

Operating and Installation Manual

NFO Sinus Optimal

400V 3~ 2.2 kW 5.5 kW 11 kW 18.5 kW

with

Safe Torque Off

Contents

1	Safety aspects	4
2	Technical data.....	5
3	Mechanical installation.....	7
	3.1 Mounting	7
	3.1.1 2.2 kW and 5.5 kW models.....	7
	3.1.2 11 kW and 18.5 kW models.....	8
4	Electrical installation	8
	4.1 Power terminal connection.....	9
	4.1.1 Connectors and cables	9
	4.1.2 Power terminal use	10
	4.1.3 Connecting mains supply	10
	4.1.4 Connecting motor	11
	4.1.5 Motors in parallel	11
	4.1.6 Motor configuration	11
	4.2 Signal terminal connection.....	12
	4.2.1 Signal terminals and their use	12
	4.2.2 Safe Torque Off (STO) installation	13
	4.2.3 Signal terminals configuration	15
	4.2.4 Negative logic	15
	4.2.5 Analog voltage inputs	15
	4.2.6 Analog current inputs.....	15
	4.2.7 Connecting potentiometer	16
	4.2.8 Serial channel RS485.....	16
5	Parameter settings and operation.....	17
	5.1 General notes	17
	5.2 Keyboard and display	17
	5.3 Indicators and Motor status.....	18
	5.4 Select application.....	19
	5.5 Autotuning and motor parameters	19
	5.5.1 Full tuning	19
	5.5.2 Basic tuning	20
	5.5.3 Calculated tuning.....	20
	5.6 Operating modes	20
	5.6.1 Manual Mode	21
	5.6.2 Auto Mode	21
	5.6.3 Bus Mode (Serial channel / Field bus).....	22
	5.6.4 Fire Mode.....	23
	5.7 Parameter specifications.....	24
	5.7.1 Parameter summary	24
	5.7.2 Parameter table	24
	5.8 Setting control parameters.....	28
	5.8.1 Acceleration and deceleration ramps	28
	5.8.2 Phase order	29
	5.8.3 Stop mode	29
	5.8.4 Energy save function	29
	5.8.5 Power On, Start and Stop delay	30
	5.8.6 Motor brake, <i>DC-Brake</i>	30
	5.8.7 Speed regulator, <i>Kp-speed</i> and <i>Ti-speed</i>	30
	5.8.8 Frequency sleep setting	31
	5.8.9 Frequency bypass	31
	5.8.10 Increased start current (current boost)	31
	5.8.11 Control Mode	32

5.8.12	Autostart	32
5.8.13	Analog input type	32
5.8.14	DIN selectable functions	32
5.8.15	Digital potentiometer (Increment / Decrement)	33
5.8.16	Fire Mode configuration	33
5.9	Frequency control without load compensation – Frequency Mode	34
5.9.1	Setpoint source for Frequency Mode	34
5.9.2	Analog frequency setpoint range	34
5.10	RPM regulation with speed estimation – Speed Mode	34
5.10.1	Setpoint source for Speed Mode	35
5.10.2	Analog speed setpoint range	35
5.11	Process regulation, PI regulator	35
5.11.1	Setpoint source for PI-reg mode	37
5.11.2	Regulator setting, Reg Amp, Reg Kp and Reg Ti	38
5.12	Motor safety functions	38
5.12.1	PTC input	38
5.12.2	Electronic motor overload protection	38
5.13	Output signals	39
5.13.1	Relay 1 (Alarm relay)	39
5.13.2	Relay 2 (Run indication)	39
5.13.3	Analog outputs	39
5.14	Communication interfaces	40
5.15	Display setup	40
5.16	Status, Temperature, Counters and Version	41
5.17	Reset to factory settings	41
5.18	Alarm and fault procedures	42
5.18.1	Fault log	42
5.18.2	Fault messages	42
5.18.3	Acknowledge fault	44
6	Communication using Modbus	44
6.1.1	Read status and actual values	45
6.1.2	Control inverter using MODE/SMODE/InverterStatus	46
6.1.3	Control inverter using DriveControl/DriveStatus	47
7	Control using Profinet/Profibus	48
8	Brake chopper and power surge regulator	49
9	Getting started	49
9.1	Installation	49
9.2	Running in Manual mode	49
9.3	Running in Auto mode	50
9.3.1	Setvalue selection in automode	50
9.3.2	Running with fixed frequency	50
9.3.3	Running with analog setpoint	50
9.3.4	Process regulation with fixed setpoint	50
9.3.5	Process regulation with analog setpoint	51
9.3.6	Alternating fixed frequency and process regulation	51
9.3.7	Ventilation control with both analog and fixed setpoints	52
9.3.8	Ventilation control with analog setpoint and Fire Mode	52

Introduction

The frequency inverter described in this operating manual is used for frequency (Hz) or speed (rpm) control of three-phase AC induction motors. 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, and it is designed for standard unshielded motor cable.

