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

NFO Sinus® G2

Operating and installation manual 0.37 – 15 kW 400V IP20 and IP54

NFO DRIVES

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Contents

1 Introduction

The frequency inverter described in this operating manual is used for speed (RPM) and 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.

NFO Sinus is a frequency inverter which uses the patent "Natural field orientation" system to give perfect speed control of induction motors all the way from zero to full speed.

The inverter also has a patented switch connection that ensures the motor is fed a perfect sinus voltage at all times under all operating conditions.

2 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**.**

⚠ **Touching any components with the mains supply connected can be fatal!** Always disconnect the mains supply before removing the front panel. Never open the inverter side panels.

⚠ **WARNING!** Even when disconnected from the mains supply, the inverter may still be live on account of its buffer capacitors. **Always wait at least five minutes,** and take test readings between the + and – terminals to make sure no voltage remains before starting working on the inverter.

The inverter must always be earthed when mains supply is connected.

3 Technical data

Motor output										
Motor rating (kW)	0.37	0.75	1.5	2.2	3	4	5.5	7.5	11	15
Continuous rating (A)	1.3	2.1	3.5	4.9	6.7	8.8	11.1	14.8	21.5	28.5
Maximum rating (A)	1.6	2.5	4.2	5.8	8.0	10.5	13.3	17.7	25.8	32.0
Output voltage wave form	Sinus									
Output frequency	0 – 150 Hz									
Operating mode	4 quadrant (with external brake resistance, as required)									
Inverter input										
Supply voltage	3 x 380 – 440V +/-10%									
Frequency	50/60 Hz (+/-10%)									
Control inputs										
Setpoints	0-10V, 2-10V, ±10V, 0-20mA, 4-20mA, ±20mA, potentiometer 10kΩ, 7 set frequencies selectable from terminal with positive or negative logic									
Actual values	0-10V, 2-10V, ±10V									
Local mode	Keyboard: Forward, Reverse, Stop									
Acceleration time	0.2 – 500s									
Retardation time	0.2 – 500s									
Signal outputs										
Voltage (*)	0 – 10V									
Frequency (*)	0 – 32kHz, open collector									
Relay	Fault relay, operating relay, function relay (*)									
Control modes										
Frequency control	0 – 150 Hz									
Speed control	0 – 9000 rpm									
Torque control	1 – 400% of nominal motor torque, depending on inverter capacity									
Process control	PI with feedback, temperature sensor PT1000 for recording temperature at constant pressure control in the ventilation system (*), 24V supply to external sensors (*)									
Motor safety										
Thermistor input	PTC or Klixon									
Power monitor	Switch off if motor is loaded 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	IP20 or IP54									
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.									
Dimensions IP20	365 (+47) x 265 x 70				365 (+47) x 265 x 123			365 (+47) x 265 x 203		
Weight IP20	4.9 kg				6.5 kg			14 kg		
Dimensions IP54	374 (+39) x 280 x 80				374 (+39) x 280 x 150					
Weight IP54	7.0 kg				10,8 kg					

Functions marked (*) only available together with I/O card.

4 Installation

All terminals are accessed by removing the lower front panel.

Please note that the inverter must not be run for more than one minute with the front panel removed, as this affects the airflow through it.

4.1 Typical installation

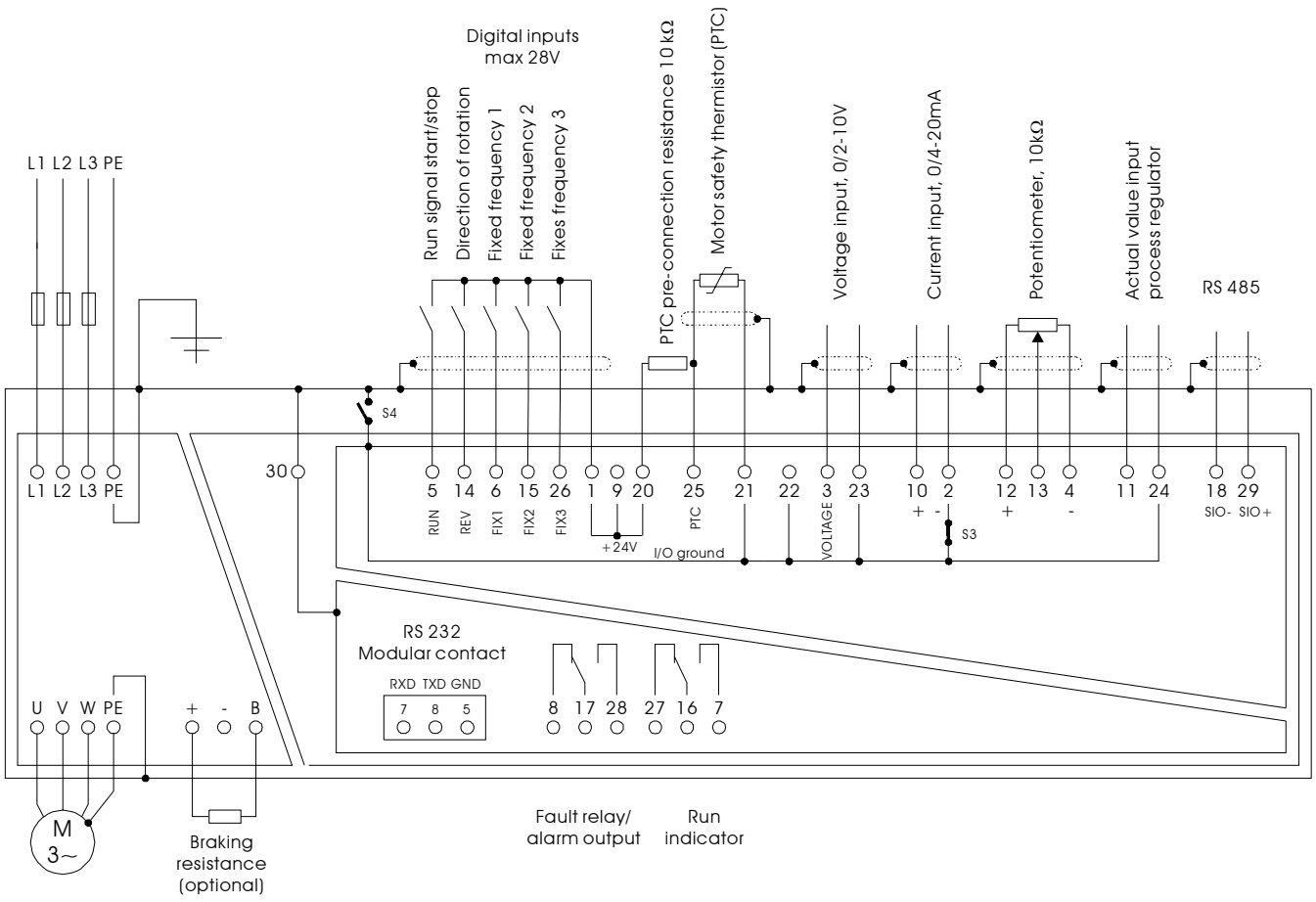


Fig.1. Typical configuration

⚠ Warning! If there is a run signal to the inverter (terminal 5), the inverter will start up when power is applied.

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 designed to be used when a number of current controlled units are connected in series.

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 .

