

Operating and Installation Manual

NFO Sinus Optimal

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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 damage, high earth currents 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 with the inverter.
-  **WARNING!** The heat sink of the inverter may get hot, depending on operating conditions. Do not touch.
-  **WARNING!** Spontaneous start. When controlled from a communication bus or remote unit, the motor may start at any moment. Pressing STOP on the inverter is not sufficient, as bus master or remote unit may regain control over inverter and start motor again. Disconnect run signal at terminal DIN1 to safely inhibit start.
-  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 an infinite time, but it may be detrimental to its life span.
- [3] Apparent output power $S_{r,eq}$ 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 | Profinet, Profibus, Modbus TCP by using AnyBus CompactCom module | | |
| 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:

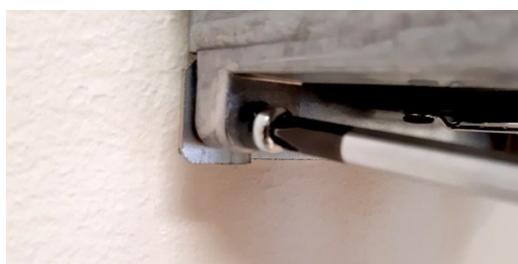
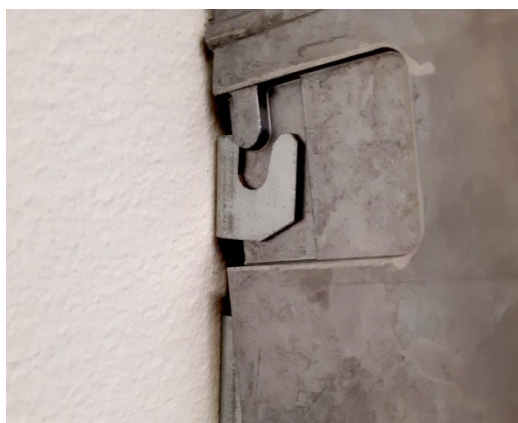
- [1] Compliance guaranteed up to 80% of nominal output power.
- [2] If short circuit should occur, the inverter may get damaged. However, it will prevent damage of connected equipment, fire and other hazards.

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 contact with dangerous voltages.

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

- Connect **mains power** to terminals **L1, L2, L3** and **PE**.
- Connect **motor cable** to terminals **U, V, W** and **PE** using standard unshielded cable.

⚠ 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.

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

⚠ First time powered up, the installer must select application, enter motor name plate data, and perform a motor tuning.

- Connect/install the necessary low voltage signalling that is required for your application, e.g. a run signal for start/stop, analog input for setpoint, communication, etc.

⚠ Make sure run signal is not activated until installer has completed the setup of the inverter.

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

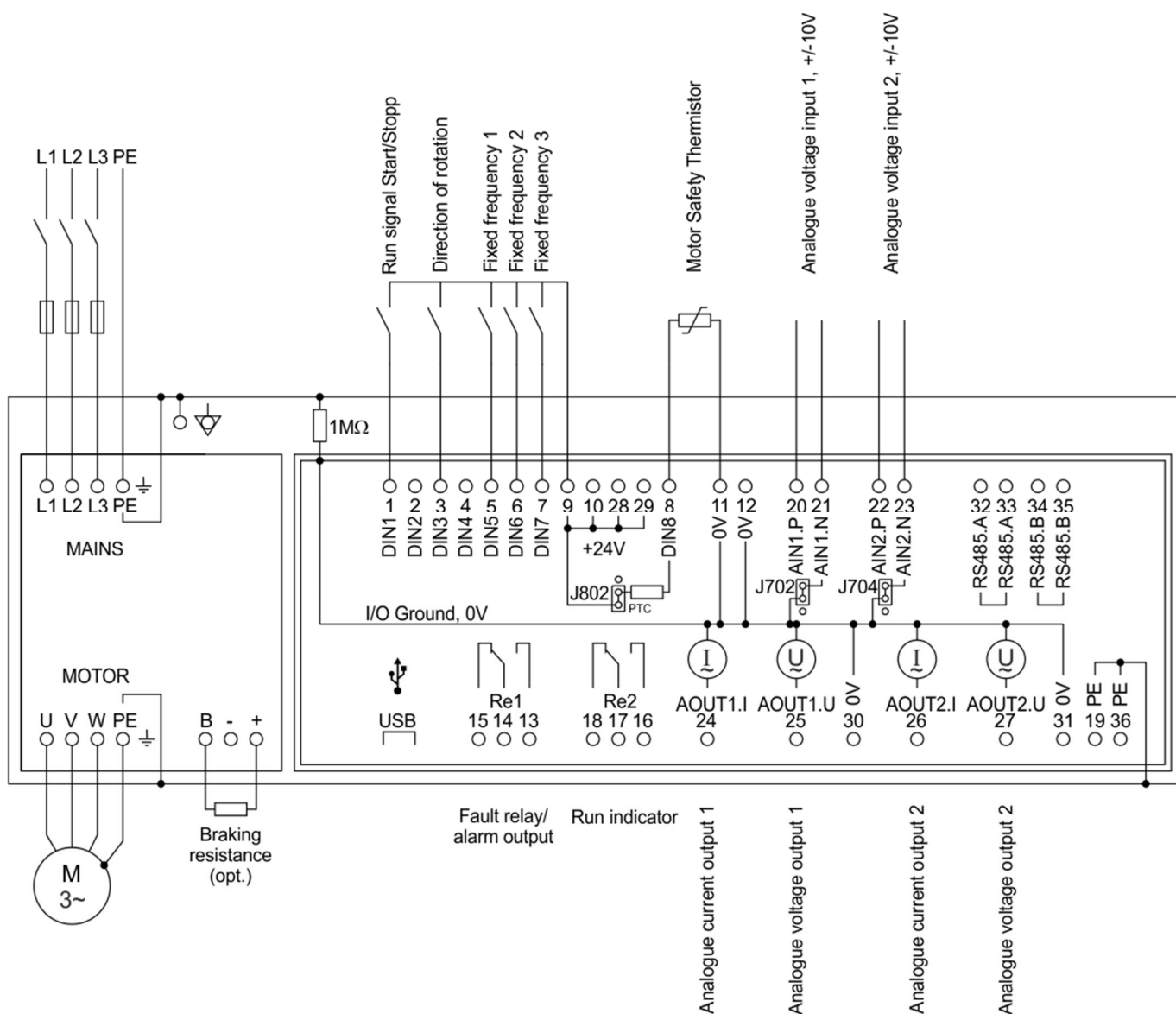


Fig.1. Default configuration

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.

⚠ If a Motor Safety Thermistor is to be used, jumper J802 must be set accordingly, see 5.12.1.

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. The signal cables should be fixed to the PCB with at least two straps.

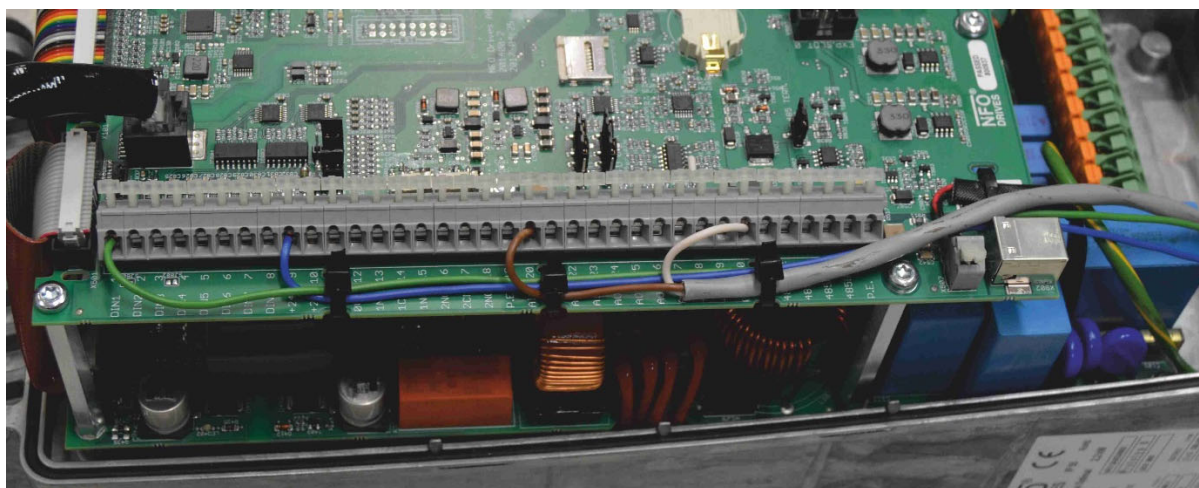


Fig. 1. Signal line wiring.

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

4.1.1 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 | Analog selection |
| 3 | DIN3 | Digital input 3 | Direction of rotation |
| 4 | DIN4 | Digital input 4 | Process regulator activation |
| 5 | DIN5 | Digital input 5 | Select fixed frequency (see Table 7) |
| 6 | DIN6 | Digital input 6 | Select fixed frequency (see Table 7) |
| 7 | DIN7 | Digital input 7 | Select fixed frequency (see Table 7) |
| 8 | DIN8 | Digital input 8 | PTC motor protection |
| 9 | +24V | | +24V max 200mA regulated voltage for digital inputs or external sensors. Short circuit protected. Can 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: $\approx 13V$ (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: $\approx 9V$ (input voltage *lower* than switch level is considered as active level)

Impedance: 10kΩ

4.1.2 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.

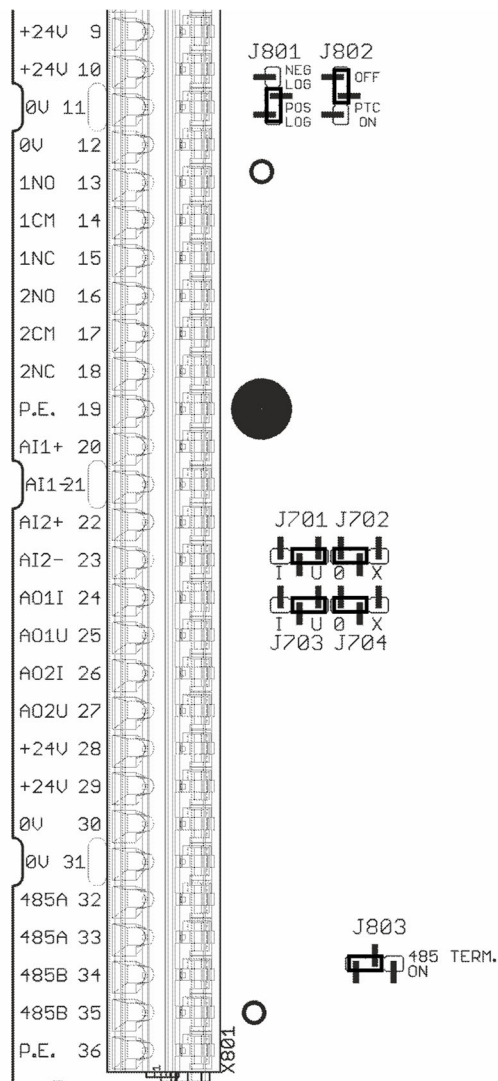


Fig. 2. Jumper placement and default settings

4.1.3 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 $\pm 24V$ 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.

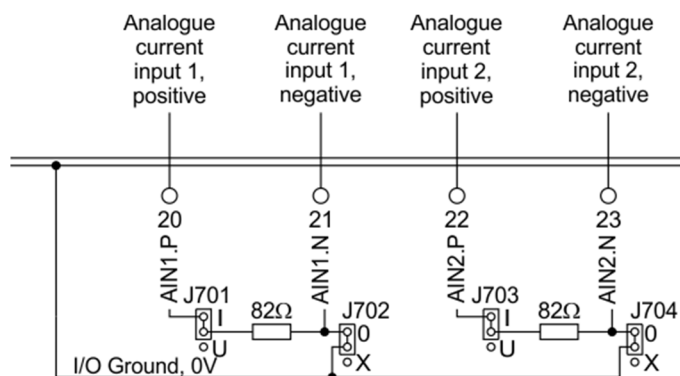


Fig.3. Analogue current input configuration

4.1.4 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.

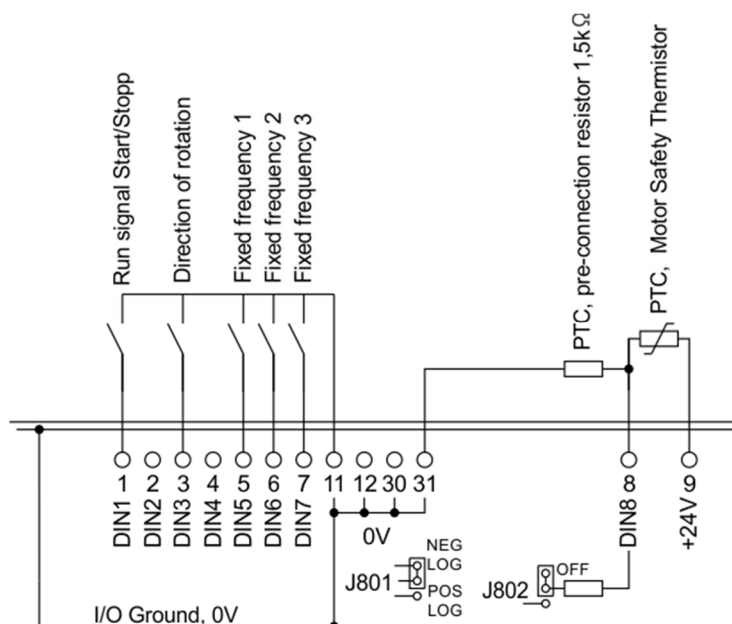


Fig.4. Connection via negative logic (jumper J801 moved)

4.1.5 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”.

