motor will start. *AutoStart* = *OFF* is also the recommended setting if the inverter shall be controlled via the serial channel.

⚠️ **WARNING: use the Autostart function with caution, and not in combination with control via the serial channel or field bus. Remember the motor will start automatically after an involuntary power failure.**

5.7.7 Stop mode, parameter *StMode*

The NFO Sinus has two different stop modes, *Brake* and *Release*.

With the *StMode* parameter set to *Brake* (as supplied): On issuing the stop command, the inverter will slow the motor down to a stop using the set retardation ramp. If there is a mains failure, the inverter will slow the motor down to a stop as quickly as possible without the motor generating a voltage surge.

With the *StMode* parameter set to *Release*: The stop command will release the motor immediately, letting it run down to an uncontrolled stop. The motor will also be released in the event of a mains failure.

⚠️ **Avoid allowing a load with high inertial torque run down uncontrolled: this could destroy the inverter through a large voltage surge generated by the motor.**

5.7.8 Energy save function, parameter *EnergySave*

The energy save function optimizes the energy consumption of the motor by lowering the magnetizing current at low loads. It is mainly used for applications at low loads i.e. fans that sometimes run at very low speeds. The magnetizing current is at maximum lowered to 25% of *I-magn*. The time for the function to adjust optimal magnetizing current is approx. 5s at a change in setpoint or load. Thanks to this, the function should only be used in application requiring low dynamics.

With the *EnergySave* parameter set to *ON* the function is enabled and to OFF disabled. *EnergySave* is default set to OFF.

5.7.9 Frequency sleep setting, parameter *FSleep*

The purpose of this function is to minimize power consumption when running motor att low speed. When both setpoint frequency and actual frequency are within the interval 0 – *Fsleep* the motor is released. The motor is started again when the setpoint frequency is outside the interval 0 – (*FSleep* + 0.5Hz). This setting applies to all modes (*Freque, Speed, Torque* and *PI-Reg*).

The default value of 0.0Hz disables this function.

Example: Fan application regulated by a temperature setpoint
FSleep = 5.0Hz
The motor runs at 30Hz when a drop in temperature updates the inverter's setpoint to 4.0Hz. The inverter will now slow the motor down according to retardation ramp down to 5Hz and then release the motor. When setpoint exceeds 5.5Hz the inverter will again start the motor.

5.7.10 Frequency bypass, parameters *Byp-fr* and *Byp-bw*

The function is used to avoid operating inverter within a selected frequency range (frequency bypass). Two parameters are used to set the frequency range: *Bypass-fr* sets the frequency's mid-frequency and *Bypass-BW* sets the bandwidth. This function is disabled when both *Bypass-fr* and *Bypass-BW* are set to 0.0 Hz.

If the inverter is accelerating (or decelerating) towards a setpoint value and the actual rotor speed enters the bypass window, the inverter will use fastest possible acceleration (or deceleration) until the rotor speed is outside the bypass window.

If the inverter follows a slowly varying setpoint (e.g. analogue setpoint 0 – 10V) and the setpoint enters the bypass window, the inverter will keep the actual speed (at bypass window start) until the input setpoint has reached a point outside the bypass window. Then the inverter will use fastest possible acceleration (or deceleration) until the rotor speed has reached the new setpoint.

Example: Acceleration from 0 to 50 Hz

Accel = 5,00s, *Bypass-fr* = 25,0Hz, *Bypass-BW* = 10,0Hz

This gives a setspeed curve as shown in Fig. 9.
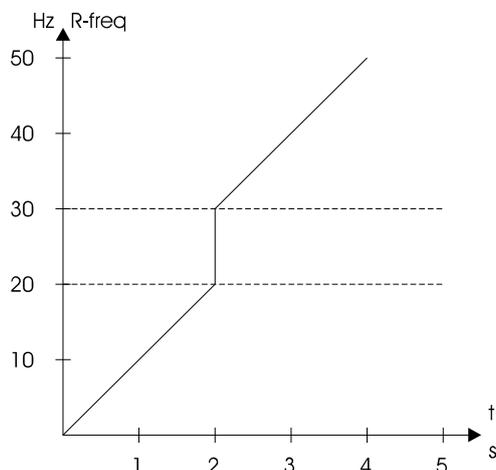
Fig. 9. Acceleration with frequency bypass

5.7.11 Speed regulator, parameters *Kp-spd* and *Ti-spd*

The inverter is equipped with a PI-type speed or frequency regulator to ensure the rotor is at the desired rpm (mode *Speed*) or frequency (mode *Freque*, mode *Torque* and mode *PI reg*) at all times under all loads (up to maximum torque). This can be set via parameters *Kp-spd* and *Ti-spd* if required. The P-amplifier (*Kp-spd*) handles fast control inputs (rapid changes in speed), while the I amplifier (*Ti-spd*) is responsible for fine-tuning the final speed.

Default setting of *Kp-spd* is set to 0.20 and *Ti-spd* to 1.00 sec, which works during most operating conditions. Loads with high inertial torque, or motors with multiple poles may need to have Kp-speed and / or Ti-speed adjusted. The following guidelines may be helpful when adjusting:

- First, set the regulator so it works more or less purely as a P-regulator. This is done by setting the maximum time (*Ti-spd*) for the integrator amplification.

- Start motor at low P amplification (*Kp-spd*). Increase the P amplification carefully until its control becomes unstable and/or shows a tendency to over-react to control signals (indicated by an overrun to a speed change). Then reduce P amplification until the control is stable again.

- At maximum integration time, it will take longer than necessary for the motor to run up to the specified speed. Reduce the integration time (*Ti-spd*) carefully, which is indicated by the fact that the speed control sets itself faster at the correct speed. If the integration time selected is too short, this will show up as an unstable response to speed changes with overruns in speed regulation. Select the integration time that gives the fastest response but without wobble.
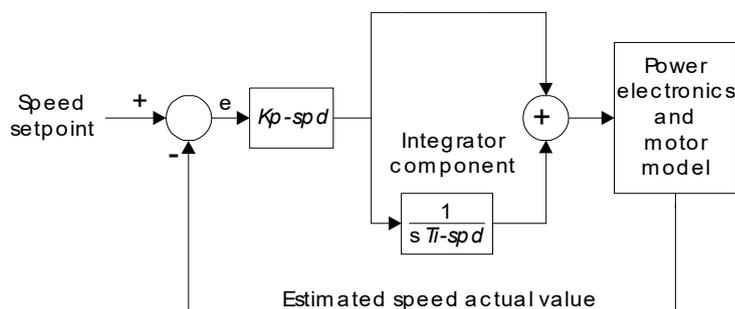

Fig. 10. Speed regulator

If you have any doubts or problems, please contact NFO Drives AB.