A 30mA rated RCD (earth leakage circuit breaker) of type A or B 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 be conducted by adequately trained and experienced personnel.


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. 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.


 **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 re-gain control over inverter and start motor again.



 For connection of mains supply, the inverter shall be permanently connected to fixed wiring including a circuit breaker which must 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 min/max 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. For such applications, the inverter includes a Safe Torque Off functionality which uses dual independent channels, for connection to an emergency stop switch.

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 ^[8] (H×D×W) [mm]	Weight [kg]
4A4D3490D	2.2 kW	1.0 - 4.9 A	5.8 A	3.3 kVA	0.14 kW	IE2	7.5 W	390x190x160	7.0
4B4D3111D	5.5 kW	3.5 - 11 A	13.3 A	7.94 kVA	0.27 kW	IE2	7.9 W	390x190x200	9.5
4C4D3221D	11 kW	6.5 - 22 A	26.4 A	14.4 kVA	0.47 kW	IE2	8.6 W	485x225x305	22
4D4D3351D	18.5 kW	14 - 35 A	42 A	23.9 kVA	0.78 kW	IE2	9.1 W	565x225x305	31

Notes:

- [1] Each inverter size is optimized for use at a wide range of nominal motor currents in the power ranges of 0.37 kW to 18.5 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.
- [8] For models 11kW and 18.5kW, height is specified excluding 35 mm mounting flange on top.

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 analog feedback in all control modes		
Speed regulator	Regulator for optimal dynamic performance		
I/O	No.	Name	Configurable levels
Digital control inputs	4 (plus 4)	DIN1 – DIN4 (DIN5 – DIN8)	
Analog control inputs	2x voltage 2x current	AIN1 U & I, AIN2 U & I (shared with DIN5 – DIN8)	0-10V, 2-10V, ±10V, 0-20mA, 4-20mA, ±20mA, Pot
Digital outputs	2	Re1, Re2	Relay, max 50VDC
Analog 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 C, RS485	
Serial protocols	2	Modbus RTU / ASCII, NFO	
Fieldbus options	Profinet, Profibus, Modbus TCP by using AnyBus CompactCom module		
Personal safety			
Safe Torque Off	Dual channel input for emergency stop switch, which when activated prevents the inverter from generating any torque (neither accelerating nor braking).		
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	Class I according to EN 61800-5-1 IP55 according to EN 60529		
EMC certification	Emissions: EN 55011:2016 +A1:2017 +A11:2020 +A2:2021, EN 61000-3-3:2013, EN IEC 61800-3:2024 Immunity: EN 61000-6-2:2005, EN 61000-4-2, -3, -4, -5, -6, -8, -11, -34 Harmonics: EN 61000-3-2:2019 (≤16A), EN 61000-3-12:2011 (>16A) ^[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] Refer to Electrical installation section for correct setup depending on inverter size.

[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 (2.2 kW & 5.5 kW models), a free space of 250 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

3.1.1 2.2 kW and 5.5 kW models

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.