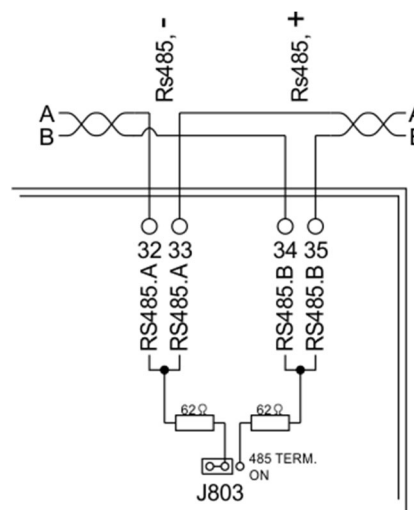


Fig.5. Connection RS485

4.1.6 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.

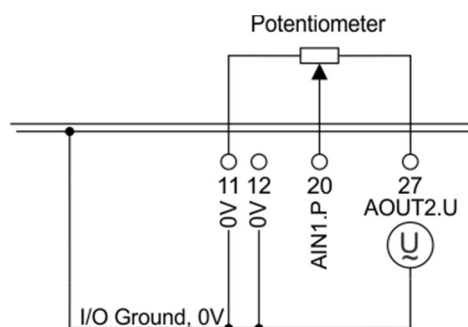


Fig.6. Connecting potentiometer

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 – 6mm² (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:

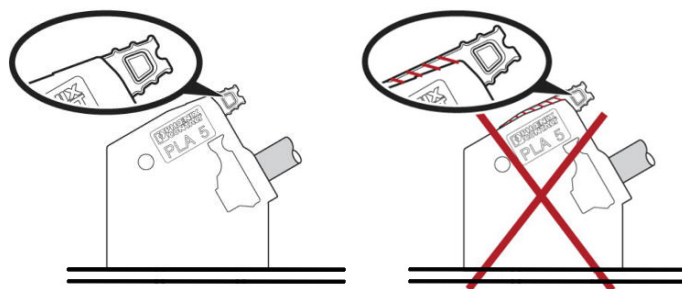


Fig.7. The connection lever of the power terminals

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 – 4.9 A) |
| 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.

-  **Setup of motor parameters and autotuning must always be performed before first motor start.**
-  **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.**
-  **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. The motor's electrical frequency is shown on the display. This is the factory default mode.
- Speed regulation for an induction motor with speed calculation (motor speed compensated for load variations) with a fixed digital or analogue setpoint. The motor's estimated speed is shown in the display.

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.

Setup of motor parameters and motor tuning must always be performed before first motor start.

5.2 Keyboard and display

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



Fig. 8. Keyboard

| Button | Function |
|--------|---|
| | Enter into parameter or parameter-group. Save parameter. |
| | Enter/toggle between normal screen and setup menu tree. Leave parameter, parameter-group or leave parameter unsaved. |
| | Toggle Operating mode between <i>Manual</i> and <i>Auto</i> . Starts motor in <i>Auto</i> mode if Run signal active. |
| | Starts motor in <i>Manual</i> mode. |
| | Stops motor in all modes. NOTE: A bus master may start motor at any time |
| | Increase parameter when changing values. Moves between parameter-groups or parameters. |
| | Decrease parameter when changing values. 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.

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:

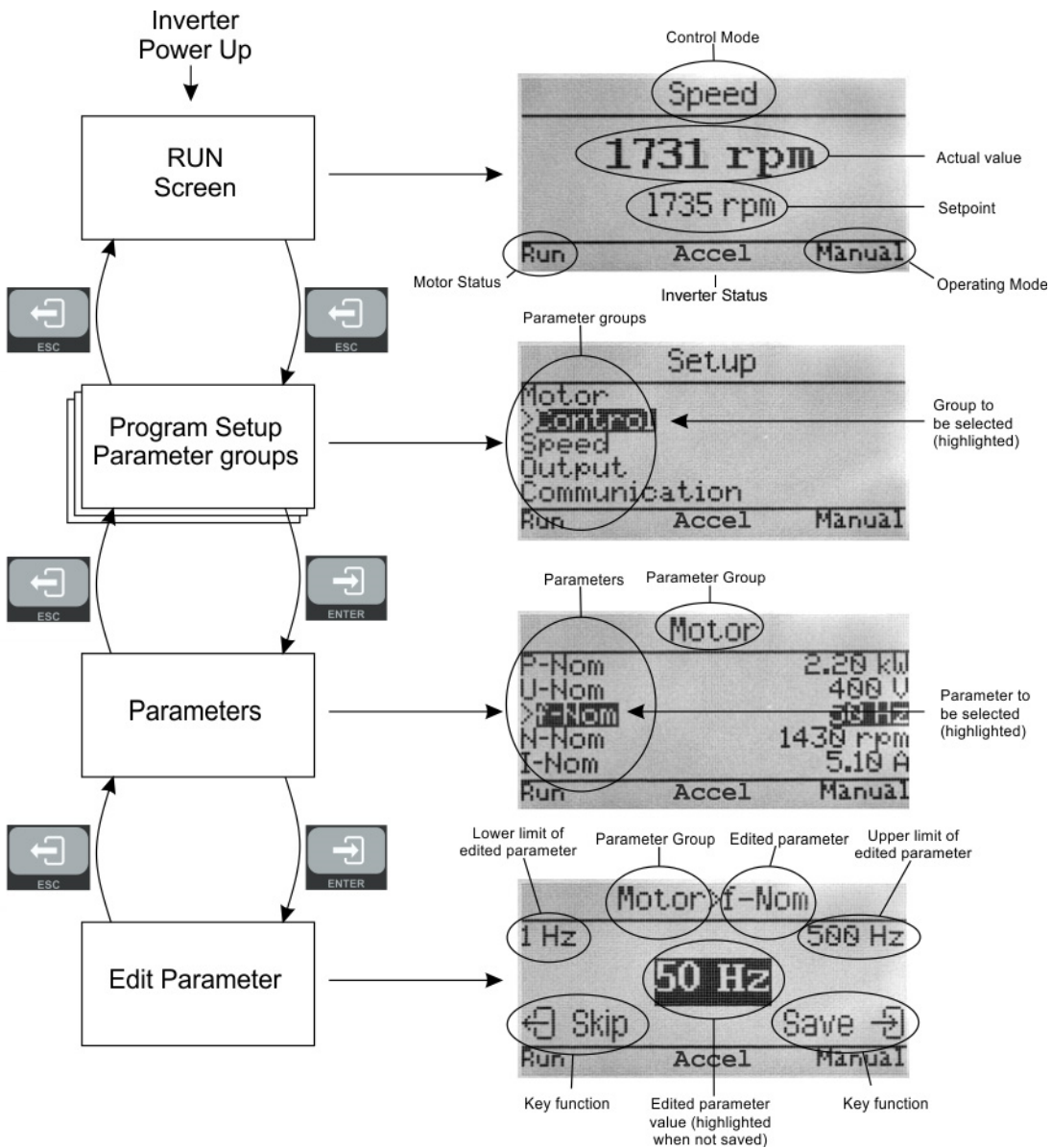


Fig. 9. Programming flowchart and screen examples with explanations

5.3 Indicators and Motor status

The indicator lights below the display have the following meaning:

| | |
|-------|--------------------------------------|
| POWER | The inverter is powered. |
| RUN | The motor is running. |
| FAIL | An alarm or error has been detected. |

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

| | |
|----------|--|
| Run | Motor is running. |
| Stopping | Motor is decelerating towards a stop. |
| Standby | Inverter standby, waiting for Run signal (DIN1). |
| Disable | Inverter is not ready or will not accept Run signal. |
| Waiting | Inverter is waiting for an internal timer to finish. |

5.4 Operating modes

The inverter has four operating modes, *Inhibit*, *Manual*, *Auto* and *Bus*. 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 signal from terminal 1 (DIN1). The *Manual* mode is normally used for test and programming, as well as running the inverter, with the use of the keyboard.

⚠ 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. If the inverter is powered up with an active run signal and *AutoStart = OFF*, the inverter will remain in mode *Inhibit* until run signal goes inactive (or *AutoStart* is set ON).

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

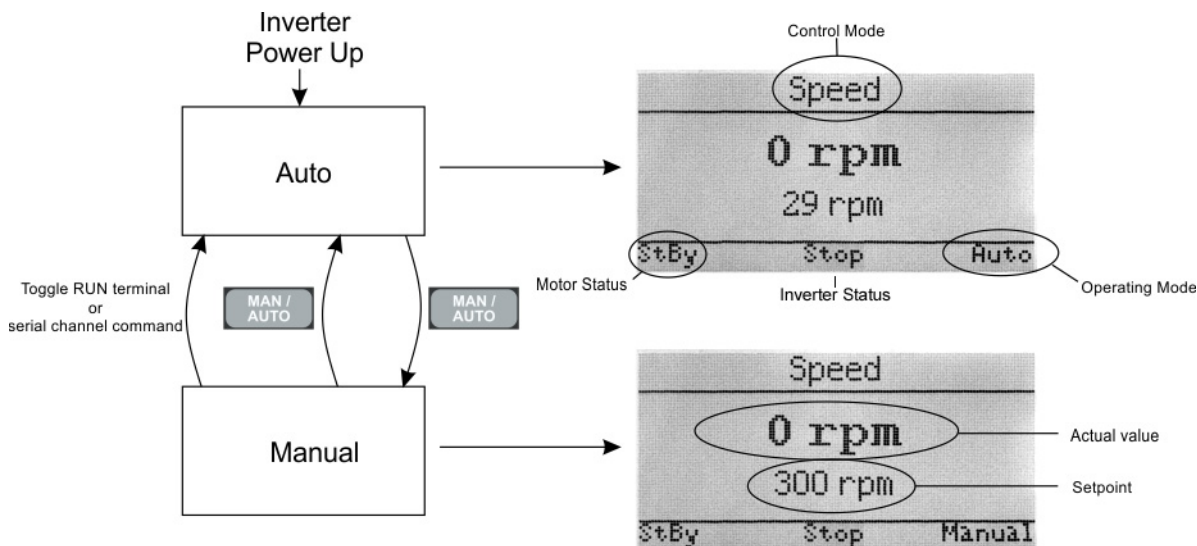


Fig. 10. Flowchart switching between modes and screen examples




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



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 . 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 .

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

5.4.2 Auto Mode

You can switch to *Auto* mode at any time by pressing . If terminal 1 (DIN1) is active the motor starts. *Auto* mode can also be reached by toggling terminal 1 (DIN1 Run) with *AutoStart* = ON, or by serial channel command. If the inverter is in *Auto* mode and run signal terminal 1 (DIN1) is not active, the Motor status shows *Standby*.

The source for the setpoint is selected by the parameter *Op Mode (Setp Source)* for the control mode concerned see 5.9.1, 5.10.1 and 5.11.1.

If selecting *Op Mode (Setp Source)* to:

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

Analog 1 F - 2 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).

Analog 1 R - 2 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.

| Function | Analog select | Direction | PI control | Select A | Select B | Select C |
|------------------|---------------|-----------|------------|----------|----------|----------|
| Terminal | DIN2 | DIN3 | DIN4 | DIN5 | DIN6 | DIN7 |
| Analog 1 Forward | 0 | 0 | 0 | 0 | 0 | 0 |
| Analog 1 Reverse | 0 | 1 | 0 | 0 | 0 | 0 |
| Fix-1 F | 0 | 0 | 0 | 1 | 0 | 0 |
| Fix-1 R | 0 | 1 | 0 | 1 | 0 | 0 |
| Fix-2 F | 0 | 0 | 0 | 0 | 1 | 0 |
| Fix-2 R | 0 | 1 | 0 | 0 | 1 | 0 |
| Fix-3 F | 0 | 0 | 0 | 1 | 1 | 0 |
| Fix-3 R | 0 | 1 | 0 | 1 | 1 | 0 |
| Fix-4 F | 0 | 0 | 0 | 0 | 0 | 1 |
| Fix-4 R | 0 | 1 | 0 | 0 | 0 | 1 |
| Fix-5 F | 0 | 0 | 0 | 1 | 0 | 1 |
| Fix-5 R | 0 | 1 | 0 | 1 | 0 | 1 |
| Fix-6 F | 0 | 0 | 0 | 0 | 1 | 1 |
| Fix-6 R | 0 | 1 | 0 | 0 | 1 | 1 |
| Fix-7 F | 0 | 0 | 0 | 1 | 1 | 1 |
| Fix-7 R | 0 | 1 | 0 | 1 | 1 | 1 |
| Analog 2 Forward | 1 | 0 | 0 | x | x | x |
| Analog 2 Reverse | 1 | 1 | 0 | x | x | x |
| PI control F | x | 0 | 1 | x | x | x |
| PI control R | x | 1 | 1 | x | x | x |

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

| Parameter <i>Ain</i> Type | Analogue value | Input (terminal) |
|---------------------------|------------------|--------------------------------------|
| 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) |
| 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) |

Table 8. Settings for analogue inputs AIN1 and AIN2.