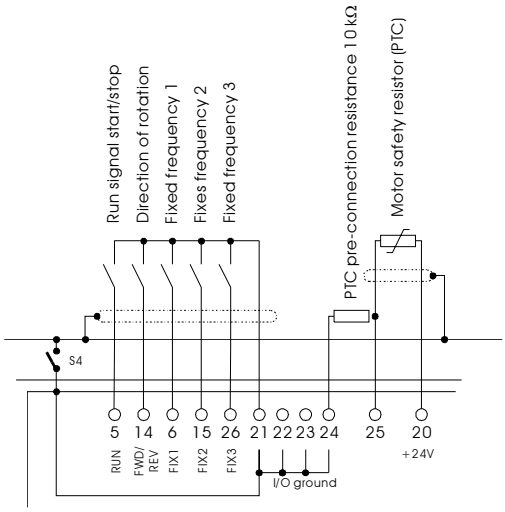


Fig. 2. Connection via negative logic (jumper S1 moved)

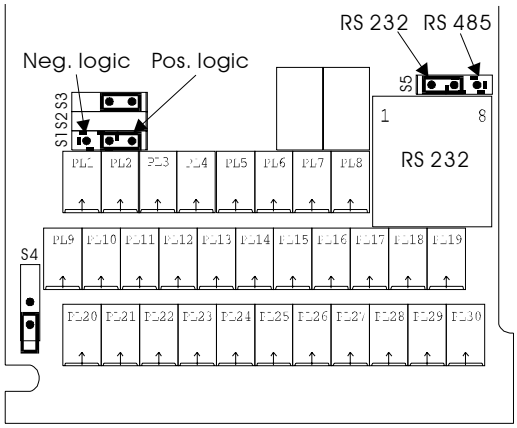


Fig. 3. Jumper locations (shown as supplied)

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.

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

If in any doubt as to installation, always contact NFO Drives AB.

4.2 Connecting mains supply

Three-phase feed inverters are connected to a three-phase mains network at a nominal voltage of 380 – 440 V 50/60 Hz between terminals L1, L2, L3 and PE. PE = ground, see Fig.1.

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
6A	6A	6 A	10 A	10 A	16 A	16 A	25 A	35 A	35 A

With the mains supply connected correctly and the motor running, the inverter draws less than 2 mA earth current in the PE core.

⚠ 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!

4.3 Connecting motor

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

The nominal motor voltage for three-phase fed inverters is 400V, so a motor with a nominal voltage of 400 V Y / 230 V D must be Y-connected and a motor with nominal voltage of 690V Y / 400 V D must be D-connected.

Current EMC standards can be met without shielded motor cable if the inverter is correctly installed otherwise. There is no limit on motor cable length, as the inverter always supplies a sinus voltage to the motor; but voltage drop in cables must be allowed for.

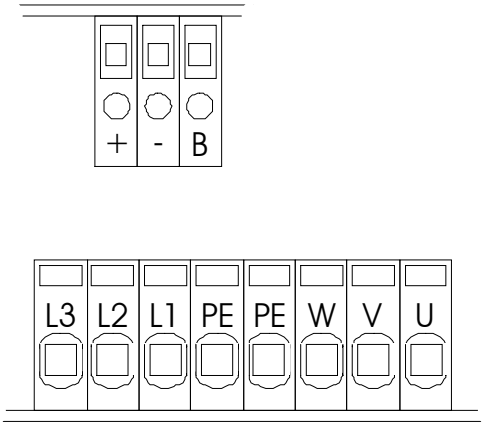
4.4 Terminal connections

B	-	+	L3	L2	L1	PE	PE	W	V	U

Fig. 4. Power terminal appearance, 0,37 – 5,5kW

The power terminals are screw terminals with a cross section of 0.5 – 4mm^2 (6mm^2 solid wire). The cable is stripped 14mm.

The power terminals for the inverters 7,5 – 15kW are divided into two rows according to *Fig. 5* below:



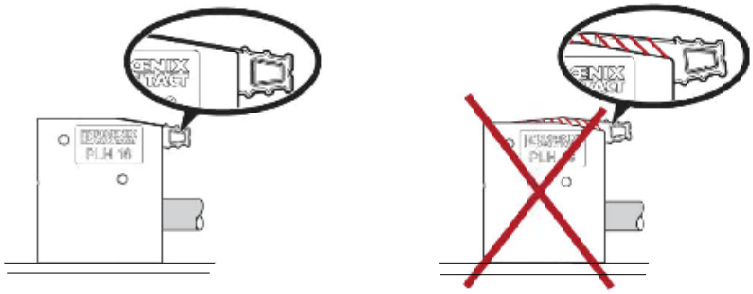


Fig. 5. Power terminal appearance, 7.5 - 15kW Fig. 6. The lever of the power terminals

The terminals L3-L2-L1-PE-W-V-U are of type "Push-Lock" with a cross section of 0.75 – 16mm^2. The cable is stripped 18mm and pushed into the connector and then the lever is closed. +, - and B are screw terminals as above.

⚠ It is important that the lever is properly closed according to Fig. 7 above.

4.4.1 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	Mains supply, phases	Mains supply 3 x 380–440V
L2		
L1		
PE	Protective earth	Power supply protective earth
PE	Protective earth	Protective earth connection motor
W	Motor connection	Motor connection
V		
U		

Table 1. Use of power terminals

If installing a number of inverters with one or more running in regenerative mode, the inverter DC links (terminals + and -) can be connected to one another so these inverters supply energy to the others. Thanks to component tolerances in the inverter, the link voltage may vary slightly from one model to another, so an equalising resistance and ultra-fast fuse must be fitted to each line. Contact NFO Drives AB for correct dimensions.

4.4.2 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	I/O ground
22	COMMON	
23	COMMON	
24	COMMON	
5	RUN	Run signal
14	REV	Direction of rotation, see Table 6.
6	FIX1	Select fixed frequency, see Table 6.
15	FIX2	Select fixed frequency, see Table 6.
26	FIX3	Select fixed frequency, see Table 6.
25	PTC	PTC motor protection, requires resistance at 10 kΩ connected to +24 V
12	PLUS POT	Potentiometer input 10 kΩ, positive limit, see also Table 7.
13	POT	Potentiometer input 10 kΩ, central takeoff
4	MINUS POT	Potentiometer input 10 kΩ, negative limit
3	VOLTAGE	Voltage setpoint input, see Table 7.
10	CURRENT +	Current setpoint input, positive potential, see Table 7.
2	CURRENT -	Current setpoint input, negative potential.
28	ALARM A	Fault relay, potential-free contact max 1 A, 50 V DC.
17	ALARM B	If fault in inverter, terminals 17 and 28 close.
8	ALARM C	
27	MOTOR_RUN A	Run indication, potential-free contact max 1 A, 50 V DC.
16	MOTOR_RUN B	Terminals 7 and 16 are closed when motor is running.
7	MOTOR_RUN C	
18	SIO-	RS 485, negative input
29	SIO+	RS 485, positive input
11	ACT_VOLTAGE	Process regulator actual value input.
30	PE	Protective earth
19		

