NFO Sinus

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

Operating and Installation Manual

NFO Sinus Optimal

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NFO DRIVES

Contents

Introduction

The frequency inverter described in this operating manual is used for frequency (Hz) or speed (rpm) control of three-phase ac induction motors. This manual describes how to install and use the inverter.

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

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

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

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

1 Safety aspects

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

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

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

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

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

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

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

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

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

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

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

2 Technical data

Table 1. Inverter ratings for 380-480V 3~ 50/60 Hz Type TN electrical supply network

Art. no.	Rated output power	Rated output current [1]	Max output current [2]	Apparent output power [3]	Absolute losses [4] $P_{L,CDM(90,100)}$	Efficiency class [5],[6]	Standby power [7]	Size (H×D×W) [mm]	Weight [kg]
NFO 3A4D3490D	2.2 kW	1.0-4.9 A	5.8 A	3.3 kVA	0.14 kW	IE2	7.5 W	390x190x160	7.0

Notes:

[1] The inverter is optimized for use at a wide range of nominal motor currents in the power ranges of 0.37 kW to 2.2 kW.

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

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

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

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

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

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

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

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

Table 2. Common data

Inverter output			
Output voltage waveform	Sinusoidal		
Output frequency	0 – 150 Hz		
Control modes			
Frequency control	0 – 150 Hz, Vector control without slip compensation		
Speed control	0 – 9000 rpm, Vector control with slip compensation		
Regulators			
Process control	PI with extern analogue feedback in all control modes		
Speed regulator	Regulator for optimal dynamic performance		
I/O	**No.**	**Name**	**Configurable levels**
Digital control inputs	8	DIN1 – DIN8	
Analogue control inputs	2	AIN1, AIN2	0-10V, 2-10V, ±10V, 0-20mA, 4-20mA, ±20mA, Pot
Digital outputs	2	Re1, Re2	Relay, max 50VDC
Analogue outputs	2	AOUT1, AOUT2	0-10V, 2-10V, ±10V, 0-20mA, 4-20mA, ±20mA
Voltage output	1	+24V	max 200mA
Serial control	2	USB 2.0 Type B, RS485	
Serial protocols	2	Modbus RTU / ASCII, NFO	
Fieldbus options	-		
Motor safety			
Thermistor input	PTC or Klixon		
Electronic motor overload protection	Switch off if motor load is over rated power for a long time		
Ambient conditions			
Ambient operating temp.	-10 – +45 °C		
Storage temp.	-20 – +60 °C		
Humidity	0 – 90%, non-condensing		
Protection class	IP55 according to SS-EN 60529		
EMC certification	Emissions: EN 55011:2016 EN, 55011/A1:2017, EN 61000-3-3:2013 Immunity: EN 61000-6-2:2005, EN 61000-4-2, -3, -4, -5, -6, -11 Harmonics: EN 61000-3-2:2014 [1] For use without shielded cables or additional EMC filter.		
Electrical safety	Low Voltage Directive EN 61800-5-1:2007, EN 61800-5-1/A1:2017. Motor terminal short circuit protection [2] according to IEC 60364-4-41:2005 / AMD1, clause 411. Short circuit protection functionality operates regardless of motor cable area, length or other properties, or mains power supply impedance.		
Climatic tests	Dry heat test IEC 60068-2-2 Damp heat test IEC 60068-2-78 Vibration test IEC 60068-2-6		

Notes:

[1] Compliance guaranteed up to 80% of nominal output power.

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

3 Mechanical installation

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

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

⚠ All terminals are accessed by opening the plastic cover. To be able to use the snap-and-hold-open functionality of the cover, a free space of 200 mm is required above the inverter.

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

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

3.1 Mounting

Unscrew the two lower captive screws and loosen the inverter from the backplate. Fasten backplate to a vertical surface using four screws. Make sure that the top mounting screws are sufficiently strong to hold the entire weight of the inverter. Place the inverter on the backplate by mating the chassis cut-out to the backplate hooks. Tighten the lower captive screws on both sides.

The cover is opened by unscrewing the two captive screws in the plastic cover and fold up the cover until it snaps tight. There are two possible positions for the cover. Close the cover by pulling it out and fold down. Be careful not to break the snaps in the cover when folding down. Tighten the screws in the plastic cover.

The plastic cover can be removed by unscrewing the two upper screws after the cover is opened. The cable from the cover to the control board must be carefully removed from the control board. Replace in reverse order.

4 Electrical installation

The following schematics shows the inverter default connections and default functions of the I/O:

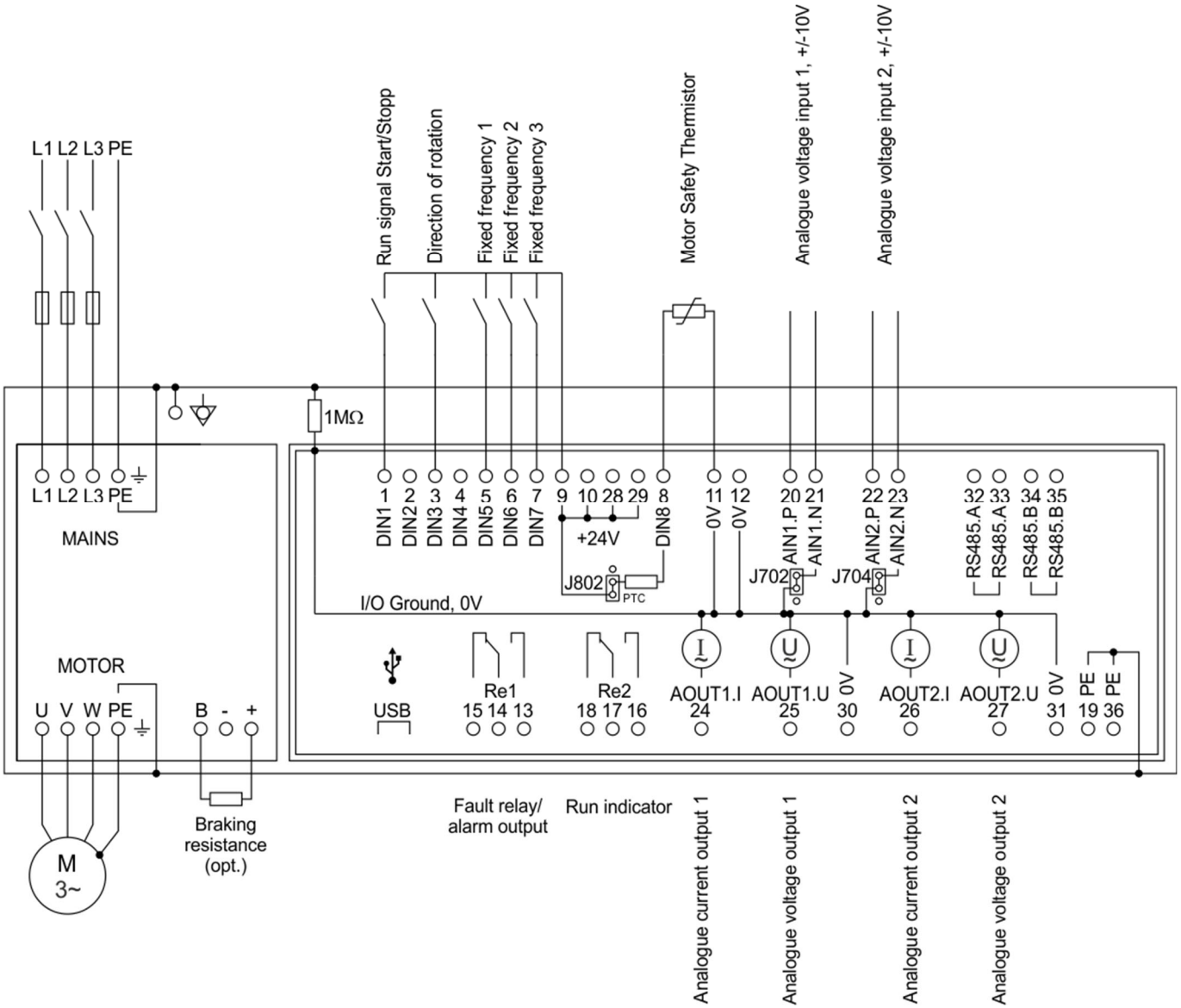


Fig.1. Default configuration

Terminals 11, 12, 30 and 31 (0V) are connected to PE with a 1MΩ resistor but can be connected galvanically to PE via an external jumper to terminal 19 or 36 (PE). These terminals may vary in terms of potential by up to 100 V from PE. The USB contact is galvanically connected to 0V.

AIN1.N and AIN2.N are connected to 0V by jumpers J701 and J703.

⚠ Warning! If option Autostart is ON and there is a run signal to the inverter (DIN1, terminal 1), the inverter will start the motor when power is applied.

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

⚠ Warning! If the Motor Safety Thermistor is to be used, jumper J802 must be set accordingly, see 5.11.1.

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

4.1 Signal terminal connection

The signal terminals are of type “tension clamp spring connection” with a usable cable cross-section of 0.13 - 2.5 mm² (AWG 26 - AWG 14). To connect the cable, carefully push the actuator downward. If a tool is used, make sure it does not damage any components on the circuit board!

4.1.1 Wiring

The signal lines should be fixed to the PCB with at least 2 straps.

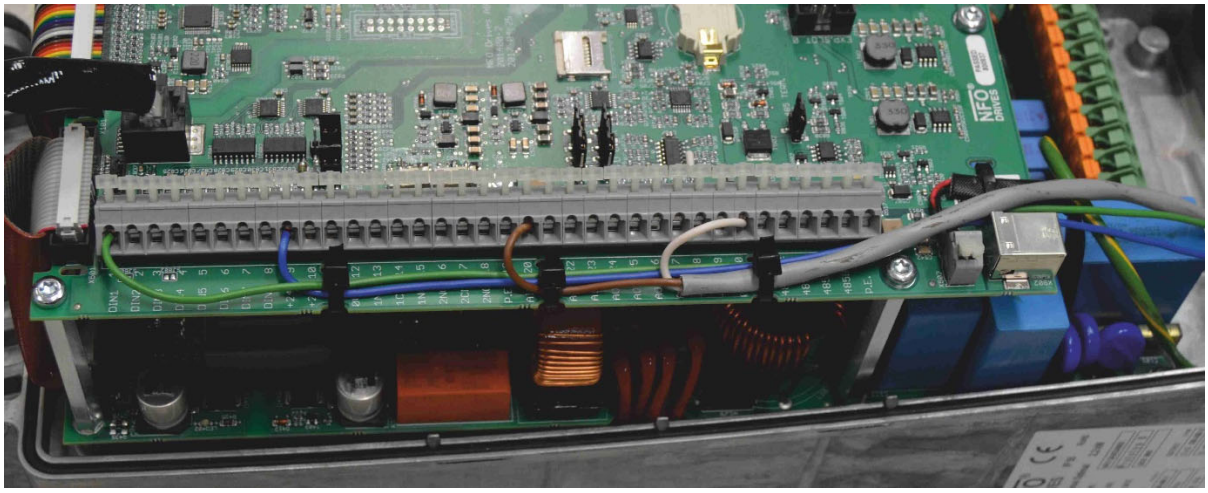


Fig. 1. Signal line wiring.

⚠ Make sure the signal wires have sufficient isolation when passing power cables.