5.4.3 Bus Mode (Serial channel / Field bus)

There are two built in communication protocols available: Modbus RTU/ASCII and NFO Classic (legacy NFO protocol). Both communicate using either USB or RS485. For other fieldbus communication protocols, the inverter also accepts an Anybus CompactCom module as an option. Please contact NFO Drives AB for more information.

For controlling the inverter or altering its parameters via Modbus or NFO Classic protocol, the Windows program "NFO Sinus Manager" is available and can be downloaded from www.nfodrives.se

5.5 Parameter specifications

5.5.1 Parameter summary

Parameters are divided into parameter groups, as shown in the table below. Please note that parameters, selectable options and default values may change without notice.


| Motor | Ramp | Run | Control | Freq. | Speed | PI-reg | Output | Comm. | Status | Temp. | Display | Count. | Version | Error |
|--------------|---------------|---------------|----------------|------------------|-----------------|----------------|--------------|----------------|-----------------|--------------|-----------------|---------------|----------------|---------------|
| P-Nom | Accel Time | Phase order | Control mode | Op mode | Op mode | Op mode | Relay 1 Mode | RS485 bustype | U-rms | Motor temp | Display par.1 | Operate time | CoProc version | Error-log |
| U-Nom | Decel Time | Stop mode | Auto-start | FixFrq1 | FixSpd1 | FixReg1 | Relay 1 Freq | RS485 addr | I-rms | Power module | Display par.2 | Run time | DSP version | Restart Delay |
| f-Nom | Ramp Brkpoint | Energy save | A.input 1 type | FixFrq2 | FixSpd2 | FixReg2 | Relay 2 Mode | RS485 baud | P-out | COP temp | Display par.3 | Brake time | GUI version | Reset Time |
| N-Nom | Alt. Accel | Pwr On delay | A.input 2 type | FixFrq3 | FixSpd3 | FixReg3 | Relay 2 Freq | RS485 char | PF | Heat sink 1 | Bklight level | Cur.lim time | Prod date | AC Fail |
| I-Nom | Alt. Decel | Run delay | D.input config | FixFrq4 | FixSpd4 | FixReg4 | Aout 1 Mode | RS485 timeout | DC Link | Heat sink 2 | Bklight timeout | DC low time | Serial number | Temp Hi |
| cos φ | | Stop delay | | FixFrq5 | FixSpd5 | FixReg5 | Aout 1 Max | RS485 autostop | Brake chop | Heat sink 3 | Menu readonly | Start count | | PTC Temp |
| Tuning | | DC brake | | FixFrq6 | FixSpd6 | FixReg6 | Aout 2 Mode | RS485 failsafe | Stator freq. | Heat sink 4 | | Alarm count | | Over load |
| R-stator | | Kp speed | | FixFrq7 | FixSpd7 | FixReg7 | Aout 2 Max | USB bustype | Rotor freq. | Fan 1 volt | | Output Energy | | Ain Fail |
| R-rotor | | Ti speed | | A.input min freq | A.input min rpm | Setpoint min | Analog 1 out | USB addr | Control freq. | Fan 2 volt | | Total Energy | | DC Low |
| L-main | | Sleep freq. | | A.input max freq | A.input max rpm | Setpoint max | Analog 2 out | USB timeout | Rotor speed | Fan 3 volt | | | | DC High |
| Sigma | | Bypass freq. | | | | Actual min | | USB autostop | Control speed | Fan 4 volt | | | | GND Fail |
| I-magn | | Bypass bandw. | | | | Actual max | | ABCC interface | Actual Torque | EXT 24V | | | | Short Circuit |
| I-limit | | Boost time | | | | Setp min limit | | ABCC bustype | Control Torque | USB 5V | | | | Imagn Low |
| Pole Count | | Boost level | | | | Setp max limit | | ABCC addr | Actual PI-reg | | | | | Current Low |
| T-nom | | | | | | Reg sign | | ABCC timeout | Setpoint Pi-reg | | | | | Current High |
| Tuned status | | | | | | Reg Kp | | ABCC autostop | Ain 1 V | | | | | Current Limit |
| | | | | | | Reg Ti | | Auto reset | Ain1 mA | | | | | Run Fail |
| | | | | | | Min freq | | | Ain 2 V | | | | | |
| | | | | | | Max freq | | | Ain2 mA | | | | | |
| | | | | | | Unit | | | Keybrd. | | | | | |
| | | | | | | Off limit | | | Terminal | | | | | |
| | | | | | | On limit | | | | | | | | |

Table 9. Parameter groups and parameters.

For parameter groups *Frequency or Speed*, only the menu/group for the selected control mode will be shown.

5.5.2 Parameter table

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

| Name | Description | Default value | Range | Type [1] |
|---------------------------|---|------------------------|--|----------|
| Motor | | | | |
| P-Nom | Nominal motor power | Table 11 | 0.18 – 5,5 kW | Standby |
| U-Nom | Nominal motor voltage | | 120 – 690 V | Standby |
| f-Nom | Nominal motor frequency | | 25 – 150 Hz | Standby |
| N-Nom | Nominal motor speed | | 300 – 3000 rpm | Standby |
| I-Nom | Nominal motor current | | Table 11 | Standby |
| cos φ | Nominal motor cos φ | | 0.5 – 1.0 | Standby |
| Tuning | Tuning command | | | Standby |
| R-stator | Motor stator resistance | Measured during tuning | | Standby |
| R-rotor | Motor rotor resistance | | | Standby |
| L-main | Motor main inductance | | | Standby |
| Sigma | Motor leak inductance | | | Standby |
| I-Magn | Magnetisation current setpoint (RMS) | | 0,1 – I _{max} [A] | Standby |
| I-Limit | Maximum motor current (RMS) | | 0,5 – I _{max} [A] | Standby |
| Pole Count | Number of poles, calculated from f-Nom and N-Nom | | | Read |
| T-nom | Nominal torque, calculated from N-Nom and I-Nom | | | Read |
| Tuned status | Status of most recent tuning command | | | Read |
| Ramp | | | | |
| Acceleration | Acceleration time from 0 to f-Nom Hz | 15.0 s ^[2] | 0.5 - 100.0 s | Stby/Run |
| Deceleration | Deceleration time from f-Nom to 0 Hz | 15.0 s ^[2] | 0.5 - 100.0 s | Stby/Run |
| Breakpoint | Breakpoint for alternate Accel/Decel | 0.0 Hz | 0 - 50.0 Hz | Stby/Run |
| Alt. Accel | Alternate Acceleration time from 0 to f-Nom Hz | 15.0 s ^[2] | 0.5 - 100.0 s | Stby/Run |
| Alt. Decel | Alternate Deceleration time from f-Nom to 0 Hz | 15.0 s ^[2] | 0.5 - 100.0 s | Stby/Run |
| Run | | | | |
| Phase Order | Controls default direction of rotation | U–V–W | U–V–W U–W–V | Standby |
| Stop Mode | Brake = motor brakes according to <i>Deceleration Ramp</i> Release = motor is released. | Brake | Brake Release | Stby/Run |
| Energy Save | OFF = Function is disabled. ON = Inverter optimizing energy consumption of the motor | OFF | OFF ON | Stby/Run |
| Pwr On Delay | Delay from when power is applied until motor can start | 4 s | 4 – 10 s | Stby/Run |
| Run Delay | Delay from Run signal detected to actual start | 0.0 s | 0.0 – 10.0 s | Stby/Run |
| Stop Delay | Delay from motor has stopped until new Run signal is accepted | 0.0 s | 0.0 – 10.0 s | Stby/Run |
| DC Brake | Time in seconds for motor DC braking before start | 0 s | 0 – 10 s | Stby/Run |
| Kp-speed | Amplifier component speed regulator | 2,0 ^[2] | 0,2 – 10,0 | Stby/Run |
| Ti-speed | Integrator component speed regulator | 0,5 ^[2] | 0,2 – 10,0 s | Stby/Run |
| Sleep Freq | Sleep frequency setting | 0.0 Hz | 0.0 – 50.0 Hz | Stby/Run |
| Bypass Freq | Bypass frequency | 0.0 Hz | 0.0 – 50.0 Hz | Stby/Run |
| Bypass BW | Bypass frequency bandwidth | 0.0 Hz | 0.0 – 50.0 Hz | Stby/Run |
| Iboost Time | Current boost time, from start | 5 s | 0 – 100 s | Stby/Run |
| Iboost Level | Current boost level | 50% | 0 – 100% | Stby/Run |
| Control | | | | |
| Control Mode | Frequency = speed control with frequency estimation Speed = speed control with rpm estimation PI-Reg = process regulator | Frequency | Frequency Speed PI-Reg | Standby |
| Autostart | 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. | OFF | OFF ON | Stby/Run |
| Analog in 1 setpoint type | Type of input used for analog setpoint. | 0-10V | 0-20mA 4-20mA +/-20mA 0-10V 2-10V +/-10V Pot | Stby/Run |
| Analog in 2 setpoint type | Same as Analog in 1 setpoint type. | 0-10V | see above | Stby/Run |
| Digital input config | Pre-set configurations of digital inputs | Default | Default OEM1 | Stby/Run |
| Frequency | | | | |
| Op mode | Setpoint source, frequency | Terminal | Table 12 | Stby/Run |
| Fix Frq 1 | Fixed frequency 1 | 10.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Fix Frq 2 | Fixed frequency 2 | 20.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Fix Frq 3 | Fixed frequency 3 | 30.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Fix Frq 4 | Fixed frequency 4 | 40.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Fix Frq 5 | Fixed frequency 5 | 50.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Fix Frq 6 | Fixed frequency 6 | 60.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Fix Frq 7 | Fixed frequency 7 | 70.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Min Ain Frq | Lowest frequency when running with analogue setpoint. | 10.0 Hz | +/-150.0 Hz | Stby/Run |
| Max Ain Frq | Highest frequency when running with analogue setpoint. | 50.0 Hz | +/-150.0 Hz | Stby/Run |