Table 2. 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

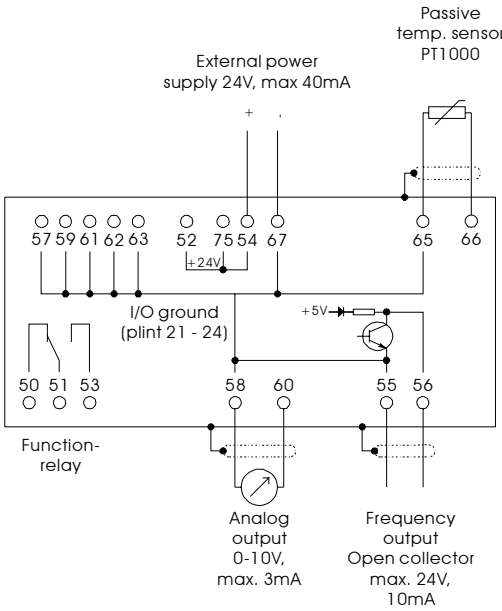


Fig. 8. Connecting expansion board

Term.	Function	Description
50	RELAY B	Function relay, potential-free contact max. 2 A, 50 V DC, 50 W. see section 5.12.1
51	RELAY A	Function relay
52	+24V	+24V, max. 40mA (not the same power as terminals 1, 9 and 20)
53	RELAY C	Function relay
54	+24V	
55	COMMON	Reference ground
56	FREQ OUT	Frequency output, max. 24V 10 mA ,Open Collector, see section 5.12.3
57	COMMON	
58	COMMON	
59	COMMON	
60	VOLT OUT	Analog voltage output, max. 10V 3mA, see section 5.12.2
61	COMMON	
62	COMMON	
63	COMMON	
65	COMMON	
66	PT1000	Temperature sensor PT1000, process regulation, see section 5.10
67	COMMON	
75	+24V	

Table 3. Signal terminals and their use, I/O board.

4.4.3 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 4 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 4. Connecting series channel RS232.

4.4.4 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.

4.5 Installation and ventilation

The IP20 inverter is intended to be built into a cabinet with sufficient cooling, e.g. with flowing cool air. It is important to ensure that there is no air re-circulation in the cabinet. The IP54 inverter can be mounted stand-alone. The cool air temperature must not exceed 40°C.

An 80 mm clearance must be left above and below the inverter to ensure sufficient air passes through it.

⚠ The inverter must not be installed such that outlet air from another inverter or equipment blows directly into the inverter air intake.

If a number of inverters are to be installed side by side, a 20 mm gap must be left between inverters to ensure air circulates properly.

It can be fitted to the installation plate with 4 x M5 screws.

⚠ **Please note!** During installation it is important that no foreign object, such as borings or screws, fall into the inverter as a short circuit may occur.

5 Parameter settings and operation

5.1 General notes

The inverter can be used in four 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 5.8 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 5.9. This operating mode is called *Torque*.
- As a process regulator with feedback from a process controlled by an induction motor, see section 5.10. This mode is called *PI-reg*.

⚠ Autotuning must always be done before first motor start, see section 5.5, Autotuning and motor parameters.

5.2 Keyboard and display

The diagram and table below shows what the keyboard looks like and the key functions generally.

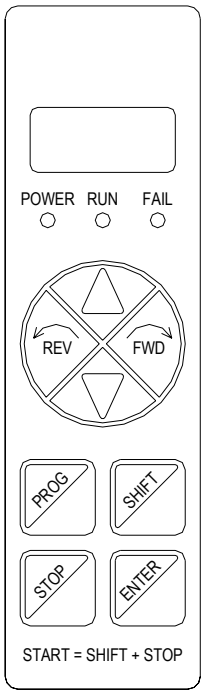


Fig. 9. Keyboard

Button	Function
FWD	Local mode: start motor clockwise. Programming mode: scroll forward through parameters or parameter groups.
REV	Local mode: start motor anti-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.

Table 5. 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.

The indicator lights at the bottom of the keyboard have meanings as follows:

POWER	Indicates the inverter is live.
RUN	Lights up when the motor is running.
FAIL	Inverter faulty

5.3 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 starts automatically when power is switched on if terminal 5 (RUN) is active and parameter *AutoStart=ON* (supplied installed).

You can switch to local mode at any time by pressing STOP, which disconnects 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.

5.3.1 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 frequency displayed can be adjusted and saved in the inverter's memory. Pressing FWD or REV accelerates the motor clockwise or anti-clockwise, the display reads *Acc. Final fr.* appears once the frequency has been reached. When the button is released, the motor is retarded if parameter *stMode* is in *Brake* position, the display reads *Ret.* If *stMode* is in the *Release* position, the motor runs down. If the inverter is run at frequency 0.0, the display will read *St still* provided the motor is stopped. The frequency can also be increased and decreased in operation by pressing ⇑ or ⇓. This way of running the motor is only designed to be used when starting.

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.

5.3.2 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.

An 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

5.3.3 External mode

When running in external mode, line one of the display shows the inverter status, and line two its current frequency. If the inverter status reads *Ext Stby*, this indicates the inverter is ready to run and is waiting for a run signal. *Ext Run* appears when the inverter is running.

The source for the setpoint is governed by the parameter *OpMode* for the operating mode concerned as in Table 12, Table 13, Table 14 and Table 17. Selecting *OpMode: Terminal* enables the setpoint source to be selected from the signal terminals as in Table 6. If using analog setpoints, the signal type is selected using parameter *AinSet* from the *Control* parameter group as in Table 7. Setpoint sources can be changed on the run.

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 6. 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 7. Settings for analog setpoint inputs at signal terminals

5.3.4 Serial channel/Field bus mode

As standard there are two different communication protocols available, NFO's (NFO) and Modbus RTU/ASCII. Both communicate via RS232/RS485. As option there are modules for other field busses available, 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* tells which type of bus/protocol is used. A separate manual describing field bus control is available at www.nfodrives.se.

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

5.4 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
	AnyBus				RegAmp			AinP10	Cur High
					RegKp			AinP03	Run Fail
					RegTi			AinP13	
					Min-fr			PT1000	
					Max-fr			M-Temp	
					Unit			OpTime	
					AinAct			RnTime	
								BrTime	

Table 8. 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
Motor					
P-Nom	Nominal motor output	5.5	Table 10	0.01 – 100kW	Init
U-Nom	Nominal motor voltage	5.5		1 – 1000V	Init
f-Nom	Nominal motor frequency	5.5		1 – 500Hz	Init
N-Nom	Nominal motor speed	5.5		5 – f-Nom * 60rpm	Init
I-Nom	Nominal motor current	5.5		Table 10	Init
cos φ	Motor cos φ	5.5		0.01 – 1.00	Init
Tuning	Autotuning command	5.5			Init
R-stat	Motor stator resistance	5.5	Table 11		Init
R-rot	Motor rotor resistance	5.5			Init
L-main	Motor main inductance	5.5			Init
Sigma	Motor leak inductance	5.5	Table 11	0,001-1,000	Init
I-magn	Magnetisation current setpoint (RMS)	5.5		0 – min(I-nom, I-limt)	Init
I-limt	Maximum motor current (RMS)	5.5	Table 11		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	5.6.1 5.7 5.8 5.9 5.10	*Speed*	*Freque* *Speed* *Torque* *PI-reg*	Init
Accel	Acceleration time from 0 to f-Nom Hz	5.6.2	30.0 s	0.2 - 500.0 s	Init/Run
Retard	Retardation time from f-Nom to 0 Hz	5.6.2	30.0 s	0.2 - 500.0 s	Init/Run
RunDly	Start delay Delay in seconds from when power is applied until motor can start.	5.6.3	0 s	0 – 3600 s	Init/Run
DC-Brk	Motor DC braking before startup. Time in seconds for which motor is braked before startup.	5.6.4	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.	5.6.5	*ON*	*OFF* *ON*	Init/Run