4.1.2 Signal terminals and their use

The following control signals with its default configuration are available:

Term.	Name	Function	Default function description
1	DIN1	Digital input 1	Run signal Start/stop
2	DIN2	Digital input 2	
3	DIN3	Digital input 3	Direction of rotation
4	DIN4	Digital input 4	
5	DIN5	Digital input 5	Select fixed frequency (see Table 7 nedan)
6	DIN6	Digital input 6	Select fixed frequency (see Table 7 nedan)
7	DIN7	Digital input 7	Select fixed frequency (see Table 7 nedan)
8	DIN8	Digital input 8	PTC motor protection
9	+24V		+24V max 200mA regulated voltage to digital inputs or external transmitters. Short circuit protected. Could also be used for auxiliary control power supply.
10	+24V		
11	0V		0V, I/O Ground
12	0V		
13	RE1.NO	Relay 1 NO	Fault relay, potential-free contact max 1 A, 50 V DC. If fault present, terminals 14 are 15 closed.
14	RE1.COM	Relay 1 COM	
15	RE1.NC	Relay 1 NC	

16	RE2.NO	Relay 2 NO	Run indication, potential-free contact max 1 A, 50 V DC. Terminals 16 and 17 are closed when motor is running.
17	RE2.COM	Relay 2 COM	
18	RE2.NC	Relay 2 NC	
19	PE		Protective earth
20	AIN1.P	Analogue input 1, pos	Analogue setpoint input, positive
21	AIN1.N	Analogue input 1, neg	Analogue setpoint input, negative (0V, I/O Ground)
22	AIN2.P	Analogue input 2, pos	Process regulator actual value input, positive
23	AIN2.N	Analogue input 2, neg	Process regulator actual value input, negative (0V, I/O Ground)
24	AOUT1.I	Analogue output 1, I	Current output 1
25	AOUT1.U	Analogue output 1, U	Voltage output 1, impedance 50Ω
26	AOUT2.I	Analogue output 2, I	Current output 2
27	AOUT2.U	Analogue output 2, U	Voltage output 2, impedance 50Ω
28	+24V		+24V (same as terminal 9 and 10)
29	+24V		
30	0V		0V, I/O Ground (same as terminal 11 and 12)
31	0V		
32	RS485.A		RS 485, -
33	RS485.A		
34	RS485.B		RS 485, +
35	RS485.B		
36	PE		Protective earth

Table 3. Signal terminals and their use

Digital inputs (terminals 1 - 8), positive logic:

Maximum input voltage: 30V
Switch level: ≈ 13V (input voltage higher than switch level is considered as active level)
Impedance: 10kΩ

Digital inputs (terminals 1 - 8), negative logic:

Maximum input voltage: 30V
Switch level: ≈ 9V (input voltage lower than switch level is considered as active level)
Impedance: 10kΩ

4.1.3 Signal terminals configuration

The jumpers on the control board are for the configuration of the analogue- & digital-inputs as well as the serial RS485 channel. The placement and default settings of the jumpers are seen in Fig. 2 and explanations about their use are described in the following sections.

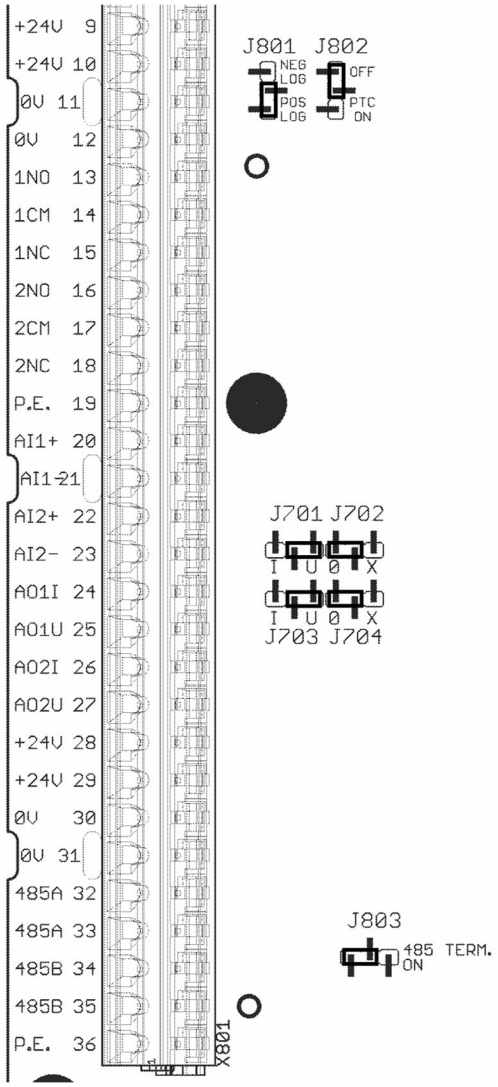


Fig. 2. Jumper placement and default settings

4.1.4 Analogue current input

To use analogue current input 1, move J701 to “I” position. If more than one unit is controlled by a single current input signal, then J702 should be removed or moved to position “X”. This allows the common-mode voltage to vary by ±24V from 0V

The same applies for J703 and J704 when using analogue current input 2.

Input resistance: 82Ω.

Note: When used as voltage inputs, J702 and J704 **must** be mounted in “0” position.

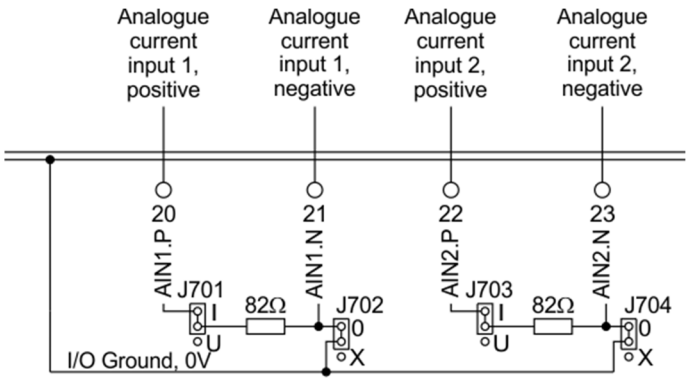


Fig.3. Analogue current input configuration

4.1.5 Negative Logic

The inverter can be configured to run the digital inputs (DIN1 to DIN8) with negative logic. This is done by moving jumper J801 to the “NEG LOG” position. The inputs are then made active by connecting them to the 0V (terminals 11,12, 30 or 31), see Fig.4.

If the PTC function is to be used with negative logic, an external resistor (1,5kΩ, min 1/2W) must be connected between the terminals DIN8 and 0V. And J802 must be in the OFF position.

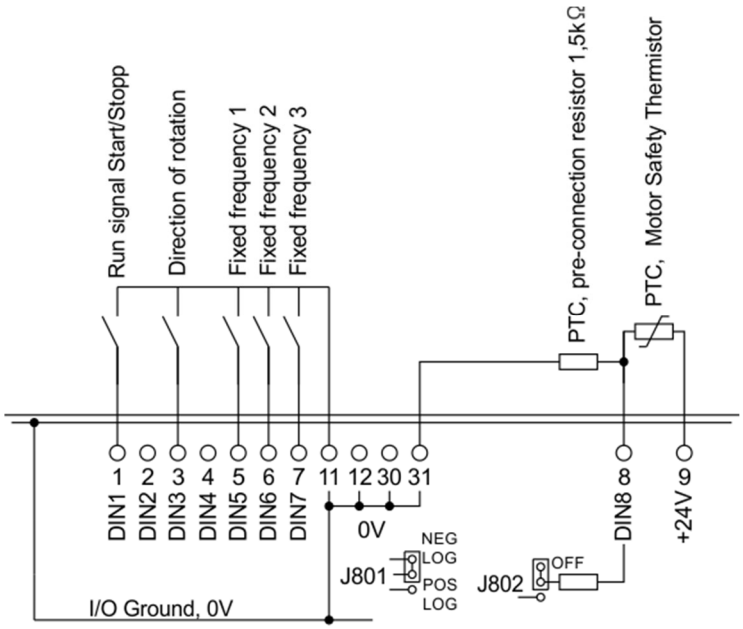


Fig.4. Connection via negative logic (jumper J801 moved)

4.1.6 Serial channel RS485

The inverter can be controlled via an RS485 type serial channel. Connection is made through terminals 32 (RS485.A) and 34 (RS485.B). If the signals are to be bridged to further units, terminals 33 and 35 can be used as in Fig.5.
Termination of the serial channel with 124Ω resistor is available by moving jumper J803 to position “485 TERM. ON”.

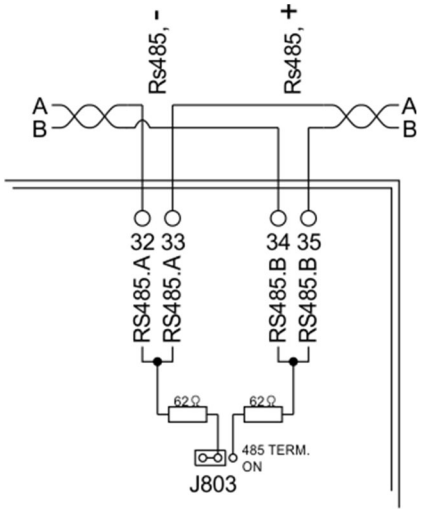


Fig.5. Connection RS485

4.1.7 Connecting potentiometer

If a potentiometer is to be used as the setpoint source, it is connected between the analogue voltage output AOUT2.U (27) and the analogue voltage input AIN1.P (11 or 12).
Change parameter *AinSet* to *Pot* and this automatically configures AOUT2.U to supply 10V.

The value of the potentiometer should be between 4,7kΩ and 22kΩ. A lower value will give a lower maximum frequency because of a 50Ω output impedance in AOUT2.U.

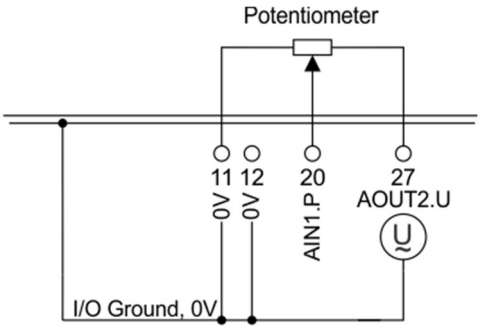


Fig.6. Connecting potentiometer

4.2 Power Terminal connection

4.2.1 Connectors and cables

The power terminals are of type “Push-Lock” with a cross section of 0.2 – 6mm^2 (AWG 24 – AWG 10). Use cable type(-s) with operating temperature rating of at least 70°C. The cable insulation shall be stripped 12 mm before pushed into the connector, and then the lever shall be closed.

⚠ It is important that the lever is pushed to its fully closed position, as shown below:

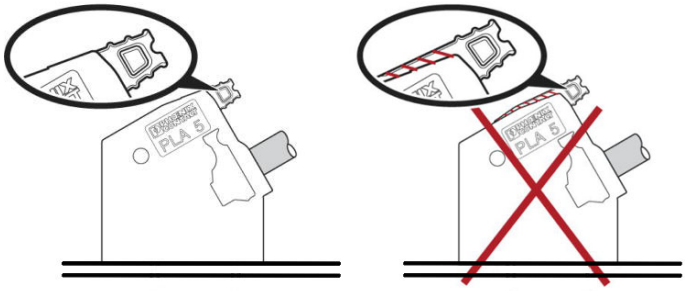


Fig.7. The connection lever of the power terminals

4.2.2 Power terminal use

Terminal	Function	Description
L1	Mains supply	Mains supply 380–480V 3~
L2		
L3		
PE	Protective earth	Power supply protective earth connector
B	Brake resistor	Connection for external brake resistor (between B and +)
-	-	Internal DC link voltage negative and positive terminals.
+	+	Positive terminal also used for external brake resistor (option)
PE	Protective earth	Motor protective earth connector
U	Motor outputs	Motor phase connectors - To be connected to the correct poles of the motor. Incorrect connection can cause erratic/unwanted behaviour of the motor.
V		
W		

Table 4. Use of power terminals

When installing two or more inverters together, with one or more of their motors running regeneratively, the inverters DC link terminals (+ and -) can be connected to each other (thus supplying energy to each other).

Note! As there are component tolerances in the inverters, the link voltage may vary slightly between units, so an equalising resistor and ultra-fast fuse must be fitted to each line.