5.7.12 Increased start current (I-boost)

With NFO Sinus it is possible to set a temporary increased current limit at startup of motor. This can be achieved if a NFO sinus inverter with a nominal power of one or two sizes bigger than the motor's nominal power is used, for example a 3kW or 4kW NFO Sinus is used with a 2.2kW motor.

After installation, when motor parameters have been entered and Autotuning have been performed, the NFO Sinus will set current limit to 120% of motors nominal current. If an oversized inverter has been chosen, there will be some extra current available up to inverter's max current limit. If desired it is possible to set the parameters *IbstTm* (I-boost time) set the time after start signal (in seconds) and IbstLv (I-boost Level, 0-100% of exceeding current capacity) the enhanced current limit is applied during I-boost time period.

Example: A 3kW NFO Sinus (I-max 8,0A) is installed with a 1.5 kW motor with I-nom 3,5 A. When tuned, the NFO Sinus will set current limit (I-limit) to 3,5 x 120 % = 4,2 A. The exceeding range up to inverter's max current limit is 8,0 – 4,2 = 3,8 A. With IbstTm = 5 s and IbstLv 50%, the current limit during the first 5 seconds will be increased to half of the remaining current capacity. That is I-limit = 4,2 + (3,8 x 50%) = 6,1 A. After the current boost time has elapsed, the inverter will return to the normal (120%) current limit.

5.8   Frequency control without load compensation, *Freque* mode

Freque mode is designed for use in standard operations, such as fans. The inverter does not compensate for the motor's slip. The selected setpoint and the actual value on the inverter display are the electrical frequency. This means that, if the setpoint is 50 Hz, the motor will run with same speed as if it were connected directly to the mains voltage at 50Hz. The inverter's internal speed regulator (set via parameters *Kp-spd* and *Ti-spd*) ensures that the electrical frequency setpoint is followed.

Parameters described below can be found in parameter group *Freq*, and is only displayed if this mode is selected.

5.8.1 Setpoint source for frequency, parameter *OpMode*

Frequency setpoint source is selected by the parameter *OpMode*, selectable values are as shown in Table 14.

OpMode	Frequency setpoint source
Terminal	Any of alternatives below, selected from terminals.
Analog F	Analog input, clockwise.
Analog R	Analog input, counter-clockwise.
Fix-1 F	Frequency from parameter F-fix1, clockwise.
Fix-2 F	Frequency from parameter F-fix2, clockwise.
Fix-3 F	Frequency from parameter F-fix3, clockwise.
Fix-4 F	Frequency from parameter F-fix4, clockwise.
Fix-5 F	Frequency from parameter F-fix5, clockwise.
Fix-6 F	Frequency from parameter F-fix6, clockwise.
Fix-7 F	Frequency from parameter F-fix7, clockwise.
Fix-1 R	Frequency from parameter F-fix1, counter-clockwise.
Fix-2 R	Frequency from parameter F-fix2, counter-clockwise.
Fix-3 R	Frequency from parameter F-fix3, counter-clockwise.
Fix-4 R	Frequency from parameter F-fix4, counter-clockwise.
Fix-5 R	Frequency from parameter F-fix5, counter-clockwise.
Fix-6 R	Frequency from parameter F-fix6, counter-clockwise.
Fix-7 R	Frequency from parameter F-fix7, counter-clockwise.

Table 14. Freque/OpMode parameter settings.

5.8.2 Fixed frequency setpoints, parameters *F-fix1 - F-fix7*

There are seven fixed frequency setpoints parameters; *F-fix1* to *F-fix7*, which can be set in range 0.0 – 150.0 Hz.

5.8.3 Analog frequency setpoint range, parameters *Fr-Min* and *Fr-Max*

Under frequency regulation, parameters *Fr-Min* and *Fr-Mmax* indicate the frequency range in which the inverter is to operate when an analog input is designated as setpoint source. The terminal and scaling to be used are set using parameter *AinSet*. Analog F and Analog R scale the range such that *Fr-Max* applies at maximum analogue input signal and *Fr-Min* at minimum input signal in the direction concerned.

If rotation is required at different directions (e.g. at ±10V or ±10mA, stopping in the middle), set *Fr-Min* to negative (−) *Fr-Max*.

5.9 RPM regulation with speed estimation, *Speed* mode

Speed mode is designed to be used for more complex operating conditions when precise RPM regulation is required. The inverter compensates for the motor's slip. The setpoint as set and the value in the display are the rotor RPM (the speed the shaft is rotating at). The inverter's internal speed regulator (set via parameters *Kp-spd* and *Ti-spd*) ensures the motor follows the speed setpoint set as far as possible.

The parameters described below can be found in the parameter group *Speed* and is only displayed when this mode is selected.

5.9.1 Setpoint source for speed, parameter *OpMode*

Speed setpoint source is selected by the parameter *OpMode*, selectable values are as shown in Table 15.

OpMode	Frequency setpoint source
Terminal	Any of the alternatives below, selected from terminals.
Analog F	Analog input, clockwise.
Analog R	Analog input, counter-clockwise.
Fix-1 F	Speed from parameter C-fix1, clockwise.
Fix-2 F	Speed from parameter C-fix2, clockwise.
Fix-3 F	Speed from parameter C-fix3, clockwise.
Fix-4 F	Speed from parameter C-fix4, clockwise.
Fix-5 F	Speed from parameter C-fix5, clockwise.
Fix-6 F	Speed from parameter C-fix6, clockwise.
Fix-7 F	Speed from parameter C-fix7, clockwise.
Fix-1 R	Speed from parameter C-fix1, counter-clockwise.
Fix-2 R	Speed from parameter C-fix2, counter-clockwise.
Fix-3 R	Speed from parameter C-fix3, counter-clockwise.
Fix-4 R	Speed from parameter C-fix4, counter-clockwise.
Fix-5 R	Speed from parameter C-fix5, counter-clockwise.
Fix-6 R	Speed from parameter C-fix6, counter-clockwise.
Fix-7 R	Speed from parameter C-fix7, counter-clockwise.