EnergySave	Energy save function *OFF* = Function is disabled. *ON* = Inverter optimizing energy consumption of the motor.	5.6.6	*OFF*	*OFF* *ON*	Init/Run
StMode	Stop mode *Brake* = motor brakes as *Retard*. *Release* = motor runs down.	5.6.7	*Brake*	*Brake* *Release*	Init/Run
Kp-spd	Amplifier component speed regulator	5.6.8	0,20	0,01 – 10,00	Init/Run
Ti-spd	Integrator component speed regulator	5.6.8	1,00	0 – 10,00 s	Init/Run
FSleep	Frequency sleep setting	5.6.9	0.0 Hz	0.0-150.0 Hz	Init/Run
Byp-fr	Bypass frequency	5.6.10	0.0 Hz	0.0-150.0 Hz	Init/Run
Byp-bw	Bypass frequency bandwidth	5.6.10	0.0 Hz	0.0-150.0 Hz	Init/Run
Freque					
OpMode	Setpoint source, frequency	5.7.1	*Terminal*	Table 12	Init/Run
F-fix1	Fixed frequency 1	5.7.2	10.0 Hz	0.0-150.0 Hz	Init/Run
F-fix2	Fixed frequency 2	5.7.2	20.0 Hz	0.0-150.0 Hz	Init/Run
F-fix3	Fixed frequency 3	5.7.2	30.0 Hz	0.0-150.0 Hz	Init/Run
F-fix4	Fixed frequency 4	5.7.2	40.0 Hz	0.0-150.0 Hz	Init/Run
F-fix5	Fixed frequency 5	5.7.2	50.0 Hz	0.0-150.0 Hz	Init/Run
F-fix6	Fixed frequency 6	5.7.2	60.0 Hz	0.0-150.0 Hz	Init/Run
F-fix7	Fixed frequency 7	5.7.2	70.0 Hz	0.0-150.0 Hz	Init/Run
Fr-Min	Lowest frequency when running with analog setpoint.	5.7.3	0.0 Hz	0.0-150.0 Hz	Init/Run
Fr-Max	Highest frequency when running with analog setpoint.	5.7.3	50.0 Hz	0.0-150.0 Hz	Init/Run
Speed					
OpMode	Setpoint source, speed	5.8.1	*Terminal*	Table 13	Init/Run
C-fix1	Fixed speed 1	5.8.2	300 rpm	0-9000 rpm	Init/Run
C-fix2	Fixed speed 2	5.8.2	600 rpm	0-9000 rpm	Init/Run
C-fix3	Fixed speed 3	5.8.2	900 rpm	0-9000 rpm	Init/Run
C-fix4	Fixed speed 4	5.8.2	1200 rpm	0-9000 rpm	Init/Run
C-fix5	Fixed speed 5	5.8.2	1500 rpm	0-9000 rpm	Init/Run
C-fix6	Fixed speed 6	5.8.2	1800 rpm	0-9000 rpm	Init/Run
C-fix7	Fixed speed 7	5.8.2	2100 rpm	0-9000 rpm	Init/Run
Sp-Min	Lowest speed when running with analog setpoint.	5.8.3	0 rpm	0-9000 rpm	Init/Run
Sp-Max	Highest speed when running with analog setpoint.	5.8.3	1500 rpm	0-9000 rpm	Init/Run
Torque					
OpMode	Setpoint source, torque	5.9.1	*Terminal*	Table 14	Init/Run
T-fix1	Fixed torque 1	5.9.2	10.0 %	1 – 400 %	Init/Run
T-fix2	Fixed torque 2	5.9.2	20.0 %	1 – 400 %	Init/Run
T-fix3	Fixed torque 3	5.9.2	30.0 %	1 – 400 %	Init/Run
T-fix4	Fixed torque 4	5.9.2	40.0 %	1 – 400 %	Init/Run
T-fix5	Fixed torque 5	5.9.2	50.0 %	1 – 400 %	Init/Run
T-fix6	Fixed torque 6	5.9.2	60.0 %	1 – 400 %	Init/Run
T-fix7	Fixed torque 7	5.9.2	70.0 %	1 – 400 %	Init/Run
Tq-Min	Lowest torque when running with analog setpoint	5.9.3	10.0 %	1 – 400 %	Init/Run

Tq-Max	Highest torque when running with analog setpoint	5.9.3	100.0 %	1 – 400 %	Init/Run
Max-fr	Maximum frequency under torque control.	5.9	50 Hz	0.0 – 150.0 Hz	Init/Run
	PI Reg				
OpMode	Setpoint source, regulator	5.10.1	*Terminal*	Table 17	Init/Run
R-fix1	Fixed setpoint 1	5.10.2	40.0	-2000.0 - 2000.0	Init/Run
R-fix2	Fixed setpoint 2	5.10.2	80.0	-2000.0 - 2000.0	Init/Run
R-fix3	Fixed setpoint 3	5.10.2	120.0	-2000.0 - 2000.0	Init/Run
R-fix4	Fixed setpoint 4	5.10.2	160.0	-2000.0 - 2000.0	Init/Run
R-fix5	Fixed setpoint 5	5.10.2	200.0	-2000.0 - 2000.0	Init/Run
R-fix6	Fixed setpoint 6	5.10.2	240.0	-2000.0 - 2000.0	Init/Run
R-fix7	Fixed setpoint 7	5.10.2	280.0	-2000.0 - 2000.0	Init/Run
Setmin	Value at min. input signal from setpoint input	5.10.3	0.0	-2000.0 - 2000.0	Init/Run
Setmax	Value at max. input signal from setpoint input	5.10.3	300.0	-2000.0 - 2000.0	Init/Run
Actmin	Value at min. input signal from actual value input	5.10	0.0	-2000.0 - 2000.0	Init/Run
Actmax	Value at max. input signal from actual value input	5.10	300.0	-2000.0 - 2000.0	Init/Run
T-Min	Min. temperature	5.10.3	-20 °C	-100 – 100 °C	Init/Run
T-Max	Max. temperature	5.10.3	20 °C	-100 – 100 °C	Init/Run
RegAmp	Amplifies process regulator	5.10.4	1	1 or -1	Init/Run
RegKp	Proportional component process regulator	5.10.4	0.00	0.00 – 1.00	Init/Run
RegTi	Integrator component process regulator	5.10.4	30.0 s	1.0 – 200.0 s	Init/Run
Min-fr	Min. frequency from regulator	5.10	0.0 Hz	0.0 – 150.0 Hz	Init/Run
Max-fr	Max. frequency from regulator	5.10	50.0 Hz	0.0 – 150.0 Hz	Init/Run
Unit	Regulator units	5.10	Pa	**Table 15**	Init/Run
AinAct	Scaling of actual value input	5.10	0-10V	**Table 16**	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*	5.12.1	*Running*	*Disable* *Running* *Run Fwd* *Run Rev* *Run Setp* *Run Freq*	Init/Run
ReFreq	Switch frequency in *ReMode* = *Run Freq*	5.12.1	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	5.12.2	*Disable*	*Disable* *Freque* *Speed* *Torque*	Init/Run
V-Max	Scale factor for analog power output	5.12.2	*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	5.12.3	*Disable*	*Disable* *Freque* *Speed* *Torque*	Init/Run
F-Max	Scale factor for analog frequency output	5.12.3	*32000 Hz*	0 - 32000 Hz	Init/Run
Serial					
BusType	Serial channel information See separate manual				Init/Run
Address					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 powerfactor				Read
DClink	DC Link voltage		V		Read
FrqSet	Current frequency setpoint (*Freque* mode)		Hz		Read
FrqAct	Electrical frequency (*Freque* mode)		Hz		Read
SpdSet	Current speed setpoint (*Speed* mode)		rpm		Read
SpdAct	Rotor speed (estimated actual value, *Speed* mode)		rpm		Read
TrqSet	Current torque setpoint (as % of nominal motor torque)		%		Read
TrqAct	Current torque (as % of nominal motor torque)		%		Read
RegSet	Setpoint process regulator		As per parameter *Unit*		Read
RegAct	Actual value process regulator		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	5.10.3	°C		Read
M-temp	Estimated relative motor temp.	5.11.2	%		Read
Optime	Total time inverter has been live		0.1 hours		Read
Runtime	Total time motor has been running		0.1 hours		Read
BrTime	Total time brake chopper has been active		1 Sec		Read