| Speed | | | | |
|----------------------|---|------------|--|----------|
| Op mode | Setpoint source, speed | Terminal | Table 13 | Stby/Run |
| Fix Spd 1 | Fixed speed 1 | 300 rpm | 0-4500 rpm | Stby/Run |
| Fix Spd 2 | Fixed speed 2 | 600 rpm | 0-4500 rpm | Stby/Run |
| Fix Spd 3 | Fixed speed 3 | 900 rpm | 0-4500 rpm | Stby/Run |
| Fix Spd 4 | Fixed speed 4 | 1200 rpm | 0-4500 rpm | Stby/Run |
| Fix Spd 5 | Fixed speed 5 | 1500 rpm | 0-4500 rpm | Stby/Run |
| Fix Spd 6 | Fixed speed 6 | 1800 rpm | 0-4500 rpm | Stby/Run |
| Fix Spd 7 | Fixed speed 7 | 2100 rpm | 0-4500 rpm | Stby/Run |
| Min Ain Spd | Lowest speed when running with analogue setpoint. | 300 rpm | +/-4500 rpm | Stby/Run |
| Max Ain Spd | Highest speed when running with analogue setpoint. | 1500 rpm | +/-4500 rpm | Stby/Run |
| PI Reg | | | | |
| Op mode | Setpoint source, PI regulator | Terminal | Table 16 | Stby/Run |
| Fix Reg 1 | Fixed setpoint 1 | 20.0 | -2000.0 - 2000.0 | Stby/Run |
| Fix Reg 2 | Fixed setpoint 2 | 40.0 | -2000.0 - 2000.0 | Stby/Run |
| Fix Reg 3 | Fixed setpoint 3 | 60.0 | -2000.0 - 2000.0 | Stby/Run |
| Fix Reg 4 | Fixed setpoint 4 | 80.0 | -2000.0 - 2000.0 | Stby/Run |
| Fix Reg 5 | Fixed setpoint 5 | 100.0 | -2000.0 - 2000.0 | Stby/Run |
| Fix Reg 6 | Fixed setpoint 6 | 120.0 | -2000.0 - 2000.0 | Stby/Run |
| Fix Reg 7 | Fixed setpoint 7 | 140.0 | -2000.0 - 2000.0 | Stby/Run |
| Setpoint Min | Value at min. input signal from setpoint input | 0.0 | -2000.0 - 2000.0 | Stby/Run |
| Setpoint Max | Value at max. input signal from setpoint input | 200.0 | -2000.0 - 2000.0 | Stby/Run |
| Actual Min | Value at min. input signal from actual value input | 0.0 | -2000.0 - 2000.0 | Stby/Run |
| Actual Max | Value at max. input signal from actual value input | 200.0 | -2000.0 - 2000.0 | Stby/Run |
| Setp Min Limit | Limitation of setpoint, min level | 50.0 | -2000.0 - 2000.0 | Stby/Run |
| Setp Max Limit | Limitation of setpoint, max level | 150.0 | -2000.0 - 2000.0 | Stby/Run |
| Reg Amp | Amplifies process regulator | +1 | +1 or -1 | Stby/Run |
| Reg Kp | Proportional component process regulator | 0.10 | 0.00 – 1.00 | Stby/Run |
| Reg Ti | Integrator component process regulator | 50.0 s | 1.0 – 200.0 s | Stby/Run |
| Min Freq | Frequency setpoint at minimum regulator output | 10.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Max Freq | Frequency setpoint at maximum regulator output | 50.0 Hz | 0.0-150.0 Hz | Stby/Run |
| Unit | Regulator units | kPa | Table 14 | Stby/Run |
| Reg Off Limit | Turn off motor when actual value below off limit | 0.0 | -2000.0 - 2000.0 | Stby/Run |
| Reg On Limit | Turn on motor when actual value above on limit | 0.0 | -2000.0 - 2000.0 | Stby/Run |
| Output | | | | |
| Relay 1 Mode | <i>Disable</i> = Function disabled <i>Running</i> = Motor running <i>Run Fwd</i> = Motor running forward <i>Run Rev</i> = Motor running reverse <i>Run Setp</i> = Motor frequency has reached setpoint <i>Run Freq</i> = Motor frequency > <i>Relay 1 Freq</i> <i>Alarm</i> = Inverter in alarm state (but may still be running) <i>Fault</i> = Inverter in fault state (and is inhibited to start) <i>Ready</i> = Inverter in Standby, Running or Stopping (accept Run) <i>Curr Lim</i> = Current limit reached <i>Test mode 1 & 2</i> = To be used during production only | Alarm | Disable Running Run Fwd Run Rev Run Setp Run Freq Alarm Fault Ready Curr Limit Test Mode | Stby/Run |
| Relay 1 Freq | Frequency threshold for Relay 1 Mode <i>Run Freq</i> | 10.0 Hz | 0,0 – 150.0 Hz | Stby/Run |
| Relay 2 Mode | See options for Relay 1 Mode | Running | see above | Stby/Run |
| Relay 2 Freq | Frequency threshold for Relay 2 Mode <i>Run Freq</i> | 10.0 Hz | 0,0 – 150.0 Hz | Stby/Run |
| Analog 1 Output Mode | <i>Disable</i> = Function disabled <i>Freque</i> = Current electrical frequency <i>Speed</i> = Current rotor speed <i>Torque</i> = Current torque <i>Irms</i> = Motor current <i>Prms</i> = Output power <i>PF</i> = Output power factor <i>Setpoint</i> = Follow selected setpoint | Disable | Disable Freque Speed Torque Irms Prms PF Setpoint | Stby/Run |
| Analog 1 Output Max | Scale factor for analogue output 1 (Output voltage when reaching nominal value of selected mode) | 10.00V | 0 - 10.00 V | Stby/Run |
| Analog 2 Output Mode | See options for Analog 1 Output Mode | Disable | see above | Stby/Run |
| Analog 2 Output Max | Scale factor for analogue output 2 (Output voltage when reaching nominal value of selected mode) | 10.00V | 0 - 10.00 V | Stby/Run |
| Analog 1 out | Actual output in V x100 | n/a | 0 - 1000 | Read |
| Analog 2 out | Actual output in V x100 | n/a | 0 - 1000 | Read |
| Communication | | | | |
| RS485 bustype | Select bus type/communication protocol for RS485 port | Modbus RTU | NFO Classic Modbus RTU Modbus ASCII | Stby/Run |
| RS485 address | Bus/station address | 1 | 1 – 126 | Stby/Run |
| RS485 baudrate | Select the baudrate (bits/sec) for RS485 interface | 19200 | 1200 – 625000 | Stby/Run |
| RS485 charcode | Select data bits, parity and stop bits for RS485 interface | 8-E-1 | several values | Stby/Run |
| RS485 timeout | Set a communication timeout to stop motor or issue alarm [s] | 0.0 | 0.0 – 10.0 | Stby/Run |
| RS485 autostop | Automatic stop motor if timeout is activated | ON | OFF / ON | Stby/Run |
| RS485 failsafe | Activate pull up/pull down for RS485 A/B lines | OFF | OFF / ON | Stby/Run |

| | | | | |
|--------------------|---|------------------|---|----------|
| USB bustype | Select bus type/communication protocol for USB port | Modbus RTU | NFO Classic Modbus RTU Modbus ASCII | Stby/Run |
| USB address | Bus/station address | 1 | 1 – 126 | Stby/Run |
| USB timeout | Set a communication timeout to stop motor or issue alarm [s] | 0.0 | 0.0 – 10.0 | Stby/Run |
| USB autostop | Automatic stop motor if timeout is activated | ON | OFF / ON | Stby/Run |
| ABCC interface | Type of communication interface with ABCC module (internal) | SPI | Serial / SPI | Stby/Run |
| ABCC bustype | Shows the detected external fieldbus type | - | - | Read |
| ABCC address | ABCC module external network address (when applicable) | 126 | 1 – 126 | Stby/Run |
| ABCC timeout | Set a communication timeout to stop motor or issue alarm [s] | 0.0 | 0.0 – 10.0 | Stby/Run |
| ABCC autostop | Automatic stop motor if timeout is activated | ON | OFF / ON | Stby/Run |
| Auto Reset | OFF: Changed setting of any communication parameter will not be updated until after next power off – power on cycle. ON: Auto update settings of communication device after changing any communication parameter. | ON | OFF / ON | Stby/Run |
| Status | | | | |
| U-rms | Motor voltage (RMS) | | V | Read |
| I-rms | Motor current (RMS) | | A | Read |
| P-out | Active power output | | W | Read |
| PF | Output power factor | | - | Read |
| DC Link | DC Link voltage | | V | Read |
| Brake chop | Voltage at brake chopper terminal | | V | Read |
| Stator freq | Electrical frequency (stator) actual value | | Hz | Read |
| Rotor freq | Electrical frequency (rotor) actual value | | Hz | Read |
| Control freq | Electrical frequency setpoint (<i>Frequency mode</i>) | | Hz | Read |
| Rotor speed | Rotor speed actual value | | rpm | Read |
| Control speed | Rotor speed setpoint (<i>Speed mode</i>) | | rpm | Read |
| Actual torque | Actual torque in percent of motor nominal torque | | % | Read |
| Control torque | Torque setpoint in percent of motor nominal torque ^[3] | | % | Read |
| Actual PI-reg | Actual value process regulator | | As per parameter <i>Unit</i> | Read |
| Setpoint PI-reg | Setpoint value process regulator | | As per parameter <i>Unit</i> | Read |
| Analog 1 V | Actual input voltage | | V | Read |
| Analog 1 mA | Actual input current | | mA | Read |
| Analog 2 V | Actual input voltage | | V | Read |
| Analog 2 mA | Actual input current | | mA | Read |
| Keyboard | Bitmask input of keyboard | | - | Read |
| Terminals | Bitmask input of terminals (DIN1..8) | | - | Read |
| Temperature | | | | |
| Motor temp | Estimated motor temperature in percent of max | | % | Read |
| Power module | Power module temperature ^[4] | | °C | Read |
| COP temp | Processor chip temperature ^[4] | | °C | Read |
| Heat sink 1 | Heat sink temperature ^[4] | | °C | Read |
| Heat sink 2 | Heat sink temperature ^[4] | | °C | Read |
| Heat sink 3 | Heat sink temperature ^[4] | | °C | Read |
| Heat sink 4 | Heat sink temperature ^[4] | | °C | Read |
| Fan volt 1 | Cooling fan output voltage | | V | Read |
| Fan volt 2 | Cooling fan output voltage | | V | Read |
| Fan volt 3 | Cooling fan output voltage | | V | Read |
| Fan volt 4 | Cooling fan output voltage | | V | Read |
| EXT 24V | Actual voltage on external 24V supply | | V | Read |
| USB 5V | Actual voltage from USB connector | | V | Read |
| Display | | | | |
| Display par 1 | Selectable parameter for display left position: U _{RMS} , I _{RMS} , P _{RMS} , PF, U _{DC} , Act.Freq, Act.Speed, Act.Torque, Act.Reg, TempMotor, TempPower, TempHeatSink1-4, I[U] _{RMS} , I[V] _{RMS} , I[W] _{RMS} , | I _{RMS} | several options | Stby/Run |
| Display par 2 | Selectable parameter for display middle position (same as par 1) | P _{RMS} | several options | Stby/Run |
| Display par 3 | Selectable parameter for display right position (same as par 1) | PF | several options | Stby/Run |
| Bklight level | Illumination level for display | 50% | 10 – 100% | Stby/Run |
| Bklight tmout | Illumination dimmer timeout | 2 min | 0 – 60 min | Stby/Run |
| Menu readonly | OFF: No activation of read only mode ON: Activate readonly mode (require PIN code to deactivate) | OFF | OFF ON | Stby/Run |
| Counters | | | | |
| Operating time | Time that inverter has been powered on (hours x0.01) | | h | Read |
| Run time | Time that inverter has been running motor (hours x0.01) | | h | Read |
| Brake time | Time that inverter has activated brake chopper (seconds) | | s | Read |
| Cur.limit time | Time that inverter has been running in current limit (seconds) | | s | Read |
| DC low time | Time that inverter has activated brake chopper (seconds) | | s | Read |
| Start counter | Number of motor starts | | - | Read |
| Alarm counter | Number of logged alarms or faults | | - | Read |
| Output energy | Output energy to motor in kWh (resettable counter) | | kWh | Read |
| Total energy | Output energy to motor in MWh (non resettable counter) | | MWh | Read |
| Version | | | | |
| COP version | Firmware version of co-processor | | - | Read |
| DSP version | Firmware version of motor control processor | | - | Read |

| | | | | |
|---------------|--|-------------------|--------------|----------|
| GUI version | Firmware version of user interface | - | | Read |
| Prod.date | Production date and time | YYMMDDHHMM | | Read |
| Serial nbr | Serial number | [10 digits] | | Read |
| Error | | | | |
| Error log | Internal log of faults and alarms | | | Read |
| Restart Delay | Time from when fault disappears to restart | 10 sec | 0 – 3600 sec | Stby/Run |
| Reset Time | Time inverter must run fault free to reset individual error counters | 600 sec | 0 – 3600 sec | Stby/Run |
| AC Fail | Phase error | | | |
| Temp Hi | Heatsink overheating | | | |
| PTC Temp | Motor overheating | | | |
| Overload | Electronic motor overload protection | | | |
| Ain Fail | Analogue setpoint input signal out of range | | | |
| DC Low | Voltage in DC link too low | | | |
| DC High | Voltage in DC link too high | | | |
| GND Fail | | | | |
| Short Circuit | | | | |
| IMagn Low | Fault in motor or motor wiring | | | |
| Current Low | | | | |
| Current High | | | | |
| Current Limit | | Motor overcurrent | | |
| Run Fail | Rotor locked, start failure | | | |

Table 10. Parameters available, sorted by parameter group

Notes:

- [1] Type = Standby parameters can only be changed when motor is standby (not running).
Type = Stby/Run parameters can be changed in both standby and run.
Type = Read parameters are read-only.
- [2] Other combinations of default values for Acceleration, Deceleration, Kp-speed and Ti-speed are available.
- [3] Available in future versions.
- [4] Value for indicative purpose only as measurement has limited accuracy.

5.6 Select application

First time powered up after installation, or after performing a factory reset of parameters, the installer will be prompted to select application type for the inverter. The purpose of selecting application is to preset acceleration and deceleration ramps to a value suitable for the application in question. Please note that the preset values are a merely suggested general values. Depending on other operating conditions, the installer may have to further adjust the accel/decel ramps.

| Application | Description |
|---------------------|---|
| Pump | Set acceleration and deceleration ramps suitable for general pump applications |
| Ventilation / other | Set acceleration and deceleration ramps suitable for ventilation fan applications |
| OEM vacuum pump | To be used only with OEM vacuum pump application |

5.7 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.

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 $\cos \varphi$. 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 default 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 is 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 either 120 % of the motor's nominal current or the maximum of the inverter.

5.7.1 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 started.

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.

5.7.2 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.

5.7.3 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.


| 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 | 0,79 | 3.00 Ω | 2.00 Ω | 400 mH | 0.080 | 1.80 A | 5.80 A |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

Table 11. Default nominal motor data and motor parameters

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

5.7.4 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.