Table 15. Speed/OpMode parameter settings

5.9.2 Fixed speed setpoints, parameters C-*fix1* - C-*fix7*

There are seven fixed speed setpoint parameters, *C-fix1* to *C-fix7*, which can be set within the range 0 – 9000 rpm. However, the maximum speed is governed by the motor type and is set at three times the motor's nominal frequency up to a maximum of 150Hz. Thus a 4-pole motor with nominal frequency of 50Hz can have a maximum of 4500rpm.

5.9.3 Analog speed setpoint range, parameters *Sp-Min* and *Sp-Max*

Parameters *Sp-Min* and *Sp-Max* indicate the RPM range in which the inverter is to work when an analog input is designated as setpoint source. The terminal and scaling to be used are indicated by the parameter *AinSet*. Analog F and Analog R scale the range such that rpm *Sp-Max* applies at maximum analogue input signal and *Sp-Min* at minimum input signal in the direction concerned.

If rotation at different directions is required (e.g. at ±10V or ±10mA, stopping in the middle), set *Sp-Min* to negative (–) *Sp-Min*.

5.10   Torque regulation, *Torque* mode

Torque regulation means the motor's maximum stated torque is limited, which is done by varying the motor's rotor current limit. The torque required is stated as a percentage of the motor's nominal torque. All torque setpoints can be in the range 1 – 400 %, but parameter *I-limt* governs the maximum torque, which is set to 120% of the motor's nominal torque when autotuning (if the inverter can supply enough current).

⚠️ **Please note:** maximum torque is reduced if the motor is running in field weakening (normally over motor's nominal frequency).

⚠️ If the motor is running under no-load conditions, or the torque load is less than that set, it will accelerate to the maximum frequency set. It is important to set the maximum frequency using the parameter *Max-fr*.

5.10.1 Torque regulation setpoint source, parameter *OpMode*

The torque setpoint source is selected by parameter *OpMode*. The possible values are as shown in Table 16.

OpMode	Torque setpoint source
Terminal	Any of the alternatives below, selected from terminals.
Analog F	Analog input, clockwise.
Analog R	Analog input, counter-clockwise.
Fix-1 F	Torque from parameter T-fix1, clockwise.
Fix-2 F	Torque from parameter T-fix2, clockwise.
Fix-3 F	Torque from parameter T-fix3, clockwise.
Fix-4 F	Torque from parameter T-fix4, clockwise.
Fix-5 F	Torque from parameter T-fix5, clockwise.
Fix-6 F	Torque from parameter T-fix6, clockwise.
Fix-7 F	Torque from parameter T-fix7, clockwise.
Fix-1 R	Torque from parameter T-fix1, counter-clockwise.
Fix-2 R	Torque from parameter T-fix2, counter-clockwise.
Fix-3 R	Torque from parameter T-fix3, counter-clockwise.
Fix-4 R	Torque from parameter T-fix4, counter-clockwise.
Fix-5 R	Torque from parameter T-fix5, counter-clockwise.
Fix-6 R	Torque from parameter T-fix6, counter-clockwise.
Fix-7 R	Torque from parameter T-fix7, counter-clockwise.

Table 16. Torque/OpMode parameter settings.

5.10.2 Fixed torque setpoints, parameters *T-fix1 - T-fix7*

There are seven fixed torque setpoint parameters available, *T-fix1* to *T-fix7* which can be set in range 1 – 400 %.

5.10.3 Analog torque setpoint range, parameters *Tq-Min* and *Tq-Max*

When using torque regulation, parameters *Tq-Min* and *Tq-Max* indicate the torque range in which the inverter is to work when the analog input is designated as setpoint source. They can be set within the range 1 – 400 %.

The range is scaled such that torque *Tq-Max* applies at full run and *Tq-Min* at minimum run in each direction.

You cannot use torque regulation with rotation in different directions.

5.11   Process regulation, *PI Reg* mode

The inverter is equipped with a PI regulator used for regulation of an actual process value captured from an external sensor according to a given setpoint process value (analog input or fixed value). The regulator calculates a frequency setpoint to the inverter's frequency controller striving to achieve this motor frequency.
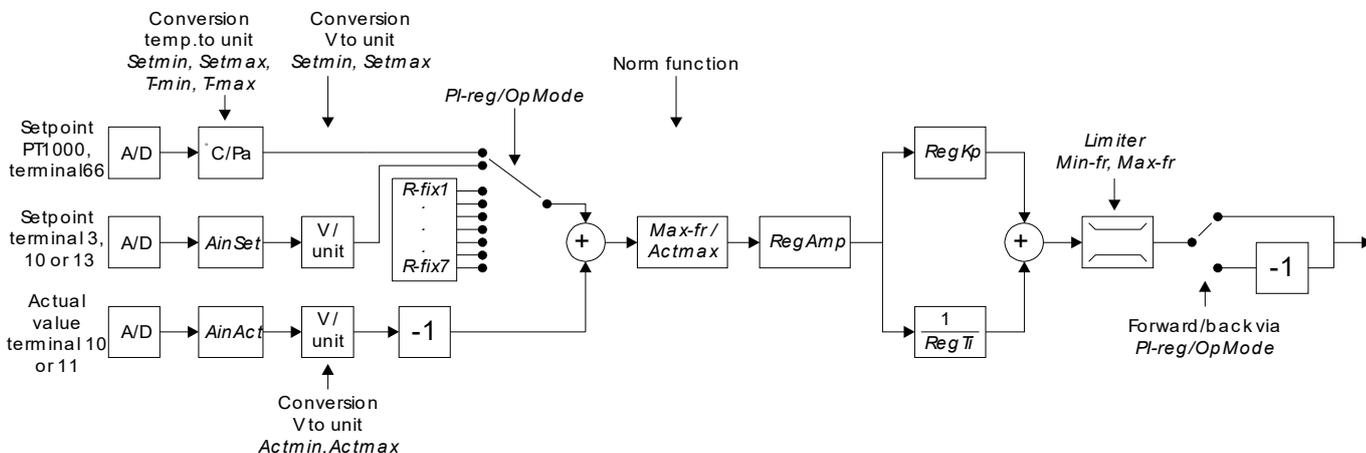

Fig. 11. Process regulator in outline

The regulator units are selected using the parameter *Unit* (both setpoint and actual value). Whatever setpoint source is used, the regulator's actual value are always sampled from the analog inputs either at terminal 10 or terminal 11. The scaling is governed by the parameter *AinAct*. Parameters *Actmin* and *Actmax* govern the maximum and minimum input signals respectively from the actual value input corresponding to the unit selected. The regulator generates an output signal in the form of a frequency setpoint in the range limited by parameters *Min-fr* and *Max-fr*.