Error					
E-logg	Fault log	5.14.1			Read
RstDly	Time from when fault disappears to restart	5.14	10 sec	0 – 3600 sec	Init/Run
TrTime	Time inverter must run perfectly not to stop	5.14	600 sec	0 – 3600 sec	Init/Run
AC Fail	Phase error	5.14.2			
Temp Hi	Cooling flange overheating	5.14.2			
PTCTemp	Motor overheating.	5.14.2			
OverLoad	Power monitor	5.11.2			
Ain Fail	Analog setpoint input signal	5.14.2			
DC Low	Voltage in DC link too low	5.14.2			
DC High	Voltage in DC link too high	5.14.2			
GND Fail	Fault in motor or motor wiring	5.14.2			
Short C					
IMagnLow					
Cur Low					
Cur High					
Run Fail	Rotor locked, start failure	5.14.2			

Table 9. Parameters available, sorted by parameter group

5.5 Autotuning and motor parameters

To run correctly, motor parameters *R-stat, R-rot, L-main, Sigma, I-magn* and *I-limt* must be set correctly. As supplied, the inverter parameters are set to run a standard motor as in section 5.1. If used with other motors, these parameters must be modified to suit. This can be done manually or via autotuning (measuring) motor parameters.

Before you can run autotuning, you need to enter the nominal motor data, parameters *P-nom, U-Nom, f-Nom, N-Nom, I-Nom* and *cos* φ. These are usually shown on the motor plate, and must be entered for the connection for which the motor is to be used (Y or D). The basic nominal data settings as supplied are shown in Table 10.

Once you have entered these parameters, you can run the *Tuning* command, which has to be confirmed to run. The motor parameters are then recorded and saved to the respective motor parameters. This procedure takes about 1 minute, depending on the motor size. You can change the motor parameters after autotuning if you wish.

So:

1. Check inverter is not running.
2. Go to programming mode 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 in (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, once parameters have been input, the screen will read *Tuning Ready*.
6. Continue setting other inverter parameters.

If a fault occurs during autotuning, two different fault messages may appear, *Tuning Fail M* and *Tuning Fail P*. The first message indicates that measuring of the motor parameters failed, the second that some parameter is out of limits when calculated.

With *Tuning Fail M*, all motor parameters remain unchanged at the values they had before starting the procedure.

Either way, the fault must be traced and corrected before the motor can start.

Faults may be due to:

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

Please note: all inputs should be made with the motor cold, i.e. the motor should have reached normal ambient temperature for the area in which it is to be used. If inputs are made with the motor hot, this may cause operating problems when starting the motor from cold.

Autotuning can also be used with the inverter in external mode (*Ext Stby*), but not with the motor running. If autotuning is used in this mode, the inverter switches to local mode automatically and the display reads *Stop* once tuning is complete and programming mode has been exited. To return to external mode, press SHIFT + STOP.

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

There is a way of calculating the other parameters if you know the motor stator resistance. You can do this by entering the known value of *R*-stat in point 2 above, and then press ⇑ three times in point 3. The display will now read *Tuning Calc ?*, press ENTER to run calculations. Please note: if the stator resistance is measured manually, it must be measured between two phase connections on an unconnected motor connected, Y or D, at which the motor is to be run. Enter half the measured value in the R-stat. This calculation method does not give precisely the same motor parameters as full (*Full*), but they are the same as with simplified (*Basic*) if the stator resistance is precisely the same. This is because, with full autotuning, all motor parameters are measured, while here they are calculated based on *R-stat* and the nominal motor data. The aim should be to use full autotuning wherever possible.

The autotuning function sets *I-limt* to 120 % of the motor's nominal rotor current or the maximum the inverter can produce.

Table 10 and Table 11 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 motor and cannot be measured from the motor terminal.

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 10. 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 9	0,68 A	Table 9	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 9	1,08 A	Table 9	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 9	1,63 A	Table 9	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 9	2,20 A	Table 9	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 9	3,11 A	Table 9	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 9	3,89 A	Table 9	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 9	4,27 A	Table 9	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 9	6,16 A	Table 9	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 9	8,11 A	Table 9	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 9	10,32 A	Table 9	32,00 A	I-magn – 32,00A

Table 11. Default motor parameter values and permitted ranges

5.6 Setting control parameters

5.6.1 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 in the *Freque* position, 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. For other settings see section 5.7.

With the *Mode* parameter in the *Speed* position, 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 5.8.

With the *Mode* parameter in the *Torque* position, 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 5.9.

With the *Mode* parameter in the *PI-reg* position, the motor is controlled such that an externally reconnected 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 5.9.2.

5.6.2 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 formulae 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 will mean the inverter current is limited, extending the acceleration time.

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

5.6.3 Run delay, parameter *RunDly*

If the inverter fails to start the motor when starting once power is applied (inverter posts *Run Fail*), the parameter *RunDly* can be set so that the inverter delays starting the motor, so the motor remains stationary. 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.

Run Dly appears in the display while the delay is active.

5.6.4 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 control the motor, and posts a *Run Fail* alarm. To handle such starts, the inverter is equipped with a DC brake function. This function

brakes the motor by a DC current for a set time, after which the motor starts. Parameter is set to the time it takes to stop the motor when it is running fastest. The size of the brake current is adjusted to the motor's nominal current.

5.6.5 Autostart, parameter *AutoStart*

The autostart function enables the motor connected to start as soon as power is applied, without any start command being required. This parameter also governs whether the inverter will attempt to restart after a fault, see section 5.14.

With the *AutoStart* parameter *ON* (as supplied), the motor will start as soon as power is applied, provided the digital input signal RUN at the terminal is active. The inverter cannot now be controlled via the serial channel unless it is switched to stop mode manually by pressing the STOP button on the keyboard.