5.8 Setting control parameters

5.8.1 Acceleration and deceleration ramps

Parameters *Acceleration* and *Deceleration* indicate how fast the motor is allowed to change speed. The units 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:

$$t_{\text{Accel}} = f\text{-Nom} * \text{Acceleration time desired} / \text{frequency change}$$

$$t_{\text{Decel}} = f\text{-Nom} * \text{Deceleration time desired} / \text{frequency change}$$

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.


$$t_{\text{Accel}} = 50 * 2 / 80 = 1.25 \text{ s}$$

$$t_{\text{Decel}} = 50 * 9 / 75 = 6.00 \text{ s}$$

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.

To enable different acceleration and deceleration times at start and/or stop, it is possible to set a breakpoint frequency. When this is set to any other value than zero, it enables the alternative acceleration and deceleration times, which are used from 0 Hz up to the breakpoint frequency.

 **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.**

5.8.2 Phase order

Parameter *Phase order* determines default rotation direction of the motor. If motor terminals (inverter output) U, V and W are connected to motor terminals U, V and W in that sequence, the default setting *U-V-W* will render clockwise rotation for a positive setpoint. However, crossed over motor cables or some other property of the installation may render the wrong desired rotation direction. This can be reversed by changing Phase order to *U-W-V*.

5.8.3 Stop mode

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

With the *Stop Mode* parameter set to *Brake* (default setting) and issuing the stop command, the inverter will slow the motor down to a stop using the set deceleration ramp.

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

After releasing the motor, the NFO Sinus will wait a certain minimum time before accepting a new RUN signal. The time is proportional to the frequency at which the motor was released. This function is used to minimize the risk of restarting with a rotating load, which could lead to output current surges and failure of the drive.

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

5.8.4 Energy save function

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, e.g. fans that sometimes run at low speed. 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. As a result of this, the function should only be used in applications not requiring high dynamics.

5.8.5 Power On, Start and Stop delay

PowerOn Delay sets the time from when inverter is powered until it accepts a start command. *PowerOn Delay* can be useful to handle short time power failures (interrupts) and restarting when operating with large inertial torque, such as a fan rotor.

Start Delay can be used to suppress short pulses of the RUN signal, thereby requiring a minimum duration of the RUN signal before actually starting the motor.

Stop Delay can be used to setup a minimum required stand-off time between the point when the motor has come to a stop, and when the inverter accepts a new RUN signal. This may be used for heavy rotating loads or when the driven system requires a minimum stop time before it may be restarted.

5.8.6 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.

5.8.7 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 2.00 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.

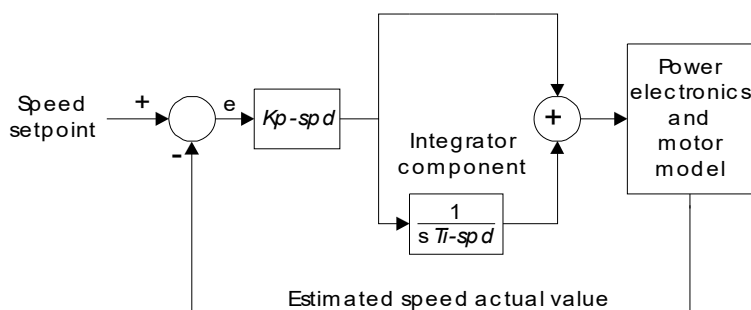


Fig. 11. Speed regulator

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

5.8.8 Frequency sleep setting

This function is to minimize power consumption when running motor at low speed. When both setpoint frequency and actual frequency are within the interval $0 - F_{sleep}$ 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.

5.8.9 Frequency bypass

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. 12.

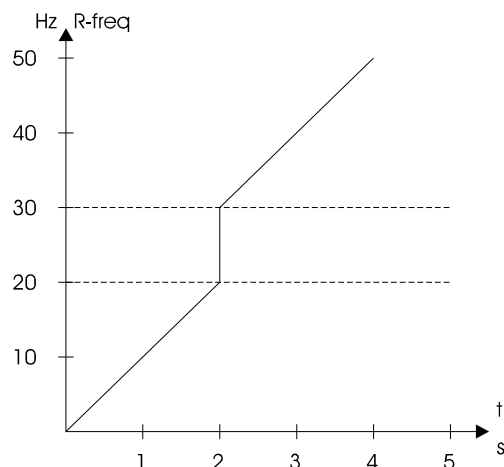


Fig. 12. Acceleration with frequency bypass

5.8.10 Increased start current (current boost)

It's possible to set a temporary increased current limit at startup. This can be achieved using a NFO Sinus inverter with a nominal power that is higher than the motor's nominal power, e.g. a 2.2kW inverter used with a 1.5kW motor.

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

5.8.11 Control Mode

With *Control Mode* parameter set to *Frequency*, the inverter uses frequency in Hz for setpoint and regulation of motor rotation. When set to *Speed*, the inverter uses values in rpm for setpoint and regulation of rotor speed. This mode has a more accurate speed estimation and it compensates for load variations. See sections 5.9 and 5.10.

5.8.12 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 5.16.

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 over the serial channel or field bus. The motor may start automatically after an involuntary power failure.

5.8.13 Analog input type

The parameter selects input type and range for the analog inputs Ain1 and Ain2. Possible settings are 0-20mA, 4-20mA, +/-20mA, 0-10V, 2-10V, +/-10V or Potentiometer. Connection of the analog input signals are described in section 4.1.3 and 4.1.6.

5.8.14 Digital input configuration

The parameter selects one predefined configuration from a set of configurations. Selectable configurations are *Default* (DIN1 through DIN8 implements all available functions), or *OEM1* (DIN2 and DIN4 are disabled).

5.9 Frequency control without load compensation, *Frequency mode*

Frequency mode is designed for use in standard operations, such as fans. The inverter does not compensate for the motors slip. The inverter display shows the electrical frequency for selected setpoint and actual value. 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 below can be found in parameter group *Frequency*, which are only displayed when this mode is selected.

5.9.1 Setpoint source for Frequency Mode

Frequency setpoint source is selected by the parameter *Op Mode (Setp Source)*.

| Op Mode | Setpoint source for Frequency mode |
|------------|---|
| Terminal | Any of alternatives below, selected from terminal as in table 7 |
| Analog 1 F | Analogue input 1 clockwise. |
| Analog 1 R | Analogue input 1 counter-clockwise. |
| Analog 2 F | Analogue input 2 clockwise. |
| Analog 2 R | Analogue input 2 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 F | Frequency from process regulator, clockwise. |
| PI-reg R | Frequency from process regulator, counter-clockwise. |

Table 12. Frequency mode setpoint source parameter settings.

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

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

When using frequency regulation, parameters *Min Ain Frq* and *Max Ain Frq* sets the frequency range in which the inverter is to operate when an analogue input is designated as setpoint source. *Max Ain Frq* applies at maximum analogue input signal and *Min Ain Frq* at minimum input signal. The settings apply for both rotational directions.

If rotation is required in both directions (e.g. at $\pm 10V$ or $\pm 20mA$, stopping in the middle), set *Min Ain Frq* to negative (-) *Max Ain Frq*.

5.10 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 is 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 as accurately as possible.

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

5.10.1 Setpoint source for Speed Mode

Speed setpoint source is selected by the parameter *Op Mode (Setp Source)*.

| Op Mode | Setpoint source for Speed mode |
|------------|---|
| Terminal | Any of the alternatives below, selected from terminal as in Table 7 |
| Analog 1 F | Analogue input 1, clockwise. |
| Analog 1 R | Analogue input 1, counter-clockwise. |
| Analog 2 F | Analogue input 2, clockwise. |
| Analog 2 R | Analogue input 2, 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 F | Frequency from process regulator, clockwise. |
| PI-reg R | Frequency from process regulator, counter-clockwise. |

Table 13. Speed mode setpoint source parameter settings

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.

5.10.2 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 both rotational directions.

If rotation in both directions is required (e.g. at $\pm 10V$ or $\pm 10mA$, stopping in the middle), set *Min Ain Spd* to negative ($-$) *Max Ain Spd*.

5.11 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 mode *Frequency* and *Speed*. The regulator is enabled by either setting the *Op Mode (Setp Source)* parameter to *PI-Reg* in the control mode used, or setting the correct digital input combination at the terminal if *Terminal* is the selected source. For backward compatibility with older NFO Sinus inverters, the process regulator can also be activated by setting parameter *Control Mode = PI-Reg*.

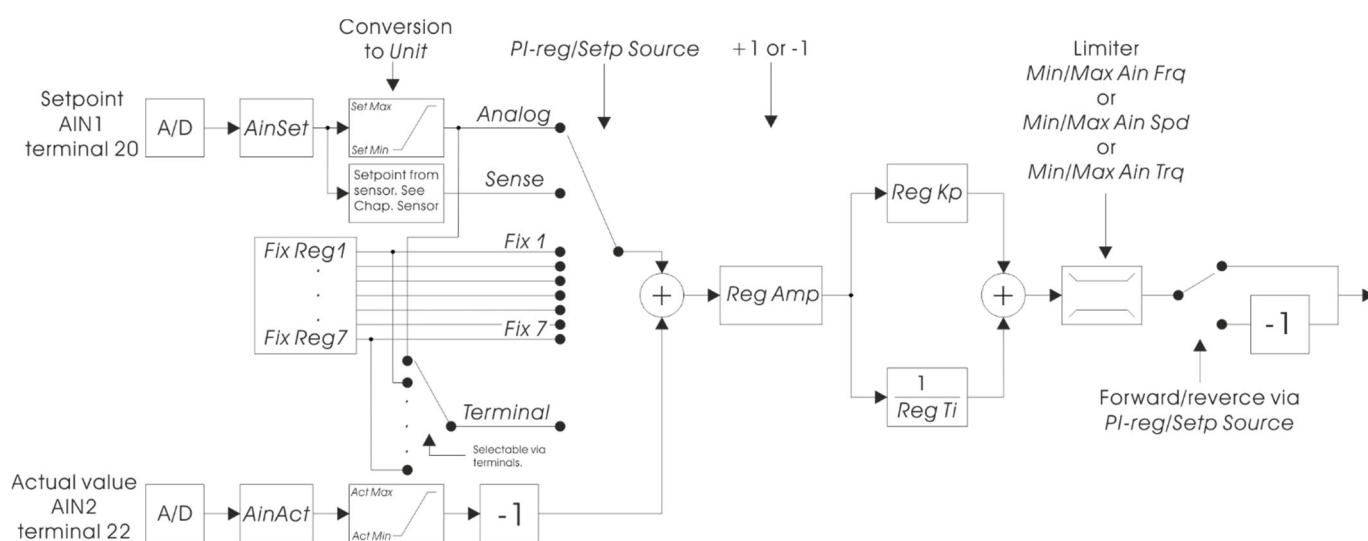


Fig. 13. Process regulator overview

The process regulator unit (default kPa) 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 by default taken from the analog input AIN2 at terminal 22. The scaling of the actual value is controlled by parameters *Actual Min* and *Actual Max* which translates the minimum and maximum signal level from the actual value input corresponding to the selected unit.

The regulator generates an output signal in the form of a setpoint (frequency or speed) in the range limited by parameters *Min Frq* and *Max Frq*, or *Min Spd* and *Max Spd*, depending on the control mode chosen. When using *Control Mode = PI-Reg* the parameters used for scaling min and max frequency are *Min Freq* and *Max Freq*.

If a potentiometer or a sensor is used for the setpoint, their output signal is scaled to the chosen regulator unit by parameters *Setpoint Min* and *Setpoint Max*. With parameters *Setpoint Min Limit* and *Setpoint Max Limit*, it is possible to limit the range of the setpoint value.

Both AIN1 and AIN2 can be configured for voltage or current input individually, see 4.1.3, Table 8 and Table 15.

If desired, the parameters *Reg Off Limit* and *Reg On Limit* can be used to turn off motor when a certain actual value has been reached, and then again turn on motor when actual value has dropped below the turn on limit. When any of the parameters *Reg Off Limit* or *Reg On Limit* are zero, this functionality is disabled. The turn off function uses the sleep frequency, therefore the sleep functionality cannot be used concurrently for some other purpose.