The regulator's sampling rate is approx. 10 samples per second.

Parameter Unit settings
Pa
kPa
bar
rpm
m^3/s
l/s
m^3/h
l/h
ppm
%
V
Hz
Nm
- (no unit)

Parameter AinAct settings	Analog value
0-10V	Voltage 0-10V
2-10V	Voltage 2-10V
+/-10V	Voltage +/- 10V
0-20mA	Current 0-20mA
4-20mA	Current 4-20mA
+/-20mA	Current +/-20mA

Table 17. Process regulator units   **Table 18**. Actual value input setting options

5.11.1 Setpoint source *OpMode*, process regulation

The regulator setpoint source is selected by the parameter *OpMode*, the possible values of which are shown in Table 18. If analogue input is selected it is scaled as shown in Table 9. All parameter units are governed by parameter *Unit*. Parameters Set*min* and *Setmax* govern the maximum and minimum input signal from the setpoint input corresponding to the unit selected.

Process regulation cannot be used running the motor in different directions.

OpMode	Source of regulator setpoint
Terminal	Any of the alternatives below, selected from terminals
Analog F	Analog input, clockwise.
Analog R	Analog input, counter-clockwise.
Fix-1 F	Setpoint from parameter R-fix1, clockwise.
Fix-2 F	Setpoint from parameter R-fix2, clockwise.
Fix-3 F	Setpoint from parameter R-fix3, clockwise.
Fix-4 F	Setpoint from parameter R-fix4, clockwise.
Fix-5 F	Setpoint from parameter R-fix5, clockwise.
Fix-6 F	Setpoint from parameter R-fix6, clockwise.
Fix-7 F	Setpoint from parameter R-fix7, clockwise.
Fix-1 R	Setpoint from parameter R-fix1, counter-clockwise.
Fix-2 R	Setpoint from parameter R-fix2, counter-clockwise.
Fix-3 R	Setpoint from parameter R-fix3, counter-clockwise.
Fix-4 R	Setpoint from parameter R-fix4, counter-clockwise.
Fix-5 R	Setpoint from parameter R-fix5, counter-clockwise.
Fix-6 R	Setpoint from parameter R-fix6, counter-clockwise.
Fix-7 R	Setpoint from parameter R-fix7, counter-clockwise.
Temp F	PT1000 input, clockwise
Temp R	PT1000 input, counter-clockwise

Table 19. PI Reg/OpMode parameter settings

5.11.2 Fixed process regulator setpoints, parameters *R-fix1 - R-fix7*

There are seven parameters available for fixed regulator setpoints, *R-fix1* to *R-fix7*. These can be set in the range -2000.0 – 2000.0. Units are selected via the parameter *Unit*.

5.11.3 Analog regulator setpoint from temperature sensor (*)

The setpoint source can be chosen from a PT1000 type temperature sensor connected to terminal 66 (OpMode Temp F or Temp R). Parameter *Unit* is selected to suit *Pa* (as supplied). Temperature readings are rescaled using *T-Min*, *T-Max*, *Setmin* and *Setmax*. Scaling is a linear function between the points at which temperature *T-Min* gives the setpoint *Setmin* and temperature *T-Max* gives the setpoint *Setmax*. Setpoint adjustment is limited by parameters *Setmin* and *Setmax*. To make the function slope negative, make *T-Min* greater than *T-Max* or *Setmin* greater than *Setmax*. *T-Min* and *T-Max* can be set in the range +/-100.0°C. To operate correctly, *Setmin* should be set to the pressure at the actual value sensor, terminal 11, required at temperature *T-Min* and *Setmax* to the pressure required at temperature *T-Max*.
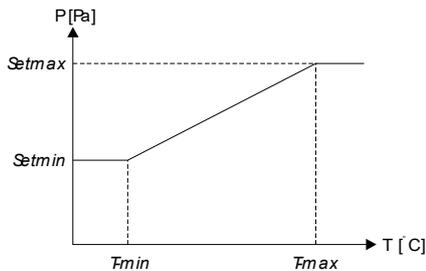
Fig. 12. Relationship between *Setmin, Setmax, T-min* and *T-max*

5.11.4 Regulator setting, parameters *RegAmp, RegKp* and *RegTi*

- The control error (calculated as setpoint less actual value) is converted from regulator unit to frequency with the factor *RegAmp * Max-fr / Actmax*. *RegAmp* can be set to 1(a positive or increasing value of the output signal if the regulator setpoint is greater than the current actual value) or -1 (a negative or decreasing value of the output signal if the regulator setpoint is greater than the current actual value). *Max-fr* is the maximum output signal in Hz. *Actmax* is the maximum actual value at the input in regulator unit.

- The proportional regulator component affects the output signal directly. *RegKp* amplifies the proportional regulator component and can be set within the range 0.00 to 1.00. 0 eliminates the proportional component completely, giving a purely integrative regulator.

- The regulator integration time *RegTi* is a time constant which governs the rate at which the regulator output signal changes at a given control error. *RegTi* can be set in the range 1.0 to 200.0 seconds, where the value 200.00 eliminates the integrator component completely, giving a purely proportional regulator.

5.12   Motor safety functions

The NFO Sinus is fitted with two different motor safety functions: a thermistor sensor input and Electronic motor overload protection which calculates the motor's approximate winding temperature continuously.