With the *AutoStart* parameter *OFF*, when power is applied, the inverter will wait for a flank on the digital input signal RUN at the terminal. When the signal goes from inactive to active, the motor will start. In this position, the inverter can also 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 also start automatically after an involuntary power failure.**

5.6.6 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 ca. 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.

5.6.7 Stop mode, parameter *StMode*

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

With the *StMode* parameter set to *Brake* (as supplied), when a stop command is issued, the inverter will brake the motor to a stop with the retardation ramp set before releasing it. If the mains fails, the inverter will brake the motor to a stop as quickly as possible without the motor generating a voltage surge.

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

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

5.6.8 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.

As supplied, *Kp-spd* is set to 0.10 and *Ti-spd* to 1.00 sec, which is fine under most operating conditions. When operating loads with high inertial torque, or motors with multiple poles, both *Kp-spd* and *Ti-spd* may need to be adjusted. The points below may be helpful when tuning:

- 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.

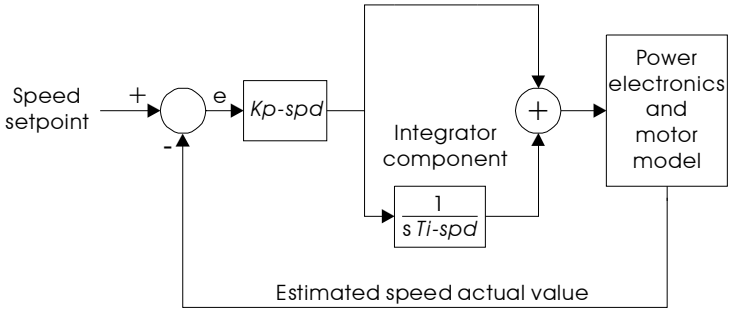


Fig. 10. Speed regulator

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

5.6.9 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 brake

the motor according to retardation ramp down to 5Hz and then release the motor. When setpoint exceeds 5.5Hz the inverter will again start the motor.

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

The NFO Sinus is equipped with a facility for avoiding operating within a selected range of frequencies by using what are known as frequency bypass. There are two parameters that are used to set the frequency range: *Byp-fr* indicates the frequency's mid-frequency and *Byp-bw* its bandwidth.

When the estimated rotor frequency is in the window, the acceleration and retardation times are set temporarily to 0, so the motor will accelerate or retard through the window at full power.

If the setpoint is set within the window, the motor will run with ramps set to 0 at the frequency selected.

This function is not available under frequency or rpm control with analog setpoint (*Freq* and *Speed* mode).

This function is disabled as supplied. This is done by setting the window mid-frequency *Byp-fr* and bandwidth *Byp-bw*, to 0.0 Hz.

Example: Acceleration from 0 to 50 Hz
Accel = 5,00s, *Byp-fr* = 25,0Hz, *Byp-bw* = 10,0Hz
Gives a speed curve as shown in Fig. 11.

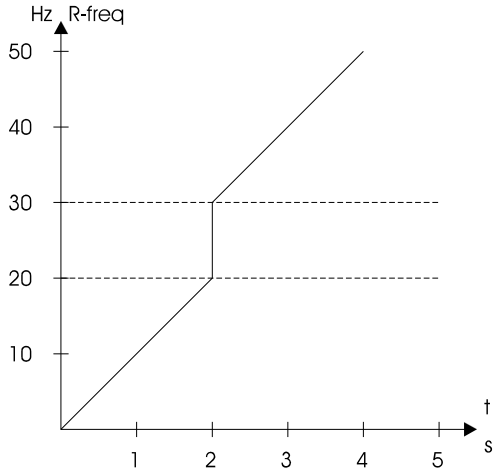


Fig. 11. Acceleration with frequency bypass

5.7 Frequency control without load compensation, *Freque* mode

Freque mode is designed to be used for simpler operations, such as operating fans. The inverter does not compensates for the motor's slip. The setpoint set and the value that appears on the inverter display is 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.

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

5.7.1 Setpoint source for frequency, parameter *OpMode*

The source for the frequency setpoint is governed by the parameter *OpMode*, the possible values of which are as shown in Table 12.

OpMode	Frequency setpoint source
Terminal	Any of alternatives below, selected from terminal as in table 6
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 12. Freque/OpMode parameter settings.

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

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

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

Under rpm 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*, see Table 7. *Analog F* and *Analog R* scale the range such that *Fr-Max* applies at full run and *Fr-Min* at minimum run in the direction concerned.

If rotation is required at different directions (e.g. at +/- 10V stopping in the middle), set *Fr-Min* to *–Fr-Max*.

5.8 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 that appears in the display is 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 only appear if this mode is selected.

5.8.1 Setpoint source for speed, parameter *OpMode*

The source of the speed setpoint is governed by the parameter *OpMode* possible values for which are shown in Table 12.

OpMode	**Frequency setpoint source**
Terminal	Any of the alternatives below, selected from terminal as in table 6
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 13. Speed/OpMode parameter settings

5.8.2 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. The maximum is governed by the motor type, however, and is set at three times the motor's nominal frequency, subject to a maximum of 150Hz, giving 4500rpm for a 4-pole motor at a nominal frequency of 50Hz.

5.8.3 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*, see Table 7. Under *Analog F* and *Analog R* the range is set such that frequency *Sp-Max* applies at full run and *Sp-Min* at minimum run in the direction concerned.

If rotation at different directions is required (e.g. at +/- 10V stopping in the middle) set *Sp-Min* to –*Sp-Max*.

5.9 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 motor can supply enough current). Please note: maximum torque is reduced if the motor is running in field weakening (normally over motor's nominal frequency).

⚠ **NB: 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. So it is important to set the maximum frequency, using the parameter *Max-fr*.**

5.9.1 Torque regulation setpoint source, parameter *OpMode*

The torque setpoint source is governed by parameter *OpMode*, the possible values of which are as shown in Table 14.

OpMode	Torque setpoint source
Terminal	Any of the alternatives below, selected from terminal as in table 6
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 14. Torque/OpMode parameter settings.

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

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

5.9.3 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.