Contact NFO Drives AB for correct dimensioning.

4.2.3 Connecting mains supply

Three-phase feed inverters are connected to a three-phase mains network at a nominal voltage of 380 – 480 V 50/60 Hz between terminals L1, L2, L3 and PE. (PE = Protective Earth = ground).

Recommended slow-blow fuses for three-phase supply:

Model	2.2 kW (1.0 – 4.9A)
Fuse	10A

Table 5. Recommended fuse

With the mains supply connected correctly and the motor running, the inverter draws less than 2 mA earth current in the PE connection. An earth leakage circuit-breaker or RCD 30mA can be used with the inverter.

⚠ **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. Do not use the mains supply for frequent on/off control of the motor.**

4.2.4 Connecting motor

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

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

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

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

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

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

5 Parameter settings and operation

5.1 General notes

The inverter can be used in the following modes of control:

- Frequency regulation of an induction motor (motor speed is not compensated for load variations) with a fixed digital or analogue 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 the factory-set mode.
- Speed regulation for an induction motor with speed calculation (motor speed compensated for load variations) with a fixed digital or analogue setpoint, see section 5.9 for more details. The motor's estimated speed is shown in the display. This mode is called *Speed*.

In the above modes, the setpoint can also be the output from the internal PI-regulator with feedback from a process controlled by an induction motor.

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

5.2 Keyboard and display

The figure and table below show the keyboard and general key functions.

Fig. 8. Keyboard

Button	Function
ENTER	Save parameter. Enter into parameter or parameter-group.
ESC	Leave parameter unsaved. Leave parameter, parameter-group or Setup. Enter Setup.
MAN / AUTO	Toggle Operating mode between *Manual* and *Auto*.
START	Starts motor in *Manual* mode. Starts motor in *Auto* mode if Run signal (DIN1) active.
STOP	Stops motor in all modes.
▲	Increase parameter when changing. Moves between parameter-groups or parameters.
▼	Decrease parameter when changing. Moves between parameter-groups or parameters.

Table 6. Button functions

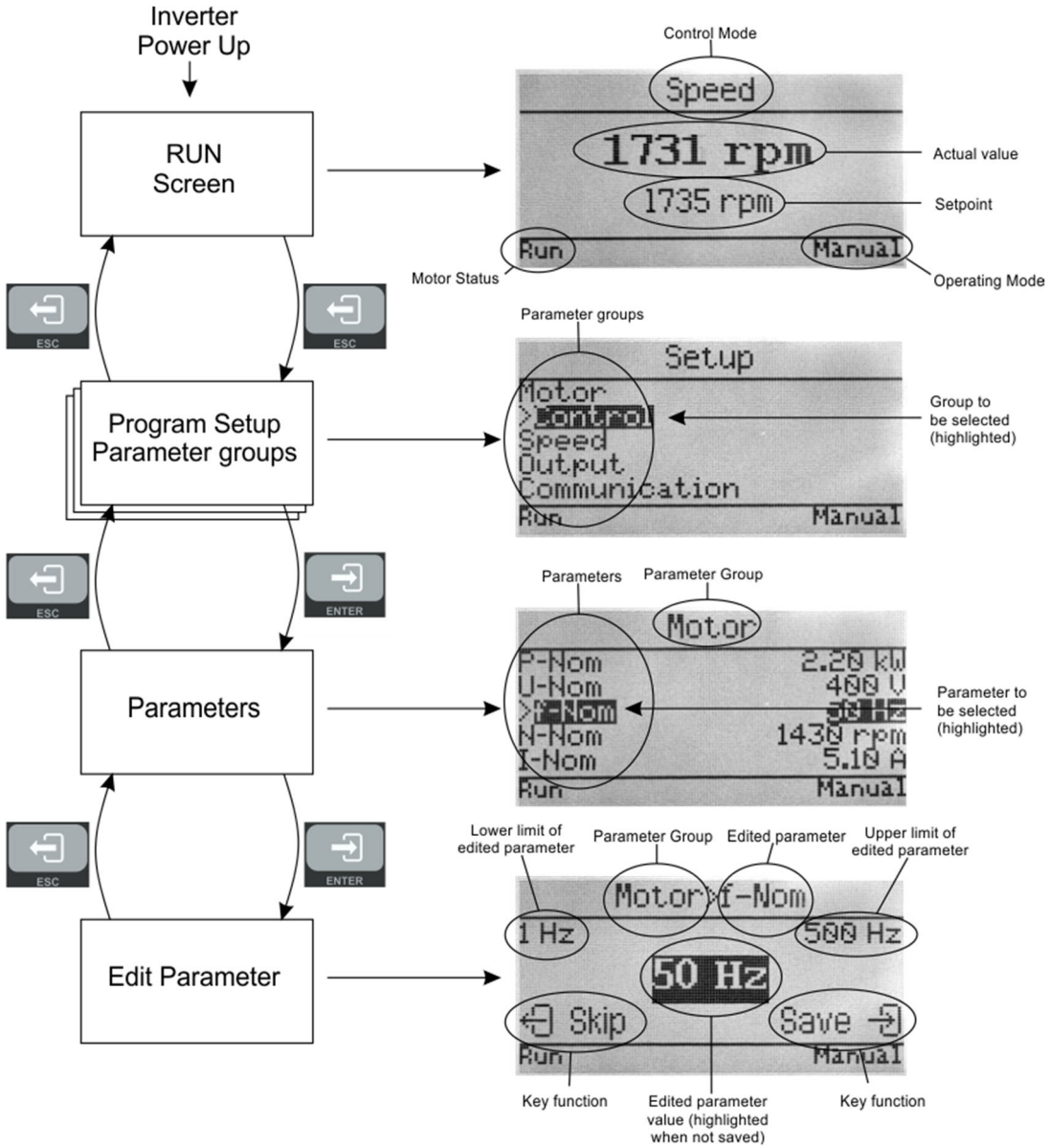
After power up, the inverter enters the RUN screen. This screen shows the status of the inverter. Setup is reached by pressing (Esc). From the Setup Screen, the RUN screen is entered again by pressing (Esc).

When a parameter or a parameter-group is selected, its text is inverted. By pressing (Enter) the parameter or parameter-group is entered.

Toggling between a parameter or parameter-group and the RUN screen can always be done by pressing and holding (Esc) for 2s.

The value of a given parameter can be increased or decreased by pressing (Up) or (Down). When adjusting parameters, the increment increases successively. When any parameter is changed but not yet saved, its value is highlighted. To save the value, press (Enter).

The following flowchart Fig. 9 shows how different screens are reached, examples of appearance and explanation of text:



*

Fig. 9. Programming flowchart and screen examples with explanations

5.3 Indicators and Motor status

The indicator lights, below the display of the keyboard, mean the following:

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

The Motor status, shown in the lower left corner of the display, means the following:

Run	Motor is running.
Stop	Motor standing still.
StBy	Inverter standby in Auto mode, waiting for Run signal (DIN1).

5.4 Operating modes

The inverter has 2 operating modes, *Auto* and *Manual*. When starting and initiating the inverter it enters the *Auto* mode and the RUN screen is shown. The *Auto* mode is used for controlling the inverter with an external start command, either from terminal 1 (DIN1) or with a serial channel command. The *Manual* mode is normally used for test and programming, as well as running the inverter, with the use of the keyboard or NFO Sinus Manager SW.

⚠ The inverter will start the motor automatically when it is powered up if terminal 1 (DIN1 = run signal) is active and parameter *AutoStart=ON*. Parameter ***AutoStart* is factory set to OFF** to prevent unintentional motor starts during commissioning.

The following flowchart Fig. 10 shows how to switch between *Manual* and *Auto* modes:

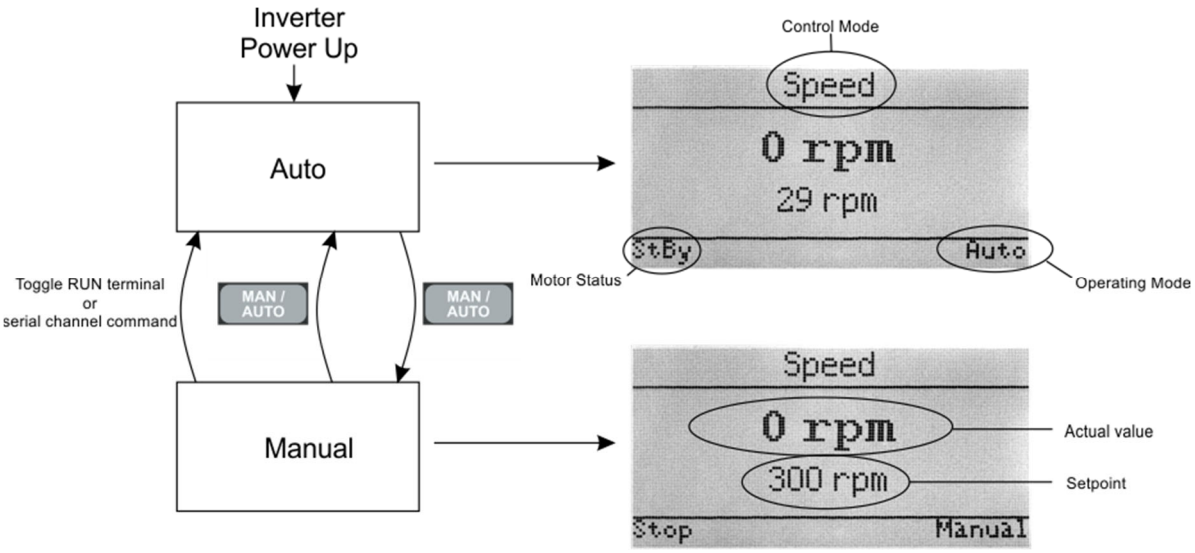


Fig. 10. Flowchart switching between modes and screen examples

You can toggle between *Auto* and *Manual* mode at any time by pressing MAN / AUTO.

The chosen mode is displayed in the right lower corner of the screen.

⚠ The inverter starts automatically, or continues to run if it is running, when entering *Auto* mode if terminal 1 (DIN1) is active.

5.4.1 Manual mode

You can switch to *Manual* mode at any time by pressing MAN / AUTO. If the motor is running in *Auto* mode, it will continue to run in *Manual* mode with the setpoint the same as the actual value at the time of the switch over.

The setpoint and actual value are shown on the screen.

The setpoint is increased by pressing ▲, decreased by pressing ▼ and saved by pressing ENTER.

The motor is started by pressing START and stopped by pressing STOP. When the motor is running, *Run* is shown in the lower left corner of the screen. When the motor is stopped, *Stop* is shown.

NB! In *St-mode, Ramp*; run will be shown, after stop has been pressed, until the motor has stopped.

5.4.2 Auto mode

You can switch to *Auto* mode at any time by pressing MAN / AUTO. If terminal 1 (DIN1) is active the motor starts. *Auto* mode can also be reached by toggling terminal 1 (Run signal DIN1) or by serial channel command. If the inverter is in *Auto* mode but active run signal terminal 1 (DIN1) is missing, the Motor status shows *StBy*.

The source for the setpoint is governed by the parameter *Setp Source* for the control mode concerned see 5.8.1, 5.9.1 and 5.10.1.

If selecting *Setp Source* to:

Terminal: enables the setpoint source to be selected from the digital input signal terminals as inTable 7. Setpoint sources can be changed while inverter is running and apply immediately.

Analog F: runs clockwise with analog setpoint. The analog signal range and input type is selected using parameter *AinSet* from the *Control* parameter group as in Table 8. The analog input value is then scaled between the lowest setpoint (*Min Ain Frq, Min Ain Spd or Set Min* = lowest analog input value) and the highest setpoint (*Max Ain Frq, Max Ain Spd or Set Max* = highest input value) se sections 5.7.4 , 5.8.3 , 5.9.3 and 5.10.1.