5.12.1 PTC input

If the motor is fitted with PTC thermistor(s) or thermocontact (Klixon), these can be connected directly to the inverter. This is done between terminal 25 (PTC) and terminal 21, 22, 23 or 24 (I/O ground) as in Fig.1. A resistance of 10 kΩ, min. 1/4W, must then also be connected between terminal 25 and +24V.

If negative logic is selected (bridge S1 moved as in Fig. 3), connect the PTC thermistor between terminal 25 (PTC) and +24V and a resistance of 10 kΩ, min. 1/4W, between terminal 25 and I/O ground as in Fig. 2.

Configuration is carried out under fault *PTCTemp* in parameter group *Error*, see section 5.15.

1, 2 or 3 PTC thermistors in series, according to DIN 44081, can be used.

5.12.2 Electronic motor overload protection

The electronic motor overload protection functionality uses the motor parameters in parameter group *Motor* as described in this manual. Therefore, it's essential that these parameters are entered correctly, and that autotuning is performed.

The protection functionality is controlled by parameters *Overld*, *S-Temp* and *F-Cool*. *Overld* can be set to *Disable* (power monitor disabled), *Alarm* (generates alarm) or *Fail* (releases motor). These parameters can be found in the parameter group *Error* and fault *Overload*.

The principle of the electronic motor overload protection is that a motor can operate at an output loss equivalent to that at nominal load (voltage, current and RPM as plated) at an ambient temperature of 40°C, for an unlimited amount of time.

If the motor is working at a higher output power loss, lower rpm or higher ambient temperature, the electronic motor overload protection will trip after a period depending on the variable's ratio in relation to the motor's nominal data.

The actual overload protection status can be read, at any time, as a percentage in the parameter *M-temp*. This value rises and falls towards a final value corresponding to the current load. The final value of 100.0% corresponds to nominal load, and the electronic motor overload protection trips when this value is passed.

The ambient motor temperature is set via the parameter *S-Temp* which can be set within the range +/-100°C. The overload protection can be triggered at lower motor loads by specifying a higher ambient temperature than it actually is, or a higher load can be allowed by entering a lower ambient temperature. Default S-Temp is + 20 °C.

If the motor is equipped with forced cooling, i.e. there is a cooling fan that is not connected to the motor shaft and thus cools at a constant rate regardless of motor speed, the parameter F-Cool shall be set to a value other than zero. The overload protection now ignores the motor speed, and replaces it with the value of the parameter *F-Cool*. If the value is set to the same as nominal motor rpm, parameter *N-Nom*, the cooling effect will then be calculated as if the motor were always running at that rpm. Parameter *F-Cool* can be set within the range 0 to 10000, '0' indicating there is no forced cooling exists.

⚠ **If the motor parameters are set correctly and autotuning is performed, the electronic motor overload protection complies with EN 61800-5-1:2007 / EN 61800-5-1/A1:2017. The protection functionality operates regardless of motor cable area, cable length, or other cable properties, and regardless of mains power supply impedance.**

⚠ **WARNING! If the motor parameters, *Overload*, *S-Temp* or *F-Cool* are changed, the Electronic motor overload protection can be deactivated and/or not comply with the standards mentioned above.**

5.13   Output signals (extension board)

NFO Sinus units are equipped with three outputs to allow monitoring different states and parameters during operation. With the extension I/O board installed, protective earth and I/O ground are automatically connected (corresponding jumper S4 fitted).

5.13.1 Function relay

The alternating function relay has a number of selectable functions used to indicate certain conditions. This relay is at terminals 50, 51 and 53 (see Fig. 4). If selected function not met, terminals 50 and 51 are closed. The relay is separated galvanically from other signals, and can be loaded up to 2 A, 50 V DC, 50 W.

To set, use parameter *ReMode,* possible values as follows:

- *Disable*, relay deactivated.
- *Running*, Motor running.
- *Run Fwd*, Motor running, shaft rotating clockwise (*FrqAct* > 0).
- *Run Rev*, Motor running, shaft rotating counter-clockwise (*FrqAct* < 0).
- *Run Setp*, Rotor frequency has reached its setpoint (*FrqAct* = *FrqSet*),
- *Run Freq*, Rotor frequency greater than parameter *ReFreq* ($\left| FrqAct \right|$ > *ReFreq*).

5.13.2 Analog voltage output

The voltage output is configured using parameter *V-Out*, is located at terminal 60 and is related to any of the ground terminals (see Fig.1). To scale the output, use parameter *V-Max*. Maximum output voltage is 10 V, maximum output current 3 mA.

Possible values for parameter *V-Out*:

- *Disable,* not configured.
- *Freque*, displays inverter's electrical frequency. Output shows voltage *V-Max* at nominal motor frequency *f-Nom*, whichever way the motor is turning, and 0V at 0Hz.
- *Speed*, displays the motor speed (estimated actual value, same as parameter *SpdAct*). Output shows voltage *V-Max* at nominal motor rpm *N-Nom*, whichever way the motor is turning and 0V at 0rpm.
- *Torque*, displays motor torque. Output shows voltage *V-Max* at nominal motor torque, whichever way it is turning.

5.13.3 Frequency output

The frequency output is configured via parameter *F-Out*, is located at terminal 56 and is related to any of the ground terminals (see Fig.1). This output is scaled using parameter *F-Max*. Maximum output frequency is 32kHz. The output signal is of the open collector type, with an internal pull-up to + 5V. If a greater output signal fluctuation is required, an external pull-up resistance can be fitted to the voltage required (max 24V). The external pull-up resistance must be at least 10kOhm.

Possible values for parameter *F-Out*:

- *Disable,* display off.
- *Freque*, shows inverter's electrical frequency. Output shows frequency *F-Max* at nominal motor frequency *f-Nom*, irrespective of direction of rotation, and 0Hz at 0 Hz.
- *Speed*, shows motor speed (estimated rpm, same as parameter *SpdAct*). Output shows frequency *F-Max* at nominal motor rpm *N-Nom*, irrespective of direction of rotation, and 0Hz at 0 rpm.
- *Torque*, shows motor torque. Output shows frequency *F-Max* at nominal motor torque, irrespective of direction of rotation.