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 Ain Type 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

5.11.1 Setpoint source for PI-reg mode

The regulator setpoint source is controlled by the parameter *Op Mode (Setp Source)*

| Op Mode | PI regulator setpoint source |
|------------|---|
| Terminal | Any of the alternatives below, selected from terminal as in Table 17. |
| Analog 1 F | Analogue input 1, clockwise. |
| Analog 1 R | Analogue input 1, counter-clockwise. |
| Analog 2 F | Analogue input 2, clockwise. |
| Analog 2 R | Analogue input 2, 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. |

Table 16. PI Reg setpoint source parameter settings

If analogue input 1 (AIN1) is selected, it is configured as shown in Table 8.

| Function | Analog select | Direction | Select A | Select B | Select C |
|----------------------|---------------|-----------|----------|----------|----------|
| Terminal Function | DIN2 | DIN3 | DIN5 | DIN6 | DIN7 |
| Analog 1 Forward | 0 | 0 | 0 | 0 | 0 |
| Analog 1 Reverse | 0 | 1 | 0 | 0 | 0 |
| Analog 2 Forward | 1 | 0 | 0 | 0 | 0 |
| Analog 2 Reverse | 1 | 1 | 0 | 0 | 0 |
| Fix Reg 1 Forward | x | 0 | 1 | 0 | 0 |
| Fix Reg 1 Reverse | x | 1 | 1 | 0 | 0 |
| Fix Reg 2 Forward | x | 0 | 0 | 1 | 0 |
| Fix Reg 2 Reverse | x | 1 | 0 | 1 | 0 |
| Fix Reg 3 Forward | x | 0 | 1 | 1 | 0 |
| Fix Reg 3 Reverse | x | 1 | 1 | 1 | 0 |
| Fix Reg 4 Forward | x | 0 | 0 | 0 | 1 |
| Fix Reg 4 Reverse | x | 1 | 0 | 0 | 1 |
| Fix Reg 5 Forward | x | 0 | 1 | 0 | 1 |
| Fix Reg 5 Reverse | x | 1 | 1 | 0 | 1 |
| Fix Reg 6 Forward | x | 0 | 0 | 1 | 1 |
| Fix Reg 6 Reverse | x | 1 | 0 | 1 | 1 |
| Fix Reg 7 Forward | x | 0 | 1 | 1 | 1 |
| Fix Reg 7 Reverse | x | 1 | 1 | 1 | 1 |

Table 17. Selected setpoint source for PI Reg / Op Mode (Setp Source) = Terminal

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

5.11.2 Regulator setting, Reg Amp, Reg Kp and Reg Ti

The process control error, which is calculated as setpoint minus actual value, is converted from process regulator unit to the actual control mode (Frequency or Speed) with the factor $Reg\ Amp * Max\ Ain / Act\ Max$. *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).

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 200.0 eliminates the integrator component completely, giving a purely proportional regulator.

5.12 Motor safety functions

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

5.12.1 PTC input

If the motor is fitted with PTC thermistor(s) or 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 4.1.4 Negative logic.

Configuration is carried out under fault *PTC Temp* in parameter group *Error*, see section 5.16.

One, two or three PTC thermistors in series, according to DIN 44081, can be used.

5.12.2 Electronic motor overload protection

The electronic motor overload protection functionality uses the motor parameters in parameter group *Motor* as described in this manual 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*, *Amb.Temp* and *Force Cool*. *Overload* can be set to *Disable* (overload protection disabled), *Indication* (status shown), *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 20°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 *Amb.Temp* in the range -20°C – +45°C. The overload protection can be triggered at lower motor loads by specifying a higher ambient temperature than it actually is; or a higher load can be allowed by entering a lower ambient temperature. Default *Amb.Temp* is +20°C.

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 *Force 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 *Force 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 *Force Cool* can be set in the range 0 to 3000, 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*, *Amb.Temp* or *Force Cool* are changed, the Electronic overload protection can be deactivated and/or not comply with the standards mentioned above.**

5.13 Output signals

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

5.13.1 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 is deactivated and indicates alarm on contacts 14-15). The relay is galvanically separated from other signals, and can handle 1 A, 50 V_{DC}. Possible settings are shown in table 10, section Output.

5.13.2 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}. Possible settings in table 10, section Output.

5.13.3 Analog outputs

The analog outputs can deliver both voltage and current signals, where the current output reflects the voltage output. The voltage range is $\pm 10V$ and the current range $\pm 20mA$. Voltage output is at terminal 25 (AOUT1.U) and terminal 27 (AOUT2.U), and current output at terminal 24 (AOUT1.I) and terminal 26 (AOUT2.I) respectively. Both are related to any of the 0V terminals.

To scale the output, use parameter *Aout* [1|2] *Max* (= current (mA) and/or voltage (V) at nominal actual value). Parameter *Aout* [1|2] *Mode* in parameter group *Output*, selects output function. Possible settings are shown in table 10, section Output.

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

5.14 Communication interfaces

The inverter is equipped with three communication ports: A RS485 multi-drop serial communication port, a USB (device) port implementing a virtual COM-port, and a plug-in connector for Anybus CompactCom module which accepts Profinet, Profibus and Modbus TCP fieldbus modules. Please contact NFO Drives for information regarding sourcing and installation of CompactCom modules.

For the RS485 and USB ports, the user can select which bus/protocol type to use (Modbus RTU, Modbus ASCII or NFO Classic), the bus/station address (1 – 126) of the inverter, and a timeout and autostop feature. Both RS485 and USB interface uses Modbus RTU and station address 1 as default. If several inverters are connected to the same RS485 multi-drop line, their addresses must be set individually (e.g. 1, 2, 3, etc.). The inverter is always considered to be a slave communication-wise, and will never start transmissions without previously receiving a packet from a master.

The RS485 port also has setup for baudrate and line/character parameters (i.e. number of data bits, parity and stop bits). Default setting for the RS485 port is 19200 bps, 8 data, even parity, 1 stop.

In addition, a failsafe (forced A/B idle line level) option can be activated for the RS485 port, which can be used if the RS485 bus lines are subject to disturbances and/or asymmetric line load that causes the idle level to become ambiguous.

The ABCC (Anybus CompactCom) interface uses by default SPI (Serial Peripheral Interface) bus for internal communication with inverter CPU. For backward compatibility with older versions of ABCC modules, it is possible to select serial interface as well. Bus/station address for ABCC interface is by default set to 126.

All three interfaces have individually configurable timeout functions which can be configured to catch fault conditions that could possibly leave the motor running while communication is lost. The functionality is activated when the timeout parameter is set to any value other than zero. When activated, the master communication device must repeatedly send any type of packet (read or write parameter) within the specified timeout period. If master fails to do so, the inverter will issue a Sio Fail (RS485/USB) or Bus Fail (ABCC) alarm. If parameter Autostop = On for the interface in question, it will also stop the motor if it's running.

There is one parameter that is common for all three interfaces and that is the Auto Reset. When set to On (default), any change of a communication parameter will take effect immediately. This is often best practice when altering any setting from the display/keypad but, if necessary, set Auto Reset = Off, and the changed communication setup will not take effect until after inverter has been restarted (power off – power on).

5.15 Display setup

The display has three positions where selectable actual values are shown (lower left, middle and right position). By default, the actual values of I_{RMS} , P_{RMS} and PF (power factor) are shown respectively. Users may change these values by altering the settings for Display Par 1, 2 and 3.

Backlight level and timeout are by default set to 50% and 2 minutes. If there is no keyboard activity within the timeout period, the display backlight will dim down to 10%. Next time any key is pressed, the backlight will resume its previous level. If timeout is set to 0, the timeout is disabled and the display will never dim down.

If the inverter is installed at a location with public access, it's possible to enable a read only lock for all setup parameters. When activated, all parameters normally writable become read only. To unlock the read only lock, user must enter pin code 139.

Note: Start/Stop and Man/Auto buttons are not locked, as this could compromise user safety. Only the ability to change the value of parameters is disabled.

5.16 Status, Temperature, Counters and Version

To obtain status and information about actual values and read-only settings, the user can access the corresponding menus: Status (actual voltages, currents, output power, analog input levels, etc.), Temperature (actual motor, power module and heat sink temperatures, as well as fan voltages and other internal voltages), Counters (running, operating, brake, current limit and undervoltage timers/counters) and Version (firmware version, serial number and production date).

5.17 Reset to factory settings

The inverter parameters can be reset to the default factory settings using the Sinus Manager (PC/Windows) programme, which can be downloaded from www.nfodrives.se

5.18 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 indicates an alarm (*Fail*),
2. the motor continues to run and the alarm relay indicates an alarm (*Alarm*),
3. there is only a fault indication on the display (*Indication*),
4. nothing (*Disable*).

The actions for each specific fault can be set individually see section 5.18.2 below.

If parameter *Auto Start* = *ON* and *Fail* is selected for the fault in question, 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 type (see Table 18). If more faults than the set *Error Count* occur within time *Reset 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.

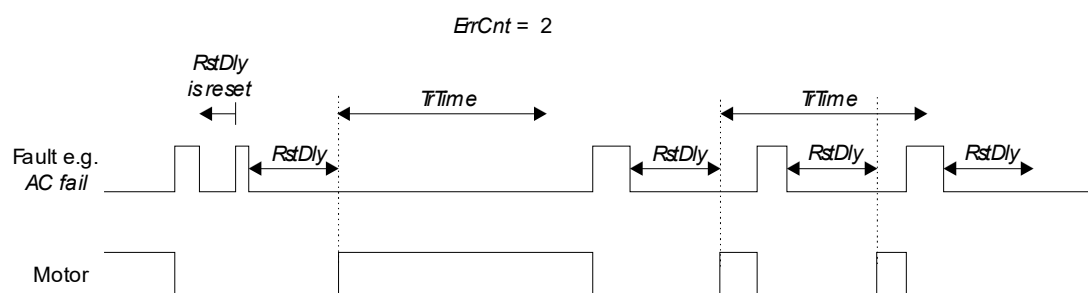


Fig. 14. Typical fault situation

5.18.1 Fault log

The last 128 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 0.01 hours (36 s) are shown. If the same fault occurs repeatedly, only the first time and most recent occurrence is logged.

5.18.2 Fault messages

All fault messages, fault types and other fault parameter setting options are shown in Table 18 below. To configure the parameters for a given fault, find the fault in parameter group *Error*.

Warning! Turning off (disable) any fault message may lead to inverter fault, and the warranty is no longer valid. If you are in any doubt how to configure the error messages, 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 but new start is inhibited)
- Indication*: Fault indication in display only (the motor is not stopped and new start is allowed)
- Disable*: Fault turned off

| Fault message | Possible fault types | Default setting | | Fault description, other fault parameters | Source of fault, action | |
|-------------------|--|-----------------|-------------|---|---|--------------|
| | | Type of fault | Error Count | | | |
| AC Fail | Fail Alarm Indication Disable | Fail | 10 | Phase error, loss of AC supply. | One supply phase missing or too high voltage difference between phases. Check fuses and supply voltage. | |
| | | | | Delay (<i>Delay</i>) | | |
| | | | | Default setting | | Range |
| | | | | 10.0 s | | 0.0 – 25.0 s |
| Temp Hi | Fail | Fail | 1 | 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 Indication Disable | Alarm | 1 | If using PTC function, the motor is overheated, thermistor input limit exceeded. | Let motor cool down. | |
| Overload | Fail Alarm Indication Disable | Alarm | 0 | The electronic motor overload protection has tripped. The motor connected has been overloaded for too long. | Let motor cool down. Adjust settings if necessary (parameters <i>Force Cool</i> and <i>Amb.Temp</i>) | |
| | | | | Forced cooling (<i>Force Cool</i>) | | |
| | | | | Default setting | | Range |
| | | | | 0 | | 0 – 3000 |
| | | | | Ambient motor temperature (<i>Amb.Temp</i>) | | |
| | | | | Default setting | | Range |
| 20 °C | -20 – 45 °C | | | | | |
| Ain Fail | Fail Alarm Indication Disable | Indication | 2 | Analogue setpoint input signal outside range. | Open or short circuit in signal line to analogue setpoint or <i>Ain Type</i> not set correctly. | |
| DC Low / Trip | Fail | Fail | 2 | DC link voltage too low, or supply is disconnected. | Power supply voltage 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 broken resistor. Deceleration time too short. Mains supply too high. Check inverter mains connections. | |
| GND Fail [S or R] | Fail Alarm Indication Disable | Fail | 0 | Earth leak current in one or more motor phases too high. S or R indicates if in Stop or Run | Possible sources of faults depending on motor operating case: | |
| Short Circ | Fail | Fail | 2 | Short-circuit between output phases | One or more output phase (U, V, W) is in contact with the protective earth (PE) or other external potential. | |
| Imagn Low | Fail Alarm Indication Disable | Fail | 2 | Magnetising current in motor too high or too low. | Short-circuit between some of the output phases (U, V, W). | |
| Cur Low | Fail Alarm Ind Disable | Fail | 2 | Current in one or more motor phases too low. | 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. | |
| Cur High | Fail Alarm Ind Disable | Fail | 2 | Current in one or more motor phases too high. | Motor parameters faulty, autotuning not performed. | |
| Cur Limit | Fail Alarm Indication Disable | Indication | 10 | Current limit has been reached. | Reduce acceleration ramp or check whether parameter I-limit matches motor used. Alarm will disappear when current falls within limit. | |

| | | | | | |
|----------|-------------------------------|-------|----|--|--|
| Run Fail | Fail Alarm Indication Disable | Fail | 10 | Inverter did not get control of the motor when starting. | Rotor is stuck. Motor was turning when started or parameter <i>R-stat</i> is set too high. Check motor is not turning when starting. Enable DC brake and/ or start delay. Verify that 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 <i>Disable</i> . |
| Sio Fail | Alarm | Alarm | 0 | Serial communication timeout. | If timeout function for the serial interface in question has been activated and communication from master is disrupted, an alarm will be issued. |
| Bus Fail | Alarm | Alarm | 0 | Field bus communication timeout or disconnection. | If timeout function for the field bus interface has been activated and communication from master is disrupted, an alarm will be issued |

Table 18. Fault messages

5.18.3 Acknowledge fault

Faults can be acknowledged in a few different ways:

- By pressing [Enter] on the display/keypad.
- If parameter Autostart = On and Run signal (DIN1) goes from active to inactive level.
- By reading parameter InvStat (Modbus register 02A4h, NFO Classic E00E8)
- By toggling bit 7 in Drive Control Word (Modbus register 0254h, NFO Classic E007C) while in Bus mode.
- By toggling bit 7 in Profidrive Control Word (Profinet/Profibus Telegram 1) while in Bus mode.
- By sending ACK cmd (code 0A00h) to parameter SMODE (Modbus register 0298h, NFO Classic E00AD)

6 Communication using Modbus

Modbus RTU or Modbus ASCII can be used for communication with the inverter. Available communication ports are RS485 (accessible from terminals) and USB type B device port implementing a virtual COM port. For setup of communication parameters, see corresponding paragraph in section 5. The inverter implements a bus slave, and will never transmit data unless transmission is initiated by a bus master. Default station address is 1.