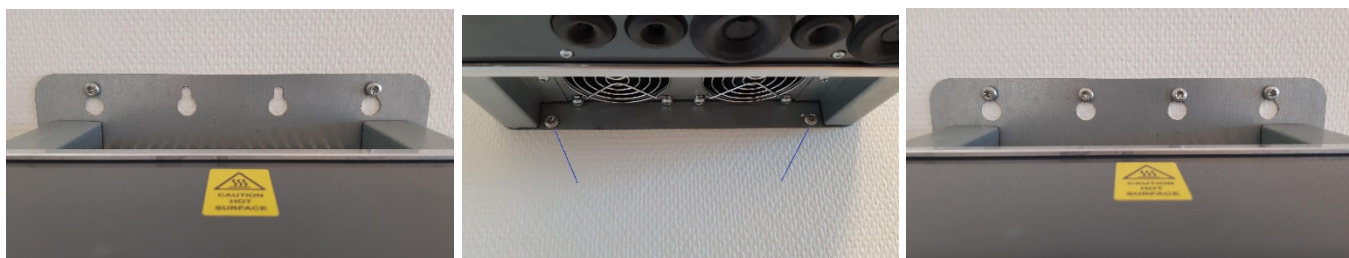
The cover is opened by unscrewing the two captive screws in the plastic cover and fold up the cover until it snaps tight. There are two possible positions for the cover. Close the cover by pulling it out and fold down. Be careful not to break the snaps in the cover when folding down. Tighten the screws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

3.1.2 11 kW and 18.5 kW models

Make sure that the wall material is sturdy and capable of holding the weight of the inverter. If necessary, reinforce the wall with chipboard or other equivalent material. Use a level and mark four positions with 70 mm c-c distance. Bottom screws are located 580 mm below.

1. Screw in two 6 mm screws in the outer positions, leaving a 3 – 5 mm gap towards the wall, and hang the inverter top flange on the two screws.
2. Adjust the vertical alignment of the inverter and mount two 6 mm screws at the bottom.
3. Finally tighten the two first top screws and mount two additional screws at the top.



4. Access to electrical terminals: The lid is opened by unscrewing the two captive screws at the bottom corners. Then flip up and remove the lid. Make sure not to break or misplace the lid during installation. When installation is complete, mount the lid and tighten the screws.

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.
- Connect **Safe Torque Off** terminals (STO1P-STO1N and STO2P-STO2N) to external emergency stop switch, or strap terminals internally if Safe Torque Off is not used.



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.