5.14   Reset to factory settings

The inverter parameters can be reset to default settings (as supplied from factory).

This can be done during Power On of the inverter by pressing both FWD and REV buttons and keep them pressed, then additionally press PROG at the moment when the software revision is shown in the display.

The inverter will now post an alarm, error message "Par fail". When this is confirmed, the inverter will work as normal, but with all parameters reset.

To reset parameters to default:

1. Inverter shall be off (not powered)
2. Press and hold FWD and REV buttons.
3. Connect mains supply.
4. Continue to hold buttons down and then also press PROG when the software revision is shown in the display.
5. Release the buttons, wait a short while and then press ENTER to acknowledge "Par fail".

5.15 Alarm and fault procedures

During operation the inverter can identify several fault conditions. When a fault occurs in the inverter one of four things can happen:

1. the motor stops and the alarm relay indicate an alarm (*Fail*),
2. the motor is still running and the alarm relay indicates an alarm (*Alarm*),
3. there is only a fault indication on the display (*Ind*),
4. nothing (*Disable*).

The actions for each specific fault can be set individually se section 5.15.2 below.

If parameter *Auto Start* = *ON* and *Fail* is selected for the fault concerned, an attempt will be made to restart the motor after a given time (*Restart Delay*) provided that the cause of the fault has disappeared. The number of restart attempts (*Error Count)* depends on the settings of the fault in question. If more faults than the set *Error Count* occur within time *Trip Time*, no further automatic restart attempts will be made and the fault has to be manually reset. Once a fault has been acknowledged, the inverter can be restarted. Any faults that occur are logged in the *Error log*. Some faults have to persist for a given time (*Delay*) before they generate a fault.
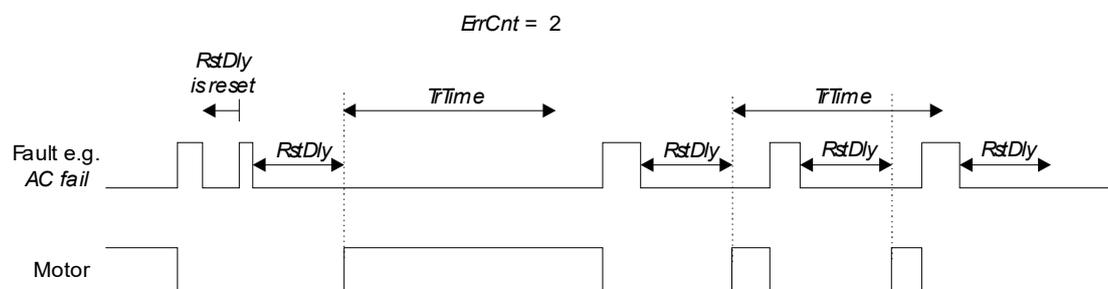

Fig. 13. Typical fault situation

5.15.1 Fault log

The last 30 faults at any time are saved in a non-volatile memory in the inverter To read the fault log, use parameter *E-logg*. Press ⇑ and ⇓ to scroll through the fault messages saved. Line one of the display shows the fault, line two when it occurred relative to when the inverter was powered up (*OpTime*) with a resolution of 0.1 hours. If the same fault occurs repeatedly, only the last time it occurred is logged. The fault log can be erased by pressing SHIFT + ENTER for 5 sec.

5.15.2 Fault messages

All fault messages, fault types and other fault parameter setting options are shown in Table 19. *ErrCnt* can be set in the range 0 – 99 for all faults. To configure the parameters for a given fault, find that fault in the parameter group *Error,* press ENTER, then scroll through the parameters using FWD/REV. To change parameters, press ⇑ or ⇓ then ENTER.

⚠ **Warning! Turning off (disable) any fault message may lead to inverter destruction! In this case the warranty is not valid. If in any doubt regarding configuration of errors, contact NFO Drives AB.**

Settings for faults:

Fail: Motor stopped and alarm relay indicates alarm
Alarm: Alarm relay indicates alarm (the motorn is not stopped)
Ind: Fault in display only (the motorn is not stopped)
Disable: Fault turned off

Fault message	Possible fault types	Default setting		Fault description, other fault parameters	Source of fault, action
		Type of fault	ErrCnt		
Par Fail	Fail	Fail	–	Some parameter when starting up was outside permitted range or reset to factory setting command was given at power up.	All parameters reset to factory settings. Press ENTER to confirm and check that all parameter values are correct. Run autotuning.
AC Fail	Fail Alarm Ind Disable	Fail	2	Phase error, power supply phases not symmetrical (3-phase supply inverters only)	One supply phase missing, difference in voltage between phases is too great or no earth connection. To switch fault off, use parameter *AC Err*. **Note: inverter may be damaged if fault message is switched off while fault still remains**.
				Delay (*Delay*)	
				Default setting | Range	
				10.0s | 0.0 – 25.5s	
Temp Hi	Fail	Fail	2	Inverter heat sink temperature too high.	Wait until inverter has cooled down. Check inverter is installed so air can circulate sufficiently. Check ambient temperature is not too high.
PTCTemp	Fail Alarm Ind Disable	Fail	2	Motor overheating, thermistor input limit exceeded. See 5.12.1	Let motor cool down.
OverLoad	Fail Alarm Ind Disable	Fail	2	The power monitor has tripped. The motor connected has been working under overload for too long time.	Let motor cool down. Adjust settings if necessary (parameters *F-Cool* and *S-Temp*) as in section Electronic motor overload protection see 5.12.2.
				Forced cooling (*F-Cool*)	
				Default setting | Range	
				0 | 0 – 10000	
				Ambient motor temperature (*S-Temp*)	
				Default setting | Range	
				20 °C | -100 – 100 °C	
Ain Fail	Fail Alarm Ind Disable	Disable	2	Analog setpoint input signal outside set range.	Open circuit in signal line to analog setpoint or *AinSet* not set correctly.
DC Low	Fail	Fail	2	DC link voltage too low.	Power supply too low. Check inverter mains connection.