***Analog R*:** as *Analog F*, but running counter-clockwise.

Fix-1 F - 7 F: runs clockwise with setpoint from corresponding fixed value parameter for the selected control mode

***Fix-1 R - 7 R*:** as *Fix-1 F – Fix-7 F*, but running counter-clockwise.

PI control F or ***PI control R****:* enables the PI regulator to control motor either clockwise or counter-clockwise according to 5.10.

Function	Run signal	Direction of rotation	PI control	Fixed frequency 1	Fixed frequency 2	Fixed frequency 3
Terminal / Function	DIN1	DIN3	DIN4	DIN5	DIN6	DIN7
Analogue Forward	1	0	0	0	0	0
Analogue Reverse	1	1	0	0	0	0
Fix-1 F	1	0	0	1	0	0
Fix-2 F	1	0	0	0	1	0
Fix-3 F	1	0	0	1	1	0
Fix-4 F	1	0	0	0	0	1
Fix-5 F	1	0	0	1	0	1
Fix-6 F	1	0	0	0	1	1
Fix-7 F	1	0	0	1	1	1
Fix-1 R	1	1	0	1	0	0
Fix-2 R	1	1	0	0	1	0
Fix-3 R	1	1	0	1	1	0
Fix-4 R	1	1	0	0	0	1
Fix-5 R	1	1	0	1	0	1
Fix-6 R	1	1	0	0	1	1
Fix-7 R	1	1	0	1	1	1
PI control F	1	0	1	x	x	x
PI control R	1	1	1	x	x	x

Table 7. Digital input control to select setpoint source. (0 = inactive, open, 1 = active, closed)

Parameter *AinSet* setting	Analogue value	Input (terminal)
0-10 V	Voltage 0-10V	20 (J701 at “U” position)
2-10 V	Voltage 2-10V	20 (J701 at “U” position)
+/-10 V	Voltage +/- 10V	20 (J701 at “U” position)
Pot	Potentiometer	11, 20 and 27 (J701 at “U” position)
0-20 mA	Current 0-20mA	20 and 21 (J701 at “I” position)
4-20 mA	Current 4-20mA	20 and 21 (J701 at “I” position)
+/-20 mA	Current +/- 20mA	20 and 21 (J701 at “I” position)

Table 8. Settings for analogue setpoint AIN1 input.

5.4.3 Serial channel/Field bus mode

There are two different standard communication protocols available, NFO’s own bus (NFO) and Modbus RTU/ASCII. Both communicate via USB or RS485. As an option there are modules for other fieldbuses available, please contact NFO Drives AB.

For controlling the inverter or altering its parameters via Modbus or NFO-bus, the Windows program “NFO Sinus Manager” is available and can be downloaded from web page www.nfodrives.se.

5.5 Parameter specifications

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

Motor	Control	Freque	Speed	PI Reg	Output	Comm.	Status	Error	GUI
P-Nom	Mode	Setp Source	Setp Source	Setp Source	Relay1 Mode	RS485	U-rms	Error-log	Backlight Time
U-Nom	Acceleration	Fix Frq 1	Fix Spd 1	Fix Reg 1	Relay1 Freq	USBPort	I-rms	Restart Delay	User Level
f-Nom	Deceleration	Fix Frq 2	Fix Spd 2	Fix Reg 2	Relay2 Mode	Fieldbus	P-out	Trip Time	Pwd Lvl 3
N-Nom	PwrOn Delay	Fix Frq 3	Fix Spd 3	Fix Reg 3	Relay2 Freq	Auto Reset	PF	AC Fail	Pwd Lvl 2
I-Nom	DC-Brake	Fix Frq 4	Fix Spd 4	Fix Reg 4	Aout1 Mode		DC Link	Temp Hi	Pwd Lvl 1
cos φ	Ain Set	Fix Frq 5	Fix Spd 5	Fix Reg 5	Max Aout1		Inv Status	PTC Temp	
Tuning	Auto Start	Fix Frq 6	Fix Spd 6	Fix Reg 6	Aout2 Mode		Frq Set	Overload	
R-stator	Stop Mode	Fix Frq 7	Fix Spd 7	Fix Reg 7	Max Aout2		Frq Act	Ain Fail	
R-rotor	Energy Save	Min Ain Frq	Min Ain Spd	Set Min			Spd Set	DC Low	
L-main	Kp-Speed	Max Ain Frq	Max Ain Spd	Set Max			Spd Act	DC High	
Sigma	Ti-Speed			Act Min			Trq Set	GND Fail	
I-Magn	Frq Sleep			Act Max			Trq Act	Short Circuit	
I-Limit	Bypass Frq			Ain Act			Reg Set	I-Magn Low	
	Bypass BW			Reg Amp			Reg Act	Current Low	
				Reg Kp			M-temp	Current High	
				Reg Ti			Op Time	Run Fail	
				Unit			Run Time		
				Sense Unit			Break Time		
				Sense Min1					
				Sense Max1					
				Sense Min2					
				Sense Max2					

Table 9. Parameter groups and parameters.

Only the parameter groups for the control mode selected are displayed, i.e. either *Freque or Speed*.

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

Name	Description	Section	Default value	Range	Type [1]
Motor					
P-Nom	Nominal motor output		Table 11	0.01 – 100kW	Init
U-Nom	Nominal motor voltage			1 – 1000V	Init
f-Nom	Nominal motor frequency			1 – 500Hz	Init
N-Nom	Nominal motor speed			5 – f-Nom * 60rpm	Init
I-Nom	Nominal motor current			Table 11	Init
cos φ	Motor cos φ			0.01 – 1.00	Init
Tuning	Autotuning command				Init
R-stator	Motor stator resistance				Init
R-rotor	Motor rotor resistance				Init
L-main	Motor main inductance				Init
Sigma	Motor leak inductance			0,001-1,000	Init
I-Magn	Magnetisation current setpoint (RMS)			0 – min (I-nom, I-Limit)	Init
I-Limit	Maximum motor current (RMS)				Init/Run
Control					
Mode	Control mode *Freque* = speed control with frequency estimation *Speed* = rpm control with speed estimation	5.7.1 5.8 5.9	*Freque*	*Freque* *Speed*	Init
Acceleration	Acceleration time from 0 to f-Nom Hz	5.7.2	15.0 s [2]	0.5 - 500.0 s	Init/Run
Deceleration	Deceleration time from f-Nom to 0 Hz	5.7.2	15.0 s [2]	0.5 - 500.0 s	Init/Run
PwrOn Delay	Start delay, seconds Delay from when power is applied until motor can start.	5.7.3	4 s	4 – 3600 s	Init/Run
DC-Brake	Motor DC braking before start-up. Time in seconds for which motor is braked before start-up.	5.7.5	0 s	0 – 3600 s	Init/Run
Ain Set	Type of input used for analog setpoint.		*0-10V*	*0-10V* *2-10V* *+/-10V* *Pot* *0-20mA* *4-20mA* *+/-20mA*	
Auto Start	Autostart mode *OFF* = Inverter awaits transition on RUN after power applied. *ON* = motor starts as soon as power is applied if RUN is active. ⚠ WARNING: If Autostart=ON and RUN signal active, the inverter will start when power is applied.	5.7.6	*OFF*	*OFF* *ON*	Init/Run
Stop Mode	Stop mode *Ramp* = motor brakes as *Deceleration*. *Coast* = motor is released.	5.7.7	*Ramp*	*Ramp* *Coast*	Init/Run
Energy Save	Energy save function *OFF* = Function is disabled. *ON* = Inverter optimizing energy consumption of the motor.		*OFF*	*OFF* *ON*	Init/Run
Kp-speed	Amplifier component speed regulator	5.7.8	1,00 [2]	0,1 – 10,00	Init/Run
Ti-speed	Integrator component speed regulator	5.7.8	1,00 [2]	0,1 – 10,00 s	Init/Run
Frq Sleep	Frequency sleep setting	5.7.9	0.0 Hz	0.0-150.0 Hz	Init/Run
Bypass Frq	Bypass frequency	5.7.10	0.0 Hz	0.0-150.0 Hz	Init/Run
Bypass BW	Bypass frequency bandwidth	5.7.10	0.0 Hz	0.0-150.0 Hz	Init/Run
Freque					
Setp Source	Setpoint source, frequency	5.8.1	*Terminal*	Table 12	Init/Run
Fix Frq 1	Fixed frequency 1	5.8.2	10.0 Hz	0.0-150.0 Hz	Init/Run
Fix Frq 2	Fixed frequency 2	5.8.2	20.0 Hz	0.0-150.0 Hz	Init/Run
Fix Frq 3	Fixed frequency 3	5.8.2	30.0 Hz	0.0-150.0 Hz	Init/Run
Fix Frq 4	Fixed frequency 4	5.8.2	40.0 Hz	0.0-150.0 Hz	Init/Run
Fix Frq 5	Fixed frequency 5	5.8.2	50.0 Hz	0.0-150.0 Hz	Init/Run
Fix Frq 6	Fixed frequency 6	5.8.2	60.0 Hz	0.0-150.0 Hz	Init/Run
Fix Frq 7	Fixed frequency 7	5.8.2	70.0 Hz	0.0-150.0 Hz	Init/Run
Min Ain Frq	Lowest frequency when running with analogue setpoint.	5.8.3	0.0 Hz	0.0-150.0 Hz	Init/Run
Max Ain Frq	Highest frequency when running with analogue setpoint.	5.8.3	50.0 Hz	0.0-150.0 Hz	Init/Run
Speed					
Setp Source	Setpoint source, speed	5.9.1	*Terminal*	Table 13	Init/Run
Fix Spd 1	Fixed speed 1	5.9.2	300 rpm	0-9000 rpm	Init/Run
Fix Spd 2	Fixed speed 2	5.9.2	600 rpm	0-9000 rpm	Init/Run
Fix Spd 3	Fixed speed 3	5.9.2	900 rpm	0-9000 rpm	Init/Run
Fix Spd 4	Fixed speed 4	5.9.2	1200 rpm	0-9000 rpm	Init/Run
Fix Spd 5	Fixed speed 5	5.9.2	1500 rpm	0-9000 rpm	Init/Run
Fix Spd 6	Fixed speed 6	5.9.2	1800 rpm	0-9000 rpm	Init/Run
Fix Spd 7	Fixed speed 7	5.9.2	2100 rpm	0-9000 rpm	Init/Run
Min Ain Spd	Lowest speed when running with analogue setpoint.	5.9.3	0 rpm	0-9000 rpm	Init/Run
Max Ain Spd	Highest speed when running with analogue setpoint.	5.9.3	1500 rpm	0-9000 rpm	Init/Run