The Modbus implementation follows “MODBUS over Serial Line Specification and Implementation Guide V1.02” and “MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b”, available from <https://www.modbus.org>

Available function codes are:

Code Description

- 03 Read Holding Registers
- 04 Read Input Registers
- 06 Write Single Register
- 16 Write Multiple Registers

Any parameter value and/or data is by default treated as a 16-bit data type, transmitted with most significant byte first (Big Endian). For 32-bit values, the low order 16-bit word is transmitted first, followed by the high order word (i.e. communication is Big Endian on a 16-bit level but Little Endian on a 32-bit level).

The available parameters of the inverter are numbered using an Application Data Interface (ADI) number, starting on 1. Each ADI (parameter index) can contain up to 64 bits of data (2x 32-bit or 4x 16-bit), but most parameter sizes are only 16 bits. Modbus register address start offset for ADI number 1 is 210h (528 in decimal), and each ADI takes up four Modbus register addresses (i.e. next Modbus register base address will be 214h, then 218h, etc).

Default bus master access to Modbus register addresses should be by using the ADI base register address (i.e. a register address that is a multiple of 4). The bus master may also choose to access the registers that are located on the “in-between addresses” (e.g. 211h, 212h and 213h), but this will only be possible if the parameter in question is 32-bit (or 2x 32-bit, 4x 16-bit, etc), and if the parameter itself requires explicit access to a register address that is not aligned with the ADI base address. If bus master makes an illegal register address access, the inverter will reply with a Modbus error code.

For bus master read access, the number of registers to read in each transmission is internally limited to the number of registers used by the ADI in question, i.e. maximum four consecutive registers (if parameter is 64 bits).

Below follows a selection of parameters that can be accessed from the inverter. A complete list of parameters can be downloaded from www.nfodrives.se

| Parameter Name | ADI | Modbus reg. addr | Type | Scaling/ Coding | Remark |
|-----------------------------------|-----|------------------|--------|--|-----------|
| I-rms (output current) | 120 | 03ECh – 03EDh | SINT32 | mA ($A \times 10^3$) | Read only |
| P-out (output power) | 121 | 03F0h – 03F1h | SINT32 | W ($kW \times 10^3$) | Read only |
| PF (output power factor) | 122 | 03F4h | SINT16 | 1×10^3 | Read only |
| Stator Freq (actual) | 125 | 0400h | SINT16 | Hz $\times 10^1$ | Read only |
| Control Freq (setpoint) | 195 | 0518h | SINT16 | Hz $\times 10^1$ | Read only |
| Rotor Speed (actual) | 22 | 0264h | SINT16 | rpm | Read only |
| Control Speed (setpoint) | 21 | 0260h | SINT16 | rpm | Read only |
| Operating Time | 39 | 02A8h – 02A9h | UINT32 | $h \times 10^2$ (one tick per every 36 s) | Read only |
| Running Time | 40 | 02ACh – 02ADh | UINT32 | $h \times 10^2$ (one tick per every 36 s) | Read only |
| Serial Control Parameters | | | | | |
| MODE | 34 | 0294h | UINT16 | 1 = Manual 2 = Auto 3 = Bus | |
| S.MODE (Command) | 35 | 0298h | UINT16 | 0 = Stop 081h = Run (from terminal) 101h = Run (from Input setpoint) | |
| Input Freq Setpoint | 124 | 03FCh | SINT16 | Hz $\times 10^1$ | |
| Input Speed Setpoint | 20 | 025Ch | SINT16 | rpm | |
| Inverter Status with Ack | 38 | 02A4h | UINT16 | Status code, see description | Read only |
| Inverter Status w/out Ack | 38 | 02A5h | UINT16 | Status code, see description | Read only |
| Alternative Serial Control | | | | | |
| Drive Control | 18 | 0254h | UINT16 | Bit field, see description | |
| Drive Status | 19 | 0258h | UINT16 | Bit field, see description | Read only |

6.1.1 Read status and actual values

If the inverter is controlled from terminals (e.g. run signal, analog input etc.), you can still use the Modbus interface for continuously reading status and actual values. First part of table above contains a selection of readable parameters that could be of interest. For status information, either read the Inverter status which returns a status code, or read the Drive status which reports status using a bit field (both described in following sections).

6.1.2 Control inverter using MODE/S.MODE/InverterStatus

To control the inverter (Start/Stop, etc) from a bus interface, the run signal (terminal DIN1) must be active. A common installation would be to strap the run signal to +24V and set parameter Autostart = Off (which is default). Then the inverter will not start by itself when powered on, but it allows control from bus.

First the master shall set the parameter MODE = 3 (bus) to gain control over the inverter. Then it can use S.MODE to send a start or stop command, see table in previous paragraph. When run command is 081h the inverter will use

whatever setpoint is available from the terminals (e.g. analog input, selected fix frequencies, etc), and for run command 101h the setpoint is taken from Input Frequency Setpoint register (when in Frequency mode), or Input Speed Setpoint register (when in Speed mode).

To setup inverter for automatic stop if communication is lost, it's possible to use the serial timeout parameter, see corresponding paragraph in section 5.

Status from inverter is reported in parameter Inverter status which can be read from Modbus register addresses 02A4h and 02A5h. Both will reply the same status code, but reading the former will also trigger an acknowledge of alarm or fault condition, if such is active. Table below shows code, corresponding text shown on inverter display, and a short description. The codes in *italic* are merely status, while other codes indicate an alarm or fault condition.

| Code | Text | Description | Code | Text | Description |
|------|--------------------|--|------|---------------------|---|
| 0 | <i>Erased</i> | <i>Error log was erased</i> | 32 | <i>Decel</i> | <i>Inverter is decelerating</i> |
| 1 | GND Fail R | Ground fail detected during run | 33 | <i>Ext Stby</i> | <i>Inverter is ready for run cmd in Auto mode</i> |
| 2 | AC Fail | Mains power error | 34 | <i>Ext Run</i> | <i>Inverter is running in Auto mode</i> |
| 3 | Temp Hi | Too high temperature on heat sink | 35 | <i>Ext Acc</i> | <i>Inverter is accelerating in Auto mode</i> |
| 4 | PTC Temp | Motor temperature sensor trip | 36 | <i>Ext Ret</i> | <i>Inverter is decelerating in Auto mode</i> |
| 5 | Overload | Electronic motor overload trip | 37 | <i>Bus Stby</i> | <i>Inverter is ready for run cmd in Bus mode</i> |
| 6 | Ain Fail | Analog input out of range | 38 | <i>Bus Run</i> | <i>Inverter is running in Bus mode</i> |
| 7 | DC Low | Internal undervoltage warning | 39 | <i>Bus Acc</i> | <i>Inverter is accelerating in Bus mode</i> |
| 8 | DC High | Internal overvoltage warning and trip | 40 | <i>Bus Ret</i> | <i>Inverter is decelerating in Bus mode</i> |
| 9 | GND Fail S | Ground fail detected during stop | 41 | <i>PI Reg</i> | <i>Process regulator is activated at terminal</i> |
| 10 | Imagn Low | Magnetization current too low or too high | 42 | <i>Calibrating</i> | <i>Calibrate procedure is ongoing</i> |
| 11 | Cur Low | Output current too low | 43 | <i>Calibr Done</i> | <i>Calibrate procedure finished</i> |
| 12 | Cur High | Output current too high | 44 | <i>BasicTun Ok</i> | <i>Basic tuning finished</i> |
| 13 | Run Fail | Locked rotor / unable to control motor | 45 | <i>Full Tun Ok</i> | <i>Full tuning finished</i> |
| 14 | Sio Fail | Serial communication timeout | 46 | <i>RsMeas Ok</i> | <i>Stator resistance measurement finished</i> |
| 15 | Bus Fail | Fieldbus communication timeout | 47 | <i>ParCalc Ok</i> | <i>Parameter calculation finished</i> |
| 16 | Tun Fail P | Tuning error, parameter value | 48 | Short Circ | Short circuit error detected |
| 17 | Tun Fail M | Tuning error, measurement | 49 | DC Low Trip | Internal undervoltage trip |
| 18 | RsMeasFail | Tuning error, stator resistance | 50 | SampleTime | Internal error, measurement sample time |
| 19 | TuneCnvFail | Tuning error, calculation | 51 | Motor Volt | Voltage detected on motor terminals |
| 20 | Dsp ComErr | Internal error, communication | 52 | <i>Unused</i> | <i>Reserved for future use</i> |
| 21 | Cop Restrtr | Internal error, restart/reboot | 53 | <i>Not Tuned</i> | <i>Tuning has not been performed</i> |
| 22 | Dsp SysErr | Internal error, measurement circuits | 54 | <i>Delay Run</i> | <i>Inverter will start after run delay time</i> |
| 23 | Cop ComErr | Internal error, communication | 55 | <i>DC Low Ctrl</i> | <i>Internal undervoltage regulation active</i> |
| 24 | <i>Stop</i> | <i>Inverter is stopped</i> | 56 | <i>DC High Ctrl</i> | <i>Internal overvoltage regulation active</i> |
| 25 | <i>Wait</i> | <i>Inverter is waiting to become ready</i> | 57 | <i>Fact Reset</i> | <i>Parameters was reset to factory default</i> |
| 26 | <i>Brake Ch</i> | <i>Brake chopper is operating</i> | 58 | <i>Cop FwUpdt</i> | <i>Firmware update of co-processor</i> |
| 27 | <i>Cur Limit</i> | <i>Current limit has been reached</i> | 59 | <i>Dsp FwUpdt</i> | <i>Firmware update of DSP</i> |
| 28 | <i>Tuning</i> | <i>Tuning is ongoing</i> | 60 | <i>Gui FwUpdt</i> | <i>Firmware update of GUI</i> |
| 29 | <i>Sleep</i> | <i>Inverter has entered sleep mode</i> | 61 | <i>Unused</i> | <i>Reserved for future use</i> |
| 30 | <i>Final Freq</i> | <i>Inverter has reached final frequency</i> | 62 | <i>Unused</i> | <i>Reserved for future use</i> |
| 31 | <i>Accel</i> | <i>Inverter is accelerating</i> | 63 | <i>Unused</i> | <i>Reserved for future use</i> |

6.1.3 Control inverter using DriveControl/DriveStatus

As an alternative to the MODE/SMODE method, it's also possible to control the inverter in a fashion more similar to controlling from Profibus/Profinet, using bit field registers for control and status. When using Drive control register, the inverter takes its setpoint from terminals (e.g. analog) or whatever setpoint is selected using other parameters.

Combining control methods MODE/SMODE with Drive control is not allowed as it can render unpredictable behaviour. Also, MODE/SMODE and/or Drive control must not be used when using Profibus, Profinet or any other Anybus CompactCom (fieldbus) module.

Drive control bit field description:

| Bit | Name | Description | Bit | Name | Description |
|-----|-----------|---|-----|-----------------|---|
| 0 | Switch on | Run command (run signal must be active) | 8 | Not used | - |
| 1 | Not used | (value echoed to drive status bit 4) | 9 | Not used | - |
| 2 | Not used | (value echoed to drive status bit 5) | 10 | Not used | - |
| 3 | Enable | Enable command (must precede Run cmd) | 11 | Not used | - |
| 4 | Not used | - | 12 | Not used | - |
| 5 | Not used | - | 13 | Not used | - |
| 6 | Not used | - | 14 | Bus control cmd | PLC takes control (must precede Enable) |
| 7 | Fault ack | Fault acknowledge on 0 to 1 transition | 15 | Not used | - |

Drive status bit field description:

| Bit | Name | Description | Bit | Name | Description |
|-----|--------------|--|-----|------------------|---|
| 0 | Ready | Ready to receive enable command | 8 | Not used | - |
| 1 | Switched on | Inverter output stage is active | 9 | Control from bus | Inverter is in bus mode |
| 2 | Enabled | Enabled, ready to receive run command | 10 | Setpoint reached | Output frequency has reached setpoint |
| 3 | Fault active | Fault condition active (may require ack) | 11 | Limit active | Inverter has reached current limit |
| 4 | Not used | (returns value of drive control bit 1) | 12 | Sleep active | Output is suspended in sleep mode |
| 5 | Not used | (returns value of drive control bit 2) | 13 | Stopmode brake | Inverter will brake/ramp to stop |
| 6 | Disabled | Run signal not present on terminal DIN1 | 14 | Reverse | Actual rotation is reverse |
| 7 | Alarm active | Alarm condition active (not require ack) | 15 | Stopping | Inverter is decelerating towards a stop |

An example of communication could be that bus master sets the Bus control command bit and then waits for inverter to respond with Control from bus bit in status. Then bus master sets the Enable bit and waits for inverter to respond with Enabled. Now the bus master may start the motor using the Switch on command bit, and inverter will respond with Switched on.