5.10 Process regulation, *PI Reg* mode

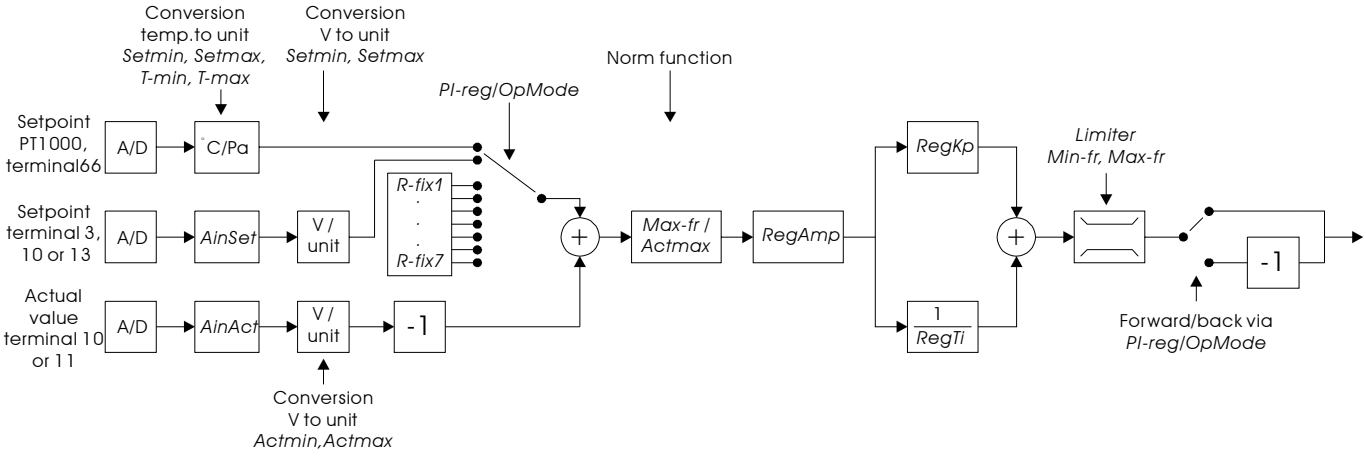


Fig. 12. Process regulator in outline

The regulator units are selected using the parameter *Unit*, see **Table 15**. Whatever setpoint source is used, the regulator's actual values are always taken from anyone of the analog inputs at terminal 10 or terminal 11. The scaling is governed by the parameter *AinAct*, see **Table 16**. 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)

Table 15 Process regulator units

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 16 Actual value input setting options

5.10.1 Setpoint source, process regulation

The regulator setpoint source is governed by the parameter *OpMode*, the possible values of which are shown in Table 17. Process regulation cannot be used running the motor in different directions. The actual value inputs are selected and scaled as shown in Table 7. 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.

OpMode	Source of regulator setpoint
Terminal	Any of the alternatives below, selected from terminal as in table 6
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 17. PI Reg/OpMode parameter settings

5.10.2 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*.

5.10.3 Analog regulator setpoint from temperature sensor (*)

The inverter can take its setpoint from a PT1000 type temperature sensor connected to terminal 66. 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*.

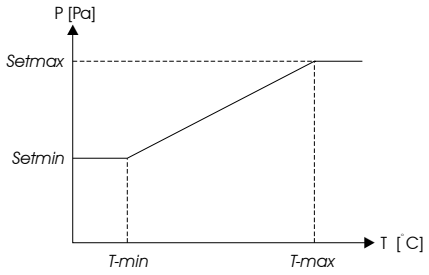


Fig. 13. Relationship between *Setmin, Setmax, T-min* and *T-max*

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

The regulator characteristics are governed by the parameters *Max-fr, Actmax, 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.

5.11 Motor safety functions

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

5.11.1 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 earth as in Fig. 2.

Configuration is carried out under fault *PTCTemp* in parameter group *Error*, see section 5.14.

5.11.2 Power monitor

The power monitor uses the motor parameters as described in section 5.5: so it is essential that these are entered correctly if the function is to work reliably. Always perform the autotuning!

This function is controlled by parameters *OverId*, *S-Temp* and *F-Cool*. *OverId* 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 power monitor works on the principle that a motor can work at an output loss equivalent to that at nominal load (voltage, current and RPM as plated) at an ambient temperature of 40°C indefinitely.

If the motor is working at a higher output loss, lower rpm or higher ambient temperature, the power monitor will cut in after a time depending on the ratio of those variables to the motor's nominal data.

The current power monitor status at any time can be read off as a percentage from the parameter *M-temp*. This value rises and falls towards a final value that corresponds to the current load. A final value of 100.0% corresponds to nominal load, and the power monitor 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 power monitor can be made to trip at lower motor loads by entering the ambient temperature as higher than it actually is, or a higher load can be allowed by entering a lower temperature.

If the motor is equipped with forced cooling, i.e. there is a cooling fan that is not connected to the motor shaft and hence cooling at a constant rate, irrespective of motor rpm, set parameter *F-Cool* to a value other than zero. The power monitor 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 output 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.

5.12 Output signals to display (*)

NFO Sinus units are equipped with three outputs to enable different status conditions and parameters to be monitored in use.

With the add-on card fitted, protective earth and I/O ground are automatically connected (corresponding jumper S4 fitted).

Before the outputs can display the correct values, the motor parameters must be set correctly, see section 5.5.

5.12.1 Function relay (*)

The function relay has a number of functions, and is used to indicate that a given status has been reached. This relay is at terminals 50, 51 and 53 (see Fig. 8). If there is no signal, 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*, display off.

- *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* (| *FrqAct* | > *ReFreq*).

5.12.2 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,* display off.
- *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.

5.12.3 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.

5.13 Reset to factory settings

The inverter parameters can be reset to what they were as supplied.

This can be done under Power On by pressing both FWD and REV buttons and holding them down, then pressing PROG at the same time 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.

So:

1. Press FWD and REV buttons.
2. Connect mains supply.
3. Hold these buttons down and press PROG when the software revision is shown in the display.
4. Press ENTER to acknowledge ”Par fail”.

5.14 Alarm and fault procedures

If a fault occurs in the inverter, it means one of the following has happened, depending on the configuration: Motor stopped and alarm relay indicates alarm (*Fail*), alarm relay indicates alarm (*Alarm*), fault in display only (*Ind*) or nothing (*Disable*). Provided parameter *AutoStart* = *ON* and *Fail* mode is selected for the fault concerned, after a given time (*RstDly*) attempts will be made to restart the motor if the cause of the fault has disappeared. How many restart attempts are made depends on the type of fault concerned (*ErrCnt*). If more faults than what *ErrCnt* is set to occur within time *TrTime*, no further automatic restart attempts will be made. Once a fault has been acknowledged, the inverter can be restarted. Any faults that occur are logged in the fault log (*E-logg*). Some faults have to persist for a given time (*Delay*) before they generate a fault.

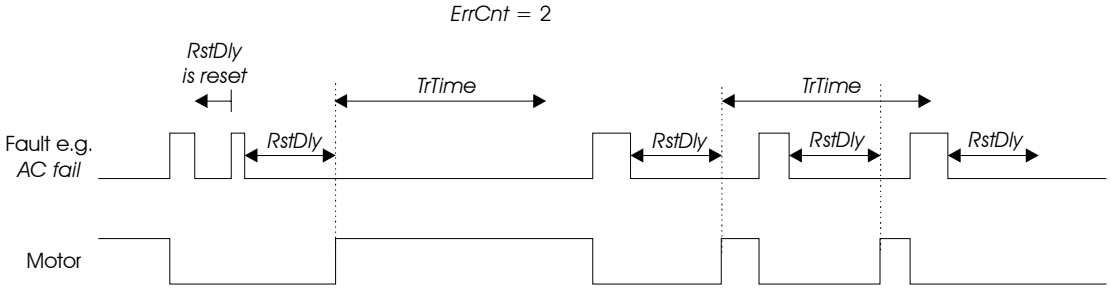


Fig. 14. Typical fault situation

5.14.1 Fault log

The last 30 faults at any time are saved in a non-volatile memory in the inverter, so they can be read off, even if the power fails. 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*) to a resolution of 0.1 hours. If the same fault occurs repeatedly, only the time it first occurred is logged. The fault log can be wiped by pressing SHIFT + ENTER.

5.14.2 Fault messages

All fault messages, fault types and other fault parameter setting options are shown in the table below. *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 you are in any doubt how to configure the error messages, always contact NFO Drives AB.