Pi Reg					
Setp Source	Setpoint source, PI regulator	5.10.1	*Terminal*	Table 16	Init/Run
Fix Reg 1	Fixed setpoint 1	5.10.1		-2000.0 - 2000.0	Init/Run
Fix Reg 2	Fixed setpoint 2	5.10.1		-2000.0 - 2000.0	Init/Run
Fix Reg 3	Fixed setpoint 3	5.10.1		-2000.0 - 2000.0	Init/Run
Fix Reg 4	Fixed setpoint 4	5.10.1		-2000.0 - 2000.0	Init/Run
Fix Reg 5	Fixed setpoint 5	5.10.1		-2000.0 - 2000.0	Init/Run
Fix Reg 6	Fixed setpoint 6	5.10.1		-2000.0 - 2000.0	Init/Run
Fix Reg 7	Fixed setpoint 7	5.10.1		-2000.0 - 2000.0	Init/Run
Set Min	Value at min. input signal from setpoint input	5.10			Init/Run
Set Max	Value at max. input signal from setpoint input	5.10			Init/Run
Act Min	Value at min. input signal from actual value input	5.10			Init/Run
Act Max	Value at max. input signal from actual value input	5.10			Init/Run
Ain Act	Type and range, actual value input	5.10	0-10V	Table 15	Init/Run
Reg Amp	Amplifies process regulator	5.10.4	+1	+1 or -1	Init/Run
Reg Kp	Proportional component process regulator	5.10.4		0.00 – 1.00	Init/Run
Reg Ti	Integrator component process regulator	5.10.4	30.0 s	1.0 – 200.0 s	Init/Run
Unit	Regulator units	5.10		Table 14	Init/Run
Sense Unit	Sensor units			Table 14	Init/Run
Sense Min1	Value at min. input signal from sensor				Init/Run
Sense Max1	Value at max. input signal from sensor				Init/Run
Sense Min2	Sensor input value at *Set Min*				Init/Run
Sense Max2	Sensor input value at *Set Max*				Init/Run
Output					
Relay1 Mode	Function relay 1 function *Disable* = Function disabled *Alarm* = Alarm in inverter *Running* = Motor running *Run Fwd* = Motor running forwards *Run Rev* = Motor running reverse *Run Setp* = Motor frequency has reached setpoint *Run Freq* = Motor frequency > *Relay1 Freq*	5.12.1	*Running*	*Disable* *Alarm* *Running* *Run Fwd* *Run Rev* *Run Setp* *Run Freq*	Init/Run
Relay1 Freq	*Run Freq1* frequency threshold (see above)	5.12.1	50.0 Hz	0,0 – 150.0 Hz	Init/Run
Relay2 Mode	Function relay 2 function *Disable* = Function disabled *Alarm* = Alarm in inverter *Running* = Motor running *Run Fwd* = Motor running forwards *Run Rev* = Motor running reverse *Run Setp* = Motor frequency has reached setpoint *Run Freq* = Motor frequency > *Relay2 Freq*	5.12.2	*Running*	*Disable* *Alarm* *Running* *Run Fwd* *Run Rev* *Run Setp* *Run Freq*	Init/Run
Relay2 Freq	*Run Freq2* frequency threshold (see above)	5.12.2	50.0 Hz	0,0 – 150.0 Hz	Init/Run
Aout1 Mode	Analogue output 1 *Disable* = Function disabled *Freque* = Current electrical frequency *Speed* = Current rotor speed *Torque* = Current torque *Irms* = Motor current	5.12.4	*Disable*	*Disable* *Freque* *Speed* *Torque* *Irms*	Init/Run
Max Aout1	Scale factor for analogue output 1	5.12.4	*10.00V*	0 - 10.00 V	Init/Run
Aout2 Mode	Analogue output 2 *Disable* = Function disabled *Freque* = Current electrical frequency *Speed* = Current rotor speed *Torque* = Current torque *Irms* = Motor current	5.12.5	*Disable*	*Disable* *Freque* *Speed* *Torque* *Irms*	Init/Run
Max Aout2	Scale factor for analogue output 2	5.12.5	*10.00V*	0 - 10.00 V	Init/Run
Communication					
RS485	RS485 settings *Bus Type* *Address* *Baud rate* *Char Code – data bit, parity bit & stop bit.* *Timeout* *Auto Stop* *Failsafe*			*Bus Type* *Address* *Baud rate* *Char Code* *Timeout* *Auto Stop* *Failsafe*	Init
USB Port	USB port settings *Bus Type* *Address* *Timeout* *Auto Stop*			*Bus Type* *Address* *Timeout* *Auto Stop*	Init
Fieldbus	Fieldbus settings *Bus Type* *Address* *Timeout* *Auto Stop*			*Bus Type* *Address* *Timeout* *Auto Stop*	Init

Auto Reset	Auto update of Communication parameters. No restart needed after changing these parameters.		*OFF*	*OFF* *ON*	Init
Status					
U-rms	Motor voltage (RMS)		V		Read
I-rms	Motor current (RMS)		A		Read
P-out	Active power output		W		Read
PF	Output power factor				Read
DC Link	DC Link voltage		V		Read
Inv Status	Inverter status				
Frq Set	Frequency setpoint (*Freque* mode)		Hz		Read
Frq Act	Electrical frequency actual value (*Freque* mode)		Hz		Read
Spd Set	Speed setpoint (*Speed* mode)		rpm		Read
Spd Act	Rotor speed (estimated actual value, *Speed* mode)		rpm		Read
Trq Set	Torque setpoint (*Torque* mode)		Nm		Read
Trq Act	Torque (estimated actual value, *Torque* mode)		Nm		Read
Reg Set	Setpoint process regulator		As per parameter *Unit*		Read
Reg Act	Actual value process regulator		As per parameter *Unit*		Read
M-temp	Estimated relative motor temp.	5.11.2	%		Read
Op time	Total time inverter has been live		0.1 hours		Read
Run time	Total time motor has been running		0.1 hours		Read
Brake Time	Total time brake chopper has been active		1 Sec		Read
Error					
Error-log	Fault log	5.14			Read
Restart Delay	Time from when fault disappears to restart	5.14	10 sec	0 – 3600 sec	Init/Run
Trip Time	Time inverter must run fault free to reset counter	5.14	600 sec	0 – 3600 sec	Init/Run
AC Fail	Phase error	5.14.2			
Temp Hi	Heatsink overheating	5.14.2			
PTC Temp	Motor overheating.	5.14.2			
Overload	Electronic motor overload protection	5.11.2			
Ain Fail	Analogue setpoint input signal out of range	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 Circuit					
IMagn Low					
Current Low					
Current High					
Run Fail	Rotor locked, start failure	5.14.2			

Table 10. Parameters available, sorted by parameter group

Notes:

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

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

5.6 Autotuning and motor parameters

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

Before running autotuning, the nominal motor data has to be entered. It consists of parameters *P-nom, U-Nom, f-Nom, N-Nom, I-Nom* and *cos* φ. These are shown on the motor plate and must be entered according to the connection used; i.e. Y (star) or D (delta), including any possible 50 / 60Hz option for the motor. The basic nominal data settings as supplied are shown in Table 11.

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

When the motor data are entered and saved, run the *Tuning* command. In the user interface, this command is located immediately succeeding the motor data section. Press [Enter] to go into the Tuning menu group, press [⇑] (arrow up) to select Full Tuning option, and again press [Enter] to start the tuning procedure. After a completed tuning, the motor parameters are recorded and saved in the inverter. Depending on the motor size, this procedure should take about one minute. When tuning is ready, press [Escape] to exit the tuning command and return to the main display.

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

5.6.1 Full tuning

To perform autotuning:

1. Check that motor is not running (press stop).
2. Go to parameter-group *Motor* and enter parameters *P-nom U-Nom, f-Nom, N-Nom, I-Nom* and *cos* φ.
3. Start the autotuning by selecting the *Tuning* command and pressing  .
4. When asked *Full,* press  (any other button will not execute the command).
5. On successful tuning, the screen will show *Ready*.
6. Continue programming the other inverter parameters, if required.

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

Faults may be due to:

- Motor not connected correctly (short or open circuit in wiring).
- Motor fault (short or open circuit).
- Motor incorrectly connected (Y-connected instead of D-connected or vice versa).
- The inverter is under or over dimensioned for the connected motor.

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

5.6.2 Basic tuning

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

5.6.3 Calculated tuning

If the stator resistance for the motor is known, the other parameters can be calculated. This can be done by entering the known value of *R*-stat in point 2 above, and then pressing  three times in point 3. The display will now show *Calc*, press  to run calculations.

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

5.6.4 Selection of tuning method

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

5.6.5 Default motor data

P-Nom	U-Nom	f-Nom	N-Nom	I-Nom	cos φ	R-stat	R-rot	L-main	Sigma	I-magn	I-limit
2.20 kW	400 V	50 Hz	1455 rpm	4.65 A	0,78	2.50 Ω	1.50 Ω	350 mH	0.085	2.00 A	5.58 A

Table 11. Default nominal motor data and motor parameters

Table 11 show default value settings for nominal data and motor parameters. Please note that these parameters cannot be measured from the motor terminal.

5.6.6 Motors in parallel

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

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

5.7 Setting control parameters

5.7.1 Control mode, parameter *Mode*

NFO Sinus can control induction motors in two different control modes: frequency without speed estimation (*Freque*), rpm with speed estimation (*Speed*).

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

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

5.7.2 Acceleration and retardation ramp, *Acceleration* and *Deceleration*

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

t_{Accel} = *f-Nom* * Acceleration time desired / frequency change
t_{Decel} = *f-Nom* * Deceleration 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_{Decel} = 50 * 9 / 75 = 6.00 s

Remember:

- The inverter cannot accelerate faster than its maximum torque allows. An acceleration time set too low leads to the inverter limiting current which gives an extended acceleration time.
- In generative operation, the inverter cannot brake harder than it can handle the motor's surplus energy. When used, the brake chopper can help handle the surplus energy, but setting the retardation time too low may cause the brake chopper circuit to become overloaded.

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

5.7.3 *Power On Delay*

PowerOn Delay sets the time from inverter is powered until it accepts a start command. *PowerOn Delay* can be useful to handle short time power failures (interrupts) when operating with large inertial torque, such as a fan rotor. Set parameter to the time it takes for the motor to stop running from the maximum possible operating frequency.

5.7.4 Analog setpoint input type, parameter *AinSet*

Selects input type and range for the analog setpoint input Ain1 whenever analog setpoint is selected in parameter *Setp Src* for actual control mode. Possible settings {0-10V, 2-10V, +/-10V, 0-20mA, 4-20mA, +/-20mA, Potentiometer. Connection of the analog input signals and the potentiometer are described in section 4.1.4 and 4.1.7 above.

5.7.5 Motor brake, *DC-Brake*

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

5.7.6 Autostart

With *AutoStart* parameter =*ON*, the motor will start as soon as power is applied, provided the digital input signal RUN at the terminal (DIN1) is active. This parameter also controls whether the inverter will attempt to restart after a fault, see section 5.14.

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

⚠ **WARNING: use the Auto Start 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.**

5.7.7 Stop mode, *Stop Mode*

The NFO Sinus has two different stop modes, *Ramp* and *Coast*.

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

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

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

5.7.8 Energy save function, *Energy Save*

The energy save function optimizes the energy consumption of the motor by lowering the magnetizing current at low loads. It is mainly used for applications at low loads i.e. fans that sometimes run at very low speeds. The magnetizing current is at maximum lowered to 25% of I-magn. The time for the function to adjust optimal magnetizing current is approx. 5s at a change in setpoint or load. Thanks to this, the function should only be used in application not requiring high dynamics.

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

5.7.9 Frequency sleep setting, *Frq Sleep*

This function is to minimize power consumption when running motor at 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 – (*Frq Sleep* + 0.5Hz). This setting applies to all modes (*Freque* and *Speed*).

The default value of 0.0Hz disables this function.

Example: Fan application regulated by a temperature setpoint.

Frq Sleep = 5.0Hz

The motor runs at 30Hz. When a drop in temperature below actual setpoint, the inverter's setpoint updates to 4.0Hz. The inverter will now slow the motor down according to retardation ramp until 5Hz where it will release the motor. The inverter will not start the motor again until setpoint is set above 5.5 Hz.

5.7.10 Frequency bypass, *Bypass-fr* and *Bypass-BW*

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

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

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

Example: Acceleration from 0 to 50 Hz

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

This gives a setspeed curve as shown in Fig. 11.