When bus master clears the Switch on bit, inverter will decelerate towards a stop. When fully stopped, the Switched on bit will be cleared and inverter is now ready for a new start command. For other status bits and their meaning, see table above.

7 Control using Profinet/Profibus

The NFO Sinus Optimal implements Profibus/Profinet Telegram 1 for control/status word and setpoint/actual value. Within the telegram, the parameters are available at following slots (all are 16-bit):

| Slot | Parameter |
|------|--|
| 1 | Profidrive Status word |
| 2 | Profidrive Actual frequency (or speed) |
| 3 | Profidrive Control word |
| 4 | Profidrive Setpoint frequency (or speed) |

Slots are sometimes numbered 0 through 3 instead, but the order of parameters are always as in list above. Actual and Setpoint values are scaled so that the range -8192 – +8192 corresponds to either -50Hz – +50Hz (when in Frequency mode), or -Nnom – +Nnom, e.g. -1500 rpm – +1500 rpm for a four-pole motor (when in Speed mode). A negative number corresponds to reverse rotation. Maximum range is -24576 – +24576 ($\pm 150\text{Hz}$ or $\pm 3 \times \text{Nnom}$).

To control the inverter (Start/Stop, etc) from a fieldbus interface, the run signal (terminal DIN1) must be active. A common installation would be to strap the run signal to +24V and set parameter Autostart = Off (which is default). Then the inverter will not start by itself when powered on, but it allows control from bus.

Profidrive control bit field description:

| Bit | Name | Description | Bit | Name | Description |
|-----|-----------|---|-----|-------------|---|
| 0 | Switch on | Run command (run signal must be active) | 8 | Not used | - |
| 1 | Not used | (value echoed to drive status bit 4) | 9 | Not used | - |
| 2 | Not used | (value echoed to drive status bit 5) | 10 | PLC control | PLC takes control (must precede Enable) |
| 3 | Enable | Enable command (must precede Run cmd) | 11 | Not used | - |
| 4 | Not used | - | 12 | Not used | - |
| 5 | Not used | - | 13 | Not used | - |
| 6 | Not used | - | 14 | Not used | - |
| 7 | Fault ack | Fault acknowledge on 0 to 1 transition | 15 | Not used | - |

Profidrive status bit field description:

| Bit | Name | Description | Bit | Name | Description |
|-----|--------------|--|-----|-------------------|---|
| 0 | Ready | Ready to receive enable command | 8 | Not used | - |
| 1 | Operating | Inverter output stage is active | 9 | Control requested | Inverter is in bus mode |
| 2 | Enabled | Enabled, ready to receive run command | 10 | Setpoint reached | Output frequency has reached setpoint |
| 3 | Fault active | Fault condition active (may require ack) | 11 | Limit active | Inverter has reached current limit |
| 4 | Not used | (returns value of drive control bit 1) | 12 | Sleep active | Output is suspended in sleep mode |
| 5 | Not used | (returns value of drive control bit 2) | 13 | Stopmode brake | Inverter will brake/ramp to stop |
| 6 | Disabled | Run signal not present on terminal DIN1 | 14 | Reverse | Actual rotation is reverse |
| 7 | Alarm active | Alarm condition active (not require ack) | 15 | Stopping | Inverter is decelerating towards a stop |

A communication example could be that master sets the PLC control bit and then waits for inverter to respond with Control requested bit in status word. Then bus master sets the Enable bit and waits for inverter to respond with Enabled. Now the bus master may start the motor using the Switch on command bit, and inverter will respond with bit Operating.

When master clears the Switch on bit, inverter will decelerate towards a stop. When fully stopped, the Operating bit will be cleared. Motor is now stopped and inverter is ready for a new start command. For other status bits and their meaning, see table above.


Please contact NFO Drives AB for Profinet/Profibus setup files (gsdml/gsd format).

8 Brake chopper and power surge regulator

If the inverter is trying to decelerate a motor with a high load inertia, energy is fed back to the inverter. This causes the voltage in the internal DC stage (power terminals + and -) to rise. To prevent the voltage rising too high and damaging the inverter, a surge regulator limits the deceleration.

If the regulator limits the deceleration too much (taking longer time than parameter *Decel*), an external brake resistor must be installed to convert the regenerated energy into heat. This resistor is mounted between power terminals + and B (see Table 4 and Fig.1). When the brake chopper is active, it appears as an indication on the display.

NOTE: The resistor's power handling capacity must be dimensioned to absorb the generated excess energy from the rotating load. Recommended resistance for inverters with 3 x 400V power supply is 100 – 300 Ω. 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.

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

If in any doubt regarding how to install this type of equipment, always contact NFO Drives AB.

9 Getting started

9.1 Installation

Perform all steps of Mechanical installation (section 3, page 7) and Electrical installation (section 4, page 8). If the inverter is already installed and you are going to power up and configure the inverter for the first time, double check that the inverter is correctly installed, both mechanically and electrically, before applying power.

First time powered up after installation, or after performing a factory reset of parameters, the installer will be prompted to select application type for the inverter. See section 5.6.

Furthermore, the motor nameplate data shall be entered in the inverters' setup, and a tuning of the motor shall be performed. See section 5.7.

At start up the inverter always goes into *Auto* mode which is used for operating with control from terminals, e.g. analog input setpoint and run signal, etc. The *Manual* mode is designed to be used for manually controlling the inverter from the keyboard with a fixed frequency, for instance if you want to check that the motor is connected and turns in the right direction. Parameter *Phase order* can be used to flip the rotation direction, see section 5.8.2.

9.2 Running in Manual mode


Procedure below can be used to check that everything is connected correctly and that motor is turning in the right direction.

- Press [MAN/AUTO] to go to *Manual* mode.
- Set the frequency desired in display window. Use [↑] and [↓] to change setpoint. Positive frequency setpoint means clockwise rotation, negative means counter clockwise.
- The motor is started by pressing [START] and stopped by pressing [STOP].

9.3 Running in Auto mode

9.3.1 Setvalue selection in automode

The source for the setpoint is controlled by parameter *Op mode (Setp Source)* for the selected control mode (parameters *Frequency/Op Mode*, *Speed/Op Mode* or *PI-Reg/Op Mode*). If Op Mode is set to *Terminal* (default) the setpoint selection is chosen according to the actual digital input combination of DIN2 – DIN7 according to Table 7.

 **The digital inputs (DIN2 – DIN7) are continuously sampled so a change of the digital input combination will immediately alter the setpoint. Make sure that the digital signals are stable without glitches to avoid sudden setpoint changes.**

9.3.2 Running with fixed frequency

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

- Press [MAN/AUTO] to go to *Manual* mode.
- Press [ESC] to enter setup.
- Set parameter *Fix Frq 2* in parameter group *Frequency* to 25 Hz.
- Set parameter *Op Mode* in parameter group *Frequency* to *Fix2 F*.
- Press [ESC] until you return to RUN screen.
- Connect a jumper between DIN1 (terminal 1, Run signal) and terminal 9 (+24V).
- Press [MAN/AUTO] to go to *Auto* mode and the motor will start.
- Optional: If you want automatic start after power up, with a permanently connected Run signal, set parameter *Autostart = On* in parameter group *Control*.

9.3.3 Running with analog setpoint

Example below applies to running motor with analogue setpoint 0 – 10 V resulting in 10 – 60 Hz frequency.

- Connect analog control signal between terminal 20 (AIN1.P) and terminal 21 (AIN1.N).
- Check that parameter *Ain 1 Type* in parameter group *Control* is set to *0-10 V*.
- Set parameter *Min Freq* in parameter group *Frequency* to 10Hz.
- Set parameter *Max Freq* in parameter group *Frequency* to 60Hz.
- Start motor by connecting terminal 1 (DIN1, Run signal)) to terminal 9 (+24V).
- Stop motor by disconnecting terminal 1 and terminal 9.

9.3.4 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 kPa pressure sensor. Control mode *Frequency* will be used.

- Set parameter *Control Mode* in parameter group *Control* to *PI-reg*.
- Connect actual value signal between terminal 22 (AIN2.P) and terminal 23 (AIN2.N).
- Check that parameter *Ain 2 Type* in parameter group *Control* is set to *0-10V*.
- Set parameter *Unit* in parameter group *PI-reg* to *kPa*.
- Set parameter *Op Mode* in parameter group *PI-reg* to *Fix1 F*.
- Adjust parameter *Fix Reg1* in parameter group *PI-reg* to desired setpoint value.
- Set desired max and min motor frequency using parameter *Max Freq* and *Max Freq* in parameter group *PI-reg*.
- Set actual value sensor measures at 0V (0 kPa) using parameter *Actual Min* in parameter group *PI-reg*.
- Set actual value sensor measures at 10V (300 kPa) using parameter *Actual 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 [MAN/AUTO].
- Stop motor by disconnecting terminal 1 and terminal 9.

9.3.5 Process regulation with analog setpoint

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

- Set parameter *Control Mode* in parameter group *Control* to *PI-reg*.
- Connect actual value signal between terminal 22 (AIN2.P) and terminal 23 (AIN2.N).
- Connect setpoint value signal between terminal 20 (AIN1.P) and terminal 21 (AIN1.N).
- Check that parameter *Ain 2 Type* in parameter group *Control* is set to *0-10V*.
- Check that parameter *Ain 1 Type* in parameter group *Control* is set to *0-10V*.
- Set parameter *Op Mode* in parameter group *PI-reg* to *Terminal*.
- Set parameter *Unit* in parameter group *PI-reg* to *kPa*.
- Set desired max and min motor frequency using parameter *Max Freq* and *Max Freq* in parameter group *PI-reg*.
- Set actual value from sensor at 0V (0 kPa) using parameter *Actual Min* in parameter group *PI-reg*.
- Set actual value from sensor at 10V (300 kPa) using parameter *Actual Max* in parameter group *PI-reg*.
- Set setpoint value from sensor at 0V (0 kPa) using parameter *Setpoint Min* in parameter group *PI-reg*.
- Set setpoint value from sensor at 10V (300 kPa) using parameter *Setpoint 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 [MAN/AUTO]
- Stop motor by disconnecting terminal 1 and terminal 9.

9.3.6 Alternating fixed frequency and process regulation

Once a process regulation configuration has been set up and trimmed using the Control Mode PI-reg, it's possible to use a combination of process regulation and a setpoint frequency, using an external time relay connected to DIN4. This could for example be used for controlling ventilation during daytime with process regulator (i.e. fan speed is controlled for producing a certain pressure), and during night time the fan operates at another (low) frequency.

- Set up and trim the regulator using *Control Mode PI-reg*.
- Set parameter *Control Mode* in parameter group *Control* to *Frequency*.
- Connect an analog control signal to terminal 20 (AIN1.P, positive) and terminal 21 (AIN1.N, negative) that gives the desired night time (low frequency) setting.
- Connect a time relay or other contact between DIN4 (PI-reg) and a +24V source. When DIN4 terminal is active, the PI-reg is activated. When DIN4 is not active, the inverter selects the night time setup frequency.

9.3.7 Ventilation control with analog setpoint and fire alarm

For ventilation installations, it is sometimes necessary to let an external signal or alarm contact override the control setpoint, e.g. in a case of fire alarm the fan should speed up to pre-defined or maximum ventilation. Example sets up for normal conditions 10 – 40 Hz using analog input 0 – 10 V as setpoint, and changes to 50Hz if alarm occurs.

- Connect analog control signal to terminal 20 (AIN1.P, positive) and terminal 21 (AIN1.N, negative).
- Connect fire alarm indication signal to DIN5 (Select A / Fix 1).
- Set parameter *Ain 1 Type* in parameter group *Control* to *0-10 V*.
- Set parameter *Op Mode (Setp Source)* in parameter group *Frequency* to *Terminal*.
- Set parameter *Fix Frq 1* in parameter group *Frequency* to 50Hz.
- Set parameter *Freq Min* in parameter group *Frequency* to 10Hz.
- Set parameter *Freq Max* in parameter group *Frequency* to 40Hz.
- Start motor by connecting terminal 1 (DIN1, Run signal)) to terminal 9 (+24V).