Meaning of fault types:

Fail: Motor stopped and alarm relay indicates alarm

Alarm: Alarm relay indicates alarm (the motorn is not stoped)

Ind: Fault in display only (the motorn is not stoped)

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. Press ENTER to acknowledge fault. To switch fault off, use parameter *AC Err*. **NB: 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. Press ENTER to acknowledge fault.
PTCTemp	Fail Alarm Ind Disable	Fail	2	Motor overheating, thermistor input limit exceeded. See 5.11.1		Let motor cool down. Press ENTER to acknowledge fault.
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 5.11.2. Press ENTER to acknowledge fault.
				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, see 5.3.3. Press ENTER to acknowledge fault.
DC Low	Fail	Fail	2	DC link voltage too low.		Power supply too low. Check inverter mains connection. Press ENTER to acknowledge fault.
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. Press ENTER to acknowledge fault.

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: 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). Open circuit in one or more outgoing phases. Resistance too high in any of the outgoing phases, poor contact/loose contact in motor or motor wiring. Motor parameters faulty, autotuning not performed. Rectify fault. Press ENTER to confirm.
Short C	Fail	Fail	2	Short-circuit between output phases	
IMagnLow	Fail Alarm Ind Disable	Fail	2	Magnetising current in motor too high or too low.	
Cur Low	Fail Alarm Ind Disable	Fail	2	Current in one or more motor phases too low.	
Cur High	Fail Alarm Ind Disable	Fail	2	Current in one or more motor phases too high.	
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 5.6.4) and/ or start delay (section 5.6.3). 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.
Cur Limt	Ind	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.

Table 18. Fault message

6 Brake chopper and power surge regulator

If a motor is trying to retard a load with high inertia, it will feed energy back to the inverter. This means the voltage in the DC link (terminals + and -) will rise. To prevent the voltage rising too high and damaging the inverter, it is fitted with a power surge regulator which does not allow retardation that generates more energy than the motor can use itself.

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

This resistance must be capable of absorbing the braking energy generated, so it must be tailored to the operating conditions concerned. The recommended resistance for an inverter with a 3 x 400V power supply is 100 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 table below shows the minimum resistance permitted for different sizes of inverter:

Size	Min. permitted resistance
0.37kW/400V	68 Ω
0.75kW/400V	68 Ω
1.5kW/400V	68 Ω
2.2kW/400V	47 Ω
3kW/400V	68 Ω
4kW/400V	47 Ω
5.5kW/400V	47 Ω
7.5kW/400V	22 Ω
11kW/400V	22 Ω
15kW/400V	22 Ω

Table 19. Minimum permitted resistance for brake resistance

If the brake chopper is active, this appears as an alarm 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.

The digital inputs (e.g. FIX1) have higher priority than analog setpoint (VOLTAGE) if parameter *OpMode* is set to *Terminal* (default), in this case the inverter will run with analog setpoint if there are no digital inputs set.

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

- Install motor and wiring as in section 4.3.
- Connect power supply as in section 4.2.
- Run autotuning as in section 5.5 to ensure motor parameters are correct.

7.1 Running in local mode

The procedure below is designed to check that everything is connected correctly and the 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 at fixed frequency

The procedure below is designed to test motor running at 25 Hz clockwise. Motor will run until STOP is pressed.

- 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 runs down) or disconnect terminal 5 (motor brakes as in ramp, parameter *Retard*).

7.3 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.

7.4 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.

7.5 Torque control with 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.

7.6 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 preassure 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 *RegTi* 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.

7.7 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 *RegTi* 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.

7.8 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.

8 Your own parameter settings

Name	Description	Setting
P-Nom	Nominal motor output	
U-Nom	Nominal motor V	
f-Nom	Nominal motor freq.	
N-Nom	Nominal motor rpm	
I-Nom	Nominal motor curr.	
cos φ	Motor cos φ	
R-stat	Motor stator resistance	
R-rot	Motor rotor resistance	
L-main	Motor main inductance	
Sigma	Motor leak inductance	
I-magn	Magnetisation current	
I-limt	Rotor current limit	
Mode	Control mode	
Accel	Acceleration time	
Retard	Retardation time	
RunDly	Start delay	
DC-Brk	DC braking	
AinSet	Setpoint type analog input	
AutoStart	Autostart mode	
EnergySave	Energy save function	
StMode	Stop mode	
Kp-spd	Amplify speed regulator	
Ti-spd	Integrator speed regulator	
FSleep	Frequency sleep setting	
Byp-fr	Bypass frequency	
Byp-bw	Bypass frequency	
OpMode	Setpoint source	
F-fix1	Fixed frequency 1	
F-fix2	Fixed frequency 2	
F-fix3	Fixed frequency 3	
F-fix4	Fixed frequency 4	
F-fix5	Fixed frequency 5	
F-fix6	Fixed frequency 6	
F-fix7	Fixed frequency 7	
Fr-Min	Min. frequency	

Fr-Max	Max. frequency	
OpMode	Setpoint source	
C-fix1	Fixed speed 1	
C-fix2	Fixed speed 2	
C-fix3	Fixed speed 3	
C-fix4	Fixed speed 4	
C-fix5	Fixed speed 5	
C-fix6	Fixed speed 6	
C-fix7	Fixed speed 7	
Sp-Min	Min. speed	
Sp-Max	Max. speed	
OpMode	Setpoint source	
T-fix1	Fixed torque 1	
T-fix2	Fixed torque 2	
T-fix3	Fixed torque 3	
T-fix4	Fixed torque 4	
T-fix5	Fixed torque 5	
T-fix6	Fixed torque 6	
T-fix7	Fixed torque 7	
Tq-Min	Min. torque	
Tq-Max	Max. torque	
Max-fr	Max. frequency	
OpMode	Setpoint source regulator	
R-fix1	Fixed setpoint 1	
R-fix2	Fixed setpoint 2	
R-fix3	Fixed setpoint 3	
R-fix4	Fixed setpoint 4	
R-fix5	Fixed setpoint 5	
R-fix6	Fixed setpoint 6	
R-fix7	Fixed setpoint 7	
Setmin	Value at min input signal	
Setmax	Value at max input signal	
Actmin	Value at min input signal	
Actmax	Value at max input signal	
T-Min	Min. temperature	
T-Max	Max. temperature	
RegAmp	Amplification	
RegKp	Proportional component	

RegTi	Integrator comp.	
Min-fr	Min. frequency	
Max-fr	Max. frequency	
Unit	Regulator units	
AinAct	Scaling actual value input	
ReMode	Function relay function	
ReFreq	Reset frequency	
V-Out	Analog V output	
V-Max	Scale factor	
F-Out	Analog freq output	
F-Max	Scale factor	
RstDly	Restart time	
TrTime	No-fault time	
AC Fail	Phase error	
Delay	Delay if phase error	
Temp Hi	Inverter overheating	
PTCTemp	Motor overheating	
OverLoad	Power monitor	
F-Cool	Forced cooling	
S-temp	Ambient temp.	
Ain Fail	Analog error	
DC Low	Low voltage in DC link	
DC High	High voltage in DC link	
GND Fail	Earth fault	
Short C	Short circuit	
ImagnLow	Magn. current too low	
Cur Low	Undercurrent in motor	
Cur High	Overcurrent in motor	
Run Fail	Start failure, rotor locked	