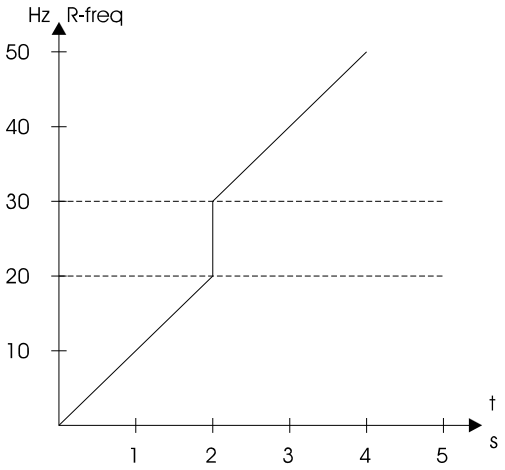


Fig. 11. Acceleration with frequency bypass

5.7.11 Acceleration with frequency bypass Speed regulator, *Kp-speed* and *Ti-speed*

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*) at all times and under all loads (up to maximum torque). The regulator performance can be set via parameters *Kp-speed* and *Ti-speed* if required. The proportional amplification (*Kp-speed*) handles fast control inputs changes (rapid changes in speed), while the I amplifier (*Ti-speed*) is responsible for fine-tuning the final speed.

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

- First, set the regulator so it works more or less purely as a P-regulator. This is done by setting the maximum time (*Ti-speed*) for the integrator amplification.
- Start motor at low P amplification (*Kp-speed*). Increase the P amplification carefully until its control becomes unstable and/or shows a tendency to over-react to control signals (indicated by a rotor speed overrun after a setspeed 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 achieve the specified speed (setspeed). Reduce the integration time (*Ti-speed*) 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 speed oscillations.

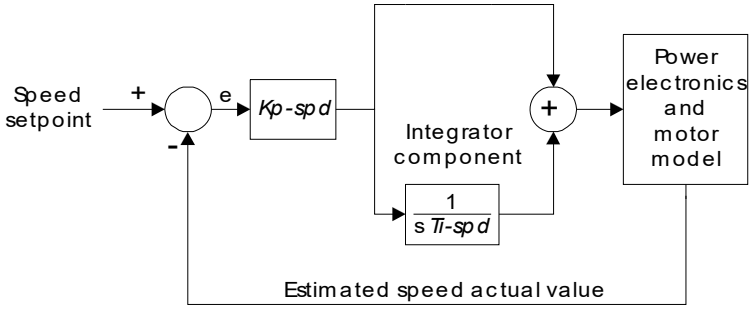


Fig. 12. Speed regulator

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

5.8 Frequency control without load compensation, *Freque* mode

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

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

5.8.1 Setpoint source for frequency, *Setp Source*

Frequency setpoint source is selected by the parameter *Setp Source*, which values are as shown in Table 12.

Setp Source	Frequency setpoint source
Terminal	Any of alternatives below, selected from terminal as in table 7
Analog F	Analogue input, clockwise.
Analog R	Analogue input, counter-clockwise.
Fix-1 F	Frequency from parameter Fix Frq 1, clockwise.
Fix-2 F	Frequency from parameter Fix Frq 2, clockwise.
Fix-3 F	Frequency from parameter Fix Frq 3, clockwise.
Fix-4 F	Frequency from parameter Fix Frq 4, clockwise.
Fix-5 F	Frequency from parameter Fix Frq 5, clockwise.
Fix-6 F	Frequency from parameter Fix Frq 6, clockwise.
Fix-7 F	Frequency from parameter Fix Frq 7, clockwise.
Fix-1 R	Frequency from parameter Fix Frq 1, counter-clockwise.
Fix-2 R	Frequency from parameter Fix Frq 2, counter-clockwise.
Fix-3 R	Frequency from parameter Fix Frq 3, counter-clockwise.
Fix-4 R	Frequency from parameter Fix Frq 4, counter-clockwise.
Fix-5 R	Frequency from parameter Fix Frq 5, counter-clockwise.
Fix-6 R	Frequency from parameter Fix Frq 6, counter-clockwise.
Fix-7 R	Frequency from parameter Fix Frq 7, counter-clockwise.
PI Reg	PI regulation with feedback, see 5.10

Table 12*. Freque/Setp Source* parameter settings.

5.8.2 Fixed frequency setpoints, *Fix Frq 1 - Fix Frq 7*

There are seven fixed frequency setpoint parameters; *Fix Frq 1 - Fix Frq 7*. These are set between 0.0 - 150.0 Hz.

5.8.3 Analogue frequency setpoint range, *Min Ain Frq* and *Max Ain Frq*

Under frequency regulation, parameters *Min Ain Frq* and *Max Ain Frq* indicate the frequency range in which the inverter is to operate when an analogue input is designated as setpoint source. The terminal and scaling to be used are set using parameter *Ain Set*, see Table 8. *Max Ain Frq* applies at maximum analogue input signal and *Min Ain Frq* at minimum input signal. The settings apply for either rotation direction (CW, CCW).

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

5.9 RPM regulation with speed estimation, *Speed* mode

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

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

5.9.1 Setpoint source for speed, *Setp Source*

Speed setpoint source is selected by the parameter *Setp Source*, which values are as shown in Table 13.

Setp Source	Frequency setpoint source
Terminal	Any of the alternatives below, selected from terminal as in Table 7
Analog F	Analogue input, clockwise.
Analog R	Analogue input, counter-clockwise.
Fix-1 F	Speed from parameter Fix Spd 1, clockwise.
Fix-2 F	Speed from parameter Fix Spd 2, clockwise.
Fix-3 F	Speed from parameter Fix Spd 3, clockwise.
Fix-4 F	Speed from parameter Fix Spd 4, clockwise.
Fix-5 F	Speed from parameter Fix Spd 5, clockwise.
Fix-6 F	Speed from parameter Fix Spd 6, clockwise.
Fix-7 F	Speed from parameter Fix Spd 7, clockwise.
Fix-1 R	Speed from parameter Fix Spd 1, counter-clockwise.
Fix-2 R	Speed from parameter Fix Spd 2, counter-clockwise.
Fix-3 R	Speed from parameter Fix Spd 3, counter-clockwise.
Fix-4 R	Speed from parameter Fix Spd 4, counter-clockwise.
Fix-5 R	Speed from parameter Fix Spd 5, counter-clockwise.
Fix-6 R	Speed from parameter Fix Spd 6, counter-clockwise.
Fix-7 R	Speed from parameter Fix Spd 7, counter-clockwise.
PI Reg	PI regulation with feedback, see 5.10

Table 13. *Speed/Setp Source* parameter settings

5.9.2 Fixed speed setpoints, *Fix Spd 1* - *Fix Spd 7*

There are seven fixed speed setpoint parameters, *Fix Spd 1* - *Fix Spd 7*. These are set between 0 - 9000rpm. However, the maximum speed is governed by the motor type and is set at three times the motor's nominal frequency up to a maximum of 150Hz. Thus a 4-pole motor with nominal frequency of 50Hz can have a maximum of 4500rpm.

5.9.3 Analogue speed setpoint range, *Min Ain Spd* and *Max Ain Spd*

Parameters *Min Ain Spd* and *Max Ain Spd* indicate the RPM range in which the inverter is to work when an analogue input is designated as setpoint source. The terminal and scaling to be used are indicated by the parameter *Ain Set*, see Table 8. *Max Ain Spd* applies at maximum analogue input signal and *Min Ain Spd* at minimum input signal. The settings apply for either rotation direction (CW, CCW).

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

5.10 Process regulation, PI regulator

The inverter is equipped with a PI regulator used for process regulation with an external actual value (sensor signal) according to a selected setpoint value. The regulator can be used in both control modes *Frequency* and *Speed*. The regulator is enabled by either setting the *Setp Source* parameter to *PI Reg* in the control mode used, or setting the correct digital input combination at the terminal if *Terminal* is chosen in *Setp Source*.

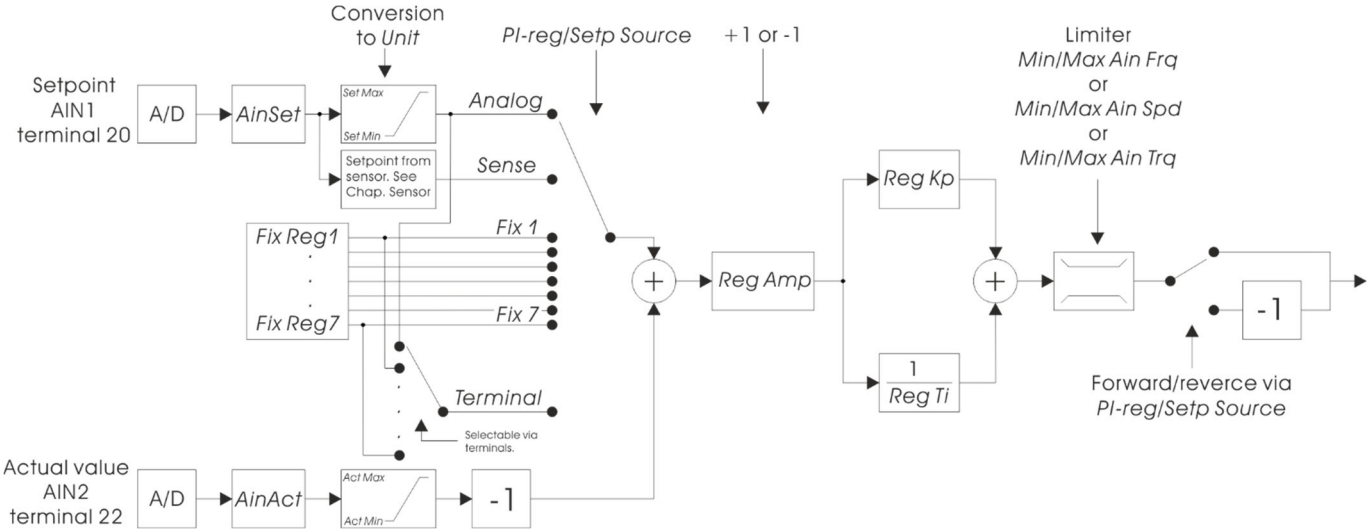


Fig. 13. Process regulator in outline

The process regulator unit is selected using the parameter *Unit* (both setpoint and actual value), see Table 14. Whatever setpoint source is used, the regulator's actual value is always taken from the analogue input AIN2 at terminal 22. The scaling of the actual value is governed by the parameter *Ain Act*, see Table 15. Parameters *Act Min* and *Act Max* 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 setpoint (frequency or speed) in the range limited by parameters *Min Ain Frq* and *Max Ain Frq, Min Ain Spd* and *Max Ain Spd or* depending on the control mode chosen.

Both AIN1 and AIN2 can be configured for voltage or current input individually, see 4.1.4, Table 8 and Table 15. The regulator's sampling rate is 10 samples per second.

Parameter *Unit* and *Sense Unit* settings
Pa, kPa, bar, rpm,
m^3/s, l/s, m^3/h, l/h,
ppm, %, V, Hz,
Nm, m, W, A,
Ω, H, s, rad/s
˚C, h, Wh, - (no unit)

Table 14 Process regulator units

Parameter *AinAct* settings	Analogue value	Input (terminal) and jumper setting
0-10V	Voltage 0-10V	22 (J703 at “U” position)
2-10V	Voltage 2-10V	22 (J703 at “U” position)
+/-10V	Voltage +/- 10V	22 (J703 at “U” position)
0-20mA	Current 0-20mA	22 and 23 (J703 at “I” position)
4-20mA	Current 4-20mA	22 and 23 (J703 at “I” position)
+/-20mA	Current +/-20mA	22 and 23 (J703 at “I” position)

Table 15 Actual value input setting options

5.10.1 Setpoint source, *Setp Source* process regulation

The regulator setpoint source is governed by the parameter *Setp Source*, the possible values of which are shown in Table 16. If analogue input is selected (AIN1), it is scaled as shown in Table 8 (input type and range). All parameter units are governed by parameter *Unit*. Parameters *Set Min* and *Set Max* govern the maximum and minimum input signal from the setpoint input corresponding to the unit selected.