DC High	Fail	Fail	2	DC link voltage too high	Motor is regenerative with no brake chopper resistance or with resistance sluggish. Retardation time too short. Mains supply too high. Check inverter mains connections.
GND Fail	Fail Alarm Ind Disable	Fail	– (0)	Earth leak current in one or more motor phases too high.	Possible sources of faults depending on motor operating case:
Short C	Fail	Fail	2	Short-circuit between output phases	One or more output phase (U, V, W) is in contact with the protective earth (PE) or other external potential. Short-circuit between some of the output phases (U, V, W).
IMagnLow	Fail Alarm Ind Disable	Fail	2	Magnetising current in motor too high or too low.	Open circuit in one or more outgoing phases.
Cur Low	Fail Alarm Ind Disable	Fail	2	Current in one or more motor phases too low.	Resistance too high in any of the outgoing phases, poor contact/loose contact in motor or motor wiring.
Cur High	Fail Alarm Ind Disable	Fail	2	Current in one or more motor phases too high.	Motor parameters faulty, autotuning not performed. Rectify fault. Press ENTER to confirm.
Cur Limt	Ind Alarm Ind Disable	Ind	–	Current limit set has been reached.	Reduce acceleration ramp or check whether parameter I-limt matches motor used. Alarm will disappear once current falls.
Run Fail	Fail Alarm Ind Disable	Fail	10	Inverter did not acquire control of motor when starting.	Motor rotor is stuck. Motor was turning when started or parameter *R-stat* is set too high. Check motor is not turning when starting. Enable DC brake (section 5.7.5) and/ or start delay (section 5.7.3). Check whether autotuning is done. Operations involving passing the 0 Hz range slowly can generate this fault by mistake. In that case, disable fault by setting fault parameter to *Disable*.
Bus Fail	Fail	Fail	–	Field bus fault	See separate manual
Sio Fail	Fail	Fail	–	Series communication error.	See separate manual
Brake Ch	Ind	Ind	–	Brake chopper on.	Motor in regenerative mode. Excess energy fed to brake chopper resistance. Alarm will disappear once energy reduces.

Table 20. Fault messages

5.15.3 Acknowledge fault

To manually acknowledge a fault, press ENTER on the keyboard.

6 Brake chopper and power surge regulator

If a motor is trying to decelerate (retardate) a load with high inertia, energy is fed back to the inverter. This causes the voltage in the DC link (terminals + and -) will rise. To prevent the voltage rising too high and damaging the inverter, a power surge regulator prohibits deceleration (retardation) that generates more energy than the motor can use.

If the inverter does not decelerate the motor fast enough (taking longer time than what parameter *Retard*), the regulator is activated. If faster retardation is required, an external brake resistor must be installed to convert the regenerated energy to heat. This resistance is mounted between terminals + and B (see Fig.1).

This resistor must be capable to absorb the generated braking energy, and therefore must be adapted to the current operating conditions. Recommended resistance for an inverter with a 400V power supply is 100 - 300 Ω.

⚠ **If the retardation time is less than 5 sec, an external braking resistance must be fitted. Avoid setting the retardation ramp (parameter *Retard*) any shorter than necessary.**

If the resistance is too low, the brake chopper circuit may be damaged. The resistor must also be low-inductive in order not to damage the brake chopper circuit. The resistor's power handling capacities must be dimensioned according to the amount of energy that is to be absorbed from retardation of the rotating load.

When the brake chopper is active, it appears as an indication on the display.

If you are in any doubt about how to install equipment, always contact NFO Drives AB.

7 Getting started

In the sections below, we look at a number of operating cases. This is designed to help get a newly installed inverter started. Parameters not mentioned are settings as supplied.

At start up the inverter always goes into external mode. This mode should be used for all operating cases. The local mode is only designed to be used when manually controlling the inverter from the keyboard with a fixed frequency (example in 7.1), for instance if you at start up want to check that the motor is connected and turns in the right direction. However, if you permanently want to run at a fixed frequency the external mode should be used (se example 7.2). This is because in case of a power failure the inverter will restart in external mode and if not configured the motor will not start.

Steps to be followed **at all times**:

- Install motor and wiring as in section 4.2.4.
- Connect power supply as in section 4.2.3.
- Run autotuning as in section 5.6 to ensure motor parameters are correct.

7.1 Running in local mode

Procedure to check that everything is connected correctly and that motor is turning in the right direction:

- Press STOP to go to local mode.
- Set frequency desired in display window. Use UP and DOWN arrows together with SHIFT.
- Press and hold FWD to run clockwise or REV to run counter-clockwise. When the button is released, the motor will stop.
- Press SHIFT + FWD and motor will keep running even once the button is released.

- Stop motor by pressing STOP (motor runs down) or press FWD or REV briefly (motor brakes as in ramp, parameter *Retard*).

7.2   Running in External mode

7.2.1 Setvalue selection in external mode

The source for the setpoint is governed by the parameter *OpMode* for the control mode concerned (parameters *Freque/OpMode, Speed/OpMode, Torque/OpMode or PI Reg/OpMode*). If OpMode is set to *Terminal* (default) the setpoint selection is chosen according to the actual digital input combination of FIX1 – FIX3. If FIX1 – FIX3 are left open the setpoint is set according to potentiometer setting.

⚠️ The digital inputs (FIX1 - FIX3) are always sampled so a change of the digital input combination (FIX1 – FIX3) will immediately alter the setpoint. Make sure that the digital signals are stable without glitches to avoid sudden setpoint changes.

7.2.2 External mode: Running with fixed frequency

The procedure below is designed to have motor running at 25 Hz clockwise. Motor will run until STOP is pressed or run signal is deactivated.

- Press STOP to go to local mode.
- Connect terminal 5 (RUN) and terminal 1 (+24V).
- Set parameter *F-fix2* in parameter group *Freque* to 25 Hz.
- Set parameter *OpMode* in parameter group *Freque* to *Fix2 F*.
- Start motor using SHIFT + STOP (go to external mode).
- Stop motor using STOP (motor is released) or disconnect terminal 5 (motor brakes, parameter *Retard*).

7.2.3 External mode: Running from terminal, fixed setpoint

The procedure below is designed for running motor starting and stopping from terminal, 8 Hz counter-clockwise.