Setp Source	Source of regulator setpoint
Terminal	Any of the alternatives below, selected from terminal as in Table 17.
Analog F	Analogue input, clockwise.
Analog R	Analogue input, counter-clockwise.
Fix-1 F	Setpoint from parameter Fix Reg 1, clockwise.
Fix-2 F	Setpoint from parameter Fix Reg 2, clockwise.
Fix-3 F	Setpoint from parameter Fix Reg 3, clockwise.
Fix-4 F	Setpoint from parameter Fix Reg 4, clockwise.
Fix-5 F	Setpoint from parameter Fix Reg 5, clockwise.
Fix-6 F	Setpoint from parameter Fix Reg 6, clockwise.
Fix-7 F	Setpoint from parameter Fix Reg 7, clockwise.
Fix-1 R	Setpoint from parameter Fix Reg 1, counter-clockwise.
Fix-2 R	Setpoint from parameter Fix Reg 2, counter-clockwise.
Fix-3 R	Setpoint from parameter Fix Reg 3, counter-clockwise.
Fix-4 R	Setpoint from parameter Fix Reg 4, counter-clockwise.
Fix-5 R	Setpoint from parameter Fix Reg 5, counter-clockwise.
Fix-6 R	Setpoint from parameter Fix Reg 6, counter-clockwise.
Fix-7 R	Setpoint from parameter Fix Reg 7, counter-clockwise.
Sense F	External sensor, clockwise.
Sense R	External sensor, counter-clockwise.

Table 16. *PI Reg/Setp Source* parameter settings

Function	Run signal	Direction of rotation	Fixed setpoint 1	Fixed setpoint 2	Fixed setpoint 3
Terminal / Function	DIN1 (1)	DIN3 (3)	DIN5 (5)	DIN6 (6)	DIN7 (7)
Analog Forward	1	0	0	0	0
Analog Reverse	1	1	0	0	0
Fix Reg 1 Forward	1	0	1	0	0
Fix Reg 2 Forward	1	0	0	1	0
Fix Reg 3 Forward	1	0	1	1	0
Fix Reg 4 Forward	1	0	0	0	1
Fix Reg 5 Forward	1	0	1	0	1
Fix Reg 6 Forward	1	0	0	1	1
Fix Reg 7 Forward	1	0	1	1	1
Fix Reg 1 Reverse	1	1	1	0	0
Fix Reg 2 Reverse	1	1	0	1	0
Fix Reg 3 Reverse	1	1	1	1	0
Fix Reg 4 Reverse	1	1	0	0	1
Fix Reg 5 Reverse	1	1	1	0	1
Fix Reg 6 Reverse	1	1	0	1	1
Fix Reg 7 Reverse	1	1	1	1	1

Table 17. Functions for *PI Reg/Setp Source* = *Terminal*

5.10.2 Fixed process regulator setpoints, *Fix Reg 1 - Fix Reg 7*

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 Setpoint from sensor

The setpoint source can be chosen from an external sensor connected to AIN1 (Sense F or Sense R Table 16). The sensor signal is rescaled and limited using a linear function between two points. The sensor signal is first scaled to *Sense Unit* with parameters *Sense Min1* and *Sense Max1* govern the maximum and minimum input signal. The setpoint is then converted to *Unit* and scaled as a linear function between two points, *Set Min* and *Sense Min2* gives the first point, *Set Max* and *Sense Max2* gives the second point. Below *Sense Min2* the setpoint is always *Set Min*, above *Sense Max2* the setpoint is always *Set Max*.

To make the function slope negative, make *Sense Min2* greater than *Sense Max2* or *Set Min* greater than *Set Max*.

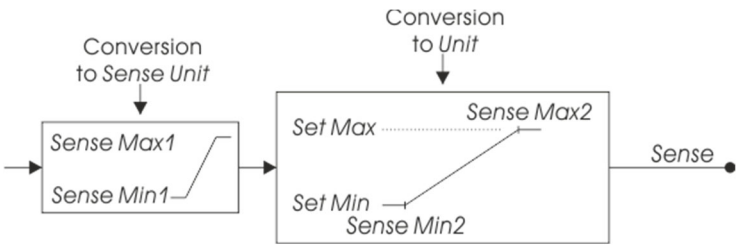


Fig. 14. Settings for Sensor input

5.10.4 Regulator setting, *Reg Amp, Reg Kp* and *Reg Ti*

- The process control error (calculated as setpoint minus actual value) is converted from process regulator unit to the mode chosen (Freque, Speed or Torque) with the factor *Reg Amp * Max Ain xxx / Act Max*, not shown in outline (xxx=Frq, Spd or Trq). *Reg Amp* 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 Ain xxx* is the maximum output signal. *Act Max* is the maximum actual value at the input in process regulator unit.
- The proportional regulator component affects the output signal directly. *Reg Kp* amplifies the proportional regulator component and can be set within the range 0.00 to 1.00. Setting *Reg Kp* = 0 eliminates the proportional component completely, giving a purely integrative regulator.
- The regulator integration time *Reg Ti* 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 Electronic motor overload protection which calculates the motor's approximate winding temperature continuously.

5.11.1 PTC input

If the motor is fitted with PTC thermistor(s) or thermo-contact (Klixon), these can be connected directly to the inverter. This is done between terminal 8 (DIN8) and terminal 11, 12, 30 or 31 (0V) as in Fig.1. Jumper J802 (PTC) must be mounted in position “ON” to enable the function.

If negative logic is selected (jumper J801 moved to the “NEG LOG” position), jumper J802 must be in the “OFF” position and a resistor must be connected according to 4.1.5 Negative Logic.

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

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

5.11.2 Electronic motor overload protection

The electronic motor overload protection functionality uses the motor parameters in parameter group *Motor* as described in this manual 5.6. Therefore, it's essential that these parameters are entered correctly, and that autotuning is performed.

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

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

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

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

The ambient motor temperature is set with parameter *S-Temp* in the range +/-100ºC. The overload protection can be triggered at lower motor loads by specifying a higher ambient temperature than it actually is; or a higher load can be allowed by entering a lower ambient temperature. Default *S-Temp* is +20ºC.

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

The Electronic motor overload protection uses thermal memory retention, which means that the calculated relative temperature of the motor is non-volatile with respect to motor stop/start commands and power cycling (mains power cycling off/on) of the inverter. The thermal memory retention is non-adjustable (power cycling doesn´t reset stored value).

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

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

5.12 Output signals

NFO Sinus units are equipped with outputs to allow monitoring different states and parameters during operation. For the outputs to display correct values, the motor parameters must be set correctly, see section 5.6.

5.12.1 Relay 1 (Alarm relay)

The alternating relay has a number of selectable functions used to indicate certain conditions. The default configuration is to indicate an alarm in the inverter. This relay is located on terminals 13, 14 and 15 (see Fig.1). With selected function active, the relay is activated (contacts 13-14 closed and 14-15 open). Exception: If *Alarm* function is selected, the relay is activated if no alarm condition exists (i.e. if an alarm is present, or if inverter is out of power, the relay deactivated and indicating alarm on contacts 14-15). The relay is galvanically separated from other signals, and can handle 1 A, 50 V_{DC}.

5.12.2 Relay 2 (Run indication)

The alternating relay has a number of selectable functions used to indicate certain conditions. The default configuration is to indicate the motor is running. This relay is located on terminals 16, 17 and 18 (see Fig.1). With selected function active, the relay is activated (contacts 16-17 closed and 17-18 open). The relay is galvanically separated from other signals, and can handle 1 A, 50 V_{DC}.

5.12.3 Relay indication functions

Parameters *Relay 1 Mode* and *Relay 2 Mode* in parameter group *Output*, selects relay function. Possible settings:

- *Disable*, not used.
- *Alarm,* indicates alarm in inverter, see 5.14.
- *Run Freq,* Rotor frequency greater than parameter *Relay2 Freq* ($|$*FrqAct*$|$ > *Relay2 Freq)*.
- *Run Setp*, Rotor frequency has reached its setpoint (*FrqAct* = *FrqSet*).
- *Run Rev,* Motor running, shaft rotating counter-clockwise (*FrqAct* < 0).
- *Run Fwd*, Motor running, shaft rotating clockwise (*FrqAct* > 0).
- *Running,* Motor running (default setting).

5.12.4 Analogue output 1 (voltage and current)

The analogue output can deliver both voltage and current signals, the current output reflects the voltage output. The voltage range is ±10V and the current range ±20mA. Voltage output is at terminal 25 (AOUT1.U) and current output at terminal 24 (AOUT1.I). Both are related to any of the 0V terminals (see Fig.1).

To scale the output, use parameter *Max Aout1* (= current (mA) and/or voltage (V) at nominal actual value). Parameter *Aout1 Mode* in parameter group *Output*, selects output function. Possible settings are:

- *Disable,* not configured (default setting).
- *Freque*, displays inverter's electrical frequency. Output shows voltage/current *Max Aout1* at nominal motor frequency *f-Nom*, –*Max Aout1* at nominal motor frequency –*f-Nom* and 0V (mA) at 0Hz.
- *Speed*, displays the motor speed (estimated actual value, same as parameter *Spd Act*). Output shows voltage/current *Max Aout1* at nominal motor rpm *N-Nom*, –*Max Aout1* at nominal motor rpm –*N-Nom* and 0V (mA) at 0rpm.
- *Torque*, displays motor torque. Output shows voltage/current *Max Aout1* at nominal motor torque.
- *Irms,* displays the motor current. Output shows voltage/current *Max Aout1* at *I-Nom* irrespective of direction of rotation, and 0V (mA) at 0A.

5.12.5 Analogue output 2 (voltage and current)

The output consists of both voltage and current outputs, the current output is a mirror of the voltage output. The voltage range is ±10V and the current range ±10mA. Voltage output is at terminal 27 (AOUT2.U) and current output at terminal 26 (AOUT2.I). Both is related to any of the 0V terminals (see Fig.1).

The output is configured using parameter *Aout2 Mode* in parameter group *Output*. To scale the output, use parameter *Max Aout2*(= current mA and/or voltage (V) at nominal values see below).

Possible values for parameter *Aout2 Mode* in parameter group Output are:

- *Disable,* not configured (default setting).
- *Freque*, displays inverter's electrical frequency. Output shows voltage *Max Aout2* at nominal motor frequency *f-Nom*, –*Max Aout2* at nominal motor frequency –*f-Nom* and 0V at 0Hz.
- *Speed*, displays the motor speed (estimated actual value, same as parameter *SpdAct*). Output shows voltage *Max Aout2* at nominal motor rpm *N-Nom*, –*Max Aout2* at nominal motor rpm –*N-Nom* and 0V at 0rpm.
- *Torque*, displays motor torque. Output shows voltage *V-Max* at nominal motor torque.
- *Irms,* displays the motor current. Output shows voltage *Max Aout2* at *I-Nom* irrespective of direction of rotation, and 0V at 0A.

As the current output (AOUT2.I) reflects the voltage output (AOUT2.U), 10V output voltage always gives 10mA output current, –10V gives -10mA and 0V gives 0mA.

⚠ **If parameter *Ain Set* is set to *Pot,* AOUT2.U will always deliver 10V irrespective of *Aout2 Mode value,* see 4.1.7**.

5.13 Reset to factory settings

The inverter parameters can be reset to the default factory settings using the Sinus Manager (PC/Windows).

5.14 Alarm and fault procedures

During operation the inverter can identify several fault conditions listed in Table 18.

When a fault occurs in the inverter one of four things can happen:

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

The actions for each specific fault can be set individually se section 5.14.2 below.

If parameter *Auto Start* = *ON* and *Fail* is selected for the fault concerned, an attempt will be made to restart the motor after a given time (*Restart Delay*) provided that the cause of the fault has disappeared. The number of restart attempts (*Error Count)* depends on the settings of the fault in question (see Table 18). If more faults than the set *Error Count* occur within time *Trip Time*, no further automatic restart attempts will be made and the fault has to be manually reset. Once a fault has been acknowledged, the inverter can be restarted. Any faults that occur are logged in the *Error log*. Some faults have to persist for a given time (*Delay*) before they generate a fault.

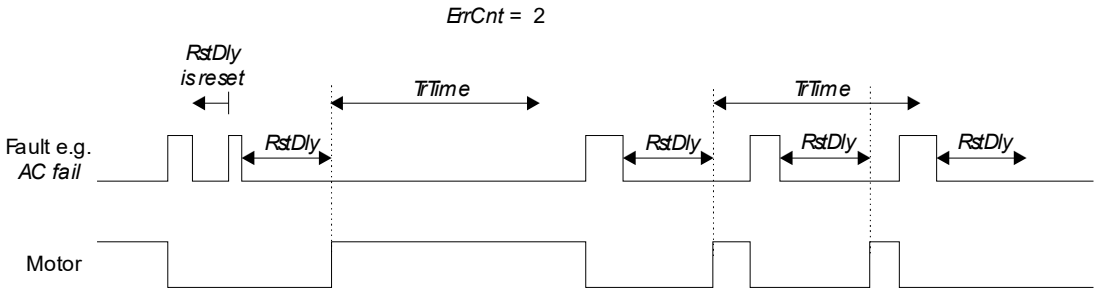


Fig. 15. Typical fault situation

5.14.1 Fault log

The last 30 faults at any time are saved in a non-volatile memory in the inverter. To read the fault log, use parameter *Error-log*. Press ▲ or ▼ to scroll through the fault messages saved. The fault type and when fault occurred relative to the inverter's operation time (*Op Time*) with a resolution of 0.1 hours are shown. If the same fault occurs repeatedly, only the time it last occurred is logged. The fault log can be erased by pressing ENTER for 5 sec while in the *Error-log*.

5.14.2 Fault messages

All fault messages, fault types and other fault parameter setting options are shown in Table 18 below. *Error Count* can be set in the range 0 – 99 for all faults. To configure the parameters for a given fault, find the fault in parameter group *Error* and press ENTER, parameters are changed according to 5.2.

⚠ **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.**

Settings for faults:

Fail: Motor stopped and alarm relay indicates alarm

Alarm: Alarm relay indicates alarm (the motor is not stopped)

Ind: Fault in display only (the motor is not stopped)

Disable: Fault turned off

5.14.3Acknowledge fault

Faults are acknowledged by pressing ENTER.

Fault message	Possible fault types	Default setting: Type of fault	Default setting: Error Count	Fault description, other fault parameters	Source of fault, action
Par Fail	Fail	Fail	–	Parameter(s) on starting up were outside permitted range or reset to factory setting command was given.	All parameters reset to factory settings. Acknowledge the fault and check that all parameter values are correct. Run autotuning.
AC Fail	Fail Alarm Ind Disable	Fail	2	Phase error, loss of supply phase. Delay (*Delay*) Default setting: 10.0s; Range: 0.0 – 25.5s	One supply phase missing, too high phase voltage difference between phases . **NB: inverter may be damaged if fault message is switched off while fault still remains**. Note! If the inverter is running generative (braking loads with high inertia) and the supply is removed or the inverter is fed from the DC bus, the AC Fail alarm will not occur.
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.
PTC Temp	Fail Alarm Ind Disable	Fail	2	If using PTC function, the motor is overheated, thermistor input limit exceeded. See 5.11.1	Let motor cool down.
Overload	Fail Alarm Ind Disable	Fail	2	The electronic motor overload protection has tripped. The motor connected has been overloaded for too long. Forced cooling (*F-Cool*) Default setting: 0; Range: 0 – 10000 Ambient motor temperature (*S-Temp*) Default setting: 20 °C; Range: -100 – 100 °C	Let motor cool down. Adjust settings if necessary (parameters *F-Cool* and *S-Temp*), as in section 5.11.2.
Ain Fail	Fail Alarm Ind Disable	Disable	2	Analogue setpoint input signal outside set range.	Open circuit in signal line to analogue setpoint or *AinSet* not set correctly, see Table 8.
DC Low	Fail	Fail	2	DC link voltage too low.	Power supply too low. Check inverter mains connection.
DC High	Fail	Fail	2	DC link voltage too high	Motor is regenerative with no brake chopper resistance or with resistance sluggish. Retardation time too short. Mains supply too high. Check inverter mains connections.

GND Fail	Fail Alarm Ind Disable	Fail	– (0)	Earth leak current in one or more motor phases too high.	Possible sources of faults depending on motor operating case: 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.
Short C	Fail	Fail	2	Short-circuit between output phases	
I-Magn Low	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 get control of the motor when starting.	Motor rotor is stuck. Motor was turning when started or parameter *R-stat* is set too high. Check motor is not turning when starting. Enable DC brake (section 5.7.5) and/ or start delay (section 5.7.3). Check whether autotuning is done. Operations involving passing the 0 Hz range slowly can generate this fault by mistake. In that case, disable fault by setting fault parameter to *Disable*.
Bus Fail	Fail	Fail	–	Field bus fault	See separate manual
Sio Fail	Fail	Fail	–	Series communication error.	See separate manual
Brake Ch	Ind	Ind	–	Brake chopper on.	Motor in regenerative mode. Excess energy fed to brake chopper resistance. Alarm will disappear once energy reduces.
Cur Limit	Ind	Ind	–	Current limit set has been reached.	Reduce acceleration ramp or check whether parameter I-limit 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 decelerate (retardate) a load with high inertia, energy is fed back to the inverter. This causes the voltage in the DC link (terminals + and -) to rise. To prevent the voltage rising too high and damaging the inverter, a power surge regulator prohibits deceleration (retardation) that generates more energy than the motor can use.

If the inverter does not decelerate the motor fast enough (taking longer time than parameter *Decel*), the regulator is activated. If faster retardation is required, an external brake resistor must be installed to convert the regenerated energy into heat. This resistance is mounted between terminals + and B (see Table 4 and Fig.1).

This resistor must be able to absorb the generated braking energy and therefore must be adapted to the current operating conditions. Recommended resistance for inverters with 3 x 400V power supply is 100 – 300 Ω.

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

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

Size	Min. permitted resistance
2.2kW/400V	100 Ω

Table 19. Minimum permitted resistance for brake resistance

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

If in any doubt regarding how to install this type of 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 *Auto* mode. This mode should be used for all operating cases. The *Manual* 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 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 *Auto* mode should be used (se example 7.2). This is because in case of a power failure the inverter will restart in *Auto* mode and if not configured, the motor will not start.

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

- Install motor and wiring as in section 4.2.4.
- Connect power supply as in section 4.3.3.
- Enter motor name plate data and run autotuning as described in section 5.6.

7.1 Running in *Manual* mode

The procedure below is designed to check that everything is connected correctly and the motor is turning in the right direction.

- Press 

to go to *Manual* mode.
- Set the frequency desired in display window. Use  and  . Positive frequency setpoint means clockwise rotation, negative means counter clockwise.
- The motor is started by pressing 

and stopped by pressing 

.

7.2 Running in Auto mode

7.2.1 Setvalue selection in automode

The source for the setpoint is governed by the parameter *Setp Source* for the control mode concerned (parameters *Freque/Setp Source, Speed/Setp Source or PI-Reg/Setp Source*). If Setp Source is set to *Terminal* (default) the setpoint selection is chosen according to the actual digital input combination of DIN5 – DIN7 according to Table 7. If DIN5 – DIN7 are left open the setpoint is set according to potentiometer setting.

⚠ **The digital inputs (DIN5 – DIN7) are always sampled so a change of the digital input combination (DIN5 – DIN7) will immediately alter the setpoint. Make sure that the digital signals are stable without glitches to avoid sudden setpoint changes.**

7.2.2 Auto mode: Running with fixed frequency

The procedure below is designed to run motor at 25 Hz clockwise. The motor will run as long as the inverter is in *Auto* mode.

- Press  to go to *Manual* mode.
- Press  to enter setup.
- Set parameter *Fix Frq 2* in parameter group *Freque* to 25 Hz.
- Set parameter *Setp Source* in parameter group *Freque* to *Fix2 F*.
- Press  for two seconds and the RUN screen in *Auto* mode is immediately reached (alt. press  several times).
- Connect a jumper between DIN1 (terminal 1, Run signal) and terminal 9 (+24V).
- Press  to go to *Auto* mode and the motor will start.

7.2.3 Auto mode: Running from terminal, fixed setpoint

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

- Connect terminal 5 (DIN5, Fixed frequency 1) and terminal (DIN3, Direction of rotation) to terminal 9 (+24V).
- Set parameter *Fix Frq 1* in parameter group *Freque* to 8 Hz.
- Check that parameter *Setp Source* in parameter group *Freque* is set to *Terminal*.
- Start motor by connecting terminal 1 (DIN1, Run signal)) to terminal 9 (+24V).
- Stop motor by disconnecting terminal 1 and terminal 9.

7.2.4 Auto mode: Running with analogue setpoint

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

- Connect analogue control signal between terminal 20 (AIN1.P) and terminal 21 (AIN1.N).
- Check that parameter *AinSet* in parameter group *Control* is set to *0-10 V*.
- Set parameter *Setp Source* in parameter group *Freque* to *Analog F*.
- Set parameter *Max Ain Frq* in parameter group *Freque* to 40Hz.
- Start motor by connecting terminal 1 (DIN1, Run signal)) to terminal 9 (+24V).
- Stop motor by disconnecting terminal 1 and terminal 9.

7.2.5 Auto mode: Process regulation with fixed setpoint

The procedure below is designed for process regulation with fixed setpoint and feedback signal 0 – 10V using a 0-300 Pa pressure sensor. Control mode *Freque* will be used.

- Set parameter *Setp Source* in parameter group *Freque* to *PI-reg*.
- Connect actual value signal between terminal 22 (AIN2.P) and terminal 23 (AIN2.N).
- 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 *Setp Source* in parameter group *PI-reg* to *Fix1 F*.
- Adjust parameter F*ix Reg1* in parameter group *PI-reg* to desired setpoint value.
- Set max. motor speed using parameter *Max Ain Frq* in parameter group *Freque* to 45 Hz.
- Set the pressure the actual value sensor measures at 0V (0 Pa) using parameter Act Min in parameter group PI-reg.
- Set the pressure the actual value sensor measures at 10V (300 Pa) using parameter Act Max in parameter group PI-reg.
- Set the regulator amplification using parameter Reg Kp in parameter group PI-reg.
- Set regulator integration time using parameter Reg Ti in parameter group PI-reg.

- Start motor by connecting terminal 1 (DIN1, Run signal)) to terminal 9 (+24V). If you are not in Auto mode press 

.
- Stop motor by disconnecting terminal 1 and terminal 9.

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

7.2.6 Auto mode: Process regulation with analogue setpoint

The procedure below is designed for process regulation with analogue setpoint 0 – 10V and feedback signal 0 – 10V using 0-300 Pa pressure sensors. Control mode *Freque* will be used.

- Set parameter *Setp Source* in parameter group *Freque* to *PI-reg*.
- Connect analogue setpoint signal between terminal 20 (AIN1.P) and terminal 21 (AIN1.N).
- Check that parameter *AinSet* in parameter group *Control* is set to *0-10V*.
- Connect actual value signal between terminal 22 (AIN2.P) and terminal 23 (AIN2.N).
- Check that parameter *AinAct* in parameter group *PI-reg* is set to *0-10V*.
- Set parameter *Setp Source* 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 Ain Frq* in parameter group *Freque* 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 *Act Min* in parameter group *PI-reg.*
- Set the pressure the actual value sensor measures at 10V (300 Pa) using parameter *Act Max* 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 1 (DIN1, Run signal)) to terminal 9 (+24V). If you are not in Auto mode press 

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