- Connect terminal 15 (FIX1), terminal 14 (REV) to terminal 1 (+24V).
- Set parameter *F-fix1* in parameter group *Freque* to 8 Hz.
- Check that parameter *OpMode* in parameter group *Freque* is set to *Terminal*.
- Start motor by connecting terminal 5 (RUN) to terminal 1 (+24V).
- Stop motor by disconnecting terminal 5 and terminal 1.

7.2.4 External mode: Running with analog setpoint

The steps below apply when running motor with analog setpoint 0-10V, max 40Hz.

- Connect analog control signal between terminal 3 (VOLTAGE) and terminal 23 (COMMON).
- Check that parameter *AinSet* in parameter group *Control* is set to *0-10V*.
- Set parameter *OpMode* in parameter group *Freque* to *Analog F*.
- Set parameter *Fr-Max* in parameter group *Freque* to 40Hz.
- Start motor by connecting terminal 5 (RUN) to terminal 1 (+24V).
- Stop motor by disconnecting terminals 5 and 1.

7.2.5 External mode: Running with Torque control and analog setpoint

The procedure below is designed for torque control of a motor with analog setpoint 0 – 10V.

- Connect analog control signal between terminal 3 (VOLTAGE) and terminal 23 (COMMON).
- Check that parameter *AinSet* in parameter group *Control* is set to *0-10V*.
- Set parameter *Mode* in parameter group *Control* to *Torque*.
- Set parameter *OpMode* in parameter group *Torque* to *Analog F*.
- Set max. motor speed using parameter *Max-fr* in parameter group *Torque* to 15 Hz.
- Start motor by connecting terminal 5 (RUN) to terminal 1 (+24V).
- Stop motor by disconnecting terminal 5 and terminal 1.

7.2.6 External mode: Process regulation with fixed setpoint

The procedure below is designed for process regulation with fixed setpoint and feedback signal 0 – 10V using a 0-300 Pa pressure sensor.

- Set parameter *Mode* in parameter group *Control* to *PI-reg*.
- Connect actual value signal between terminal 11 (ACT_VOLTAGE) and terminal 24 (COMMON).
- Check that parameter *AinAct* in parameter group *PI-reg* is set to *0-10V*.
- Set parameter *Unit* in parameter group *PI-reg* to *Pa*.
- Set parameter *OpMode* in parameter group *PI-reg* to *R-fix1 F*.
- Adjust parameter *R-fix 1* in parameter group *PI-reg* to desired setpoint value.
- Set max. motor speed using parameter *Max-fr* in parameter group *PI-reg* to 45 Hz.
- Set the pressure the actual value sensor measures at 0V (0 Pa) using parameter *Actmin* in parameter group *PI-reg.*
- Set the pressure the actual value sensor measures at 10V (300 Pa) using parameter *Actmax* in parameter group *PI-reg.*
- Set the regulator amplification using parameter *RegKp* in parameter group *PI-reg*.
- Set regulator integration time using parameter *RegT*i in parameter group *PI-reg*.
- Start motor by connecting terminal 5 (RUN) to terminal 1 (+24V). If you are not in external mode press SHIFT+STOP.
- Stop motor by disconnecting terminals 5 and 1.

Tip: You can, at any time, check parameter *RegAct* and *RegSet* in parameter group *Satus* to see the inverter's response to the actual value and the setpoint value. This could help you troubleshoot problems.

7.2.7 External mode: Process regulation with analog setpoint

The procedure below is designed for process regulation with analog setpoint 0 – 10V and feedback signal 0 – 10V using 0-300 Pa pressure sensors.

- Set parameter *Mode* in parameter group *Control* to *PI-reg*.
- Connect analog setpoint signal between terminal 3 (VOLTAGE) and terminal 23 (COMMON).
- Check that parameter *AinSet* in parameter group *Control* is set to *0-10V*.
- Connect actual value signal between terminal 11 (ACT_VOLTAGE) and terminal 24 (COMMON).
- Check that parameter *AinAct* in parameter group *PI-reg* is set to *0-10V*.
- Set parameter *OpMode* in parameter group *PI-reg* to *Analog F*.
- Set parameter *Unit* in parameter group *PI-reg* to *Pa*.
- Set max. motor speed using parameter *Max-fr* in parameter group *PI-reg* to 45 Hz.
- Set the pressure the setpoint represents at 0V (0 Pa) using parameter Set*min* in parameter group *PI-reg.*
- Set the pressure the setpoint represents at 10V (300 Pa) using parameter Set*max* in parameter group *PI-reg.*

- Set the pressure the actual value sensor measures at 0V (0 Pa) using parameter *Actmin* in parameter group *PI-reg*.
- Set the pressure the actual value sensor measures at 10V (300 Pa) using parameter *Actmax* in parameter group *PI-reg*.
- Set the regulator amplification using parameter *RegKp* in parameter group *PI-reg*.
- Set regulator integration time using parameter *RegT*i in parameter group *PI-reg*.
- Start system by connecting terminal 5 (RUN) to terminal 1 (+24V). If you are not in external mode press SHIFT+STOP.

Tip: You can, at any time, check parameter *RegAct* and *RegSet* in parameter group *Satus* to see the inverter's interpretation of the actual value and the setpoint value. This could help you troubleshoot problems.

7.2.8 External mode: Fan application with analog setpoint and fire alarm

In some fan applications it is desirable to connect an external alarm system to take over the control of the inverter, e.g. a fire alarm. In case of fire we want the inverter to run at a fixed frequency instead of the normal analog setpoint.

The steps below apply when running motor with analog setpoint 0-10V, max 40Hz and in case of fire alarm 50Hz.

- Connect analog control signal between terminal 3 (VOLTAGE) and terminal 23 (COMMON).
- Check that parameter *AinSet* in parameter group *Control* is set to *0-10V*.
- Set parameter *OpMode* in parameter group *Freque* to *Terminal*.
- Set parameter *Fr-Max* in parameter group *Freque* to 40Hz.
- Set parameter *F-fix1* in parameter group *Freque* to 50 Hz.
- Connect fire alarm indication to terminal 15 (FIX1).
- Start system by connecting terminal 5 (RUN) to terminal 1 (+24V). If you are not in external mode press SHIFT+STOP.

Since the digital inputs (e.g. FIX1) have higher priority than analog setpoint (VOLTAGE) the system will run with analog setpoint if there is no fire alarm.