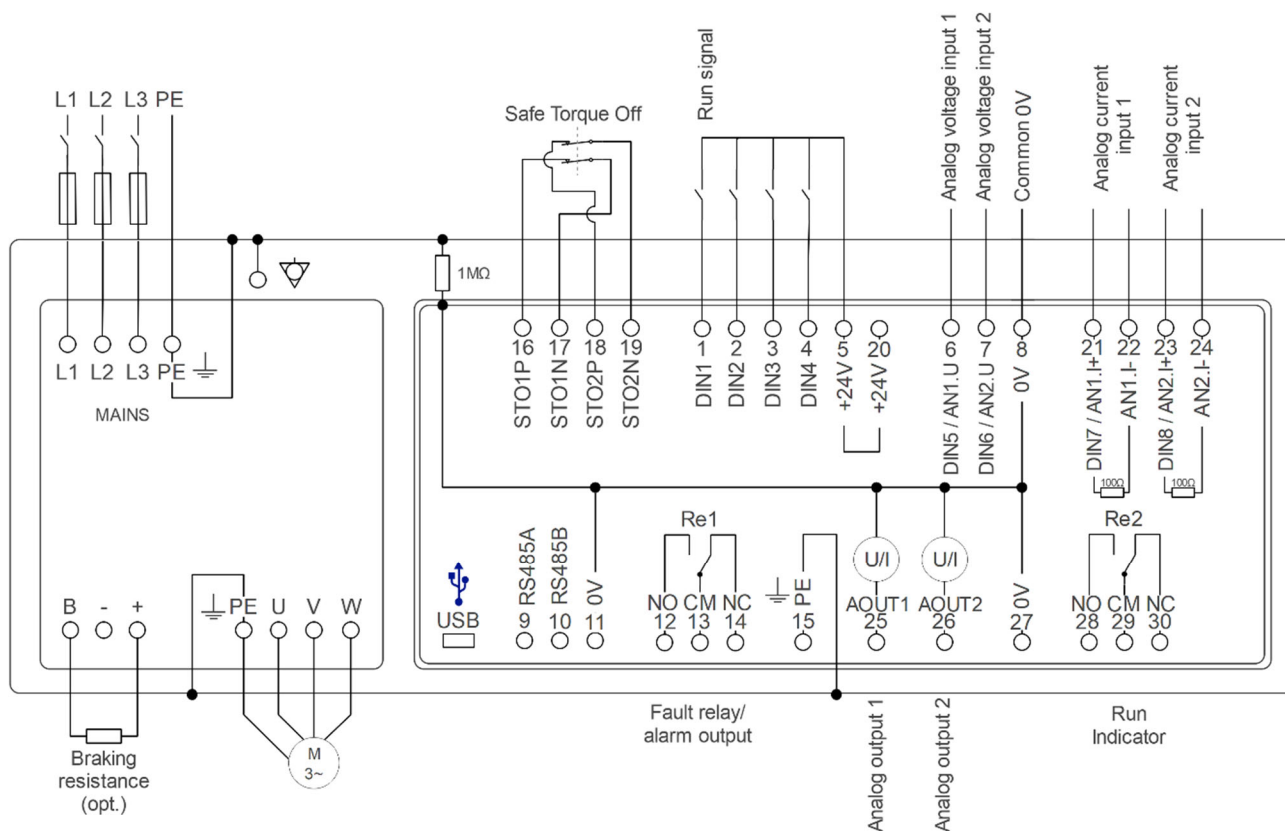


Fig. 1 Default configuration

4.1 Power terminal connection

4.1.1 Connectors and cables

The power terminals are of type “Push-Lock” with a cross section area of 0.75 – 6 mm² (AWG 20 – AWG 10) for inverter models up to 16A mains connection, and 1.5 – 16 mm² (AWG 15 – AWG 5) for inverter models with a supply current of more than 16A. Use standard unshielded cable

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 in picture below.



Inverters for supply current of more than 16A have terminal connectors that closes with spring force. Keep fingers away from clamp lever, as it closes rapidly.



Verify that power and motor cables are securely fastened by pulling each cable after terminals are closed.

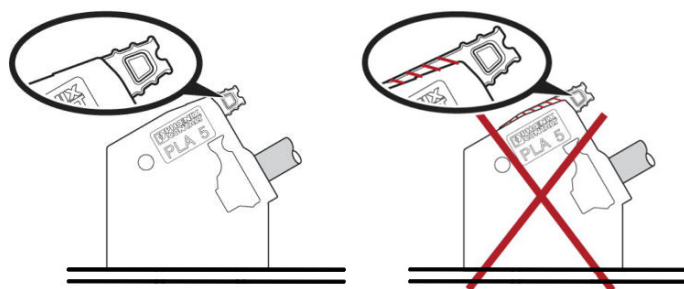


Fig. 2 The connection lever of the power terminals

4.1.2 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 or unwanted behaviour of the motor.
V		
W		

Table 3. 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 DC 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.


4.1.3 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). Rated input current, recommended slow-blow fuses and harmonics compliance for three-phase supply as in table below.

Model	Rated current	Fuse	Harmonics compliance	Restrictions and notification
2.2 kW	4 A	10 A	EN 61000-3-2	Unit is by default compliant with complete range harmonic limits up to 80% of nominal load, and up to and including the 15 th harmonic at nominal load.
5.5 kW	10 A	16 A	EN 61000-3-2	Unit is internally protected against harmonic surges. For compliance with harmonics limits at nominal load, use external harmonics filter of type BLOCK HF1K 7-400.
11 kW	20 A	32 A	EN 61000-3-12	Unit is internally protected against harmonic surges. For compliance with harmonics limits at nominal load, installer must verify that mains network has a short circuit power (S_{sc}) of no less than 1.42 MVA.
18.5 kW	32 A	63 A	EN 61000-3-12	Unit is internally protected against harmonic surges. For compliance with harmonics limits at nominal load, installer must verify that mains network has a short circuit power (S_{sc}) of no less than 2.47 MVA.






Table 4. Recommended fuses and harmonic compliance

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 of type A or B 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.**


4.1.4 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 shall be configured for Y-connection, and a motor with nominal voltage of 690V–Y / 400V–D shall 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.
-  An external brake-resistor must be fitted if the retardation time is less than 5 sec, or if the driven load has a substantial inertia. See section 8.
-  **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).

4.1.5 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.

4.1.6 Motor configuration

For small 400V–Y / 230V–D motors, in the low end of the inverter's range of nominal motor power, it is often better to configure the motor for 230V (D) even though the inverter uses 400V. With 230V (D) configuration, the nominal current is higher and this helps to extend the low end range of power handling capability of the inverter.

4.2 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 before inserting cable. If a tool is used, make sure it does not damage any components on the circuit board. Use the built-in anchor points for securing the signal cables to the board edge, with one or more straps.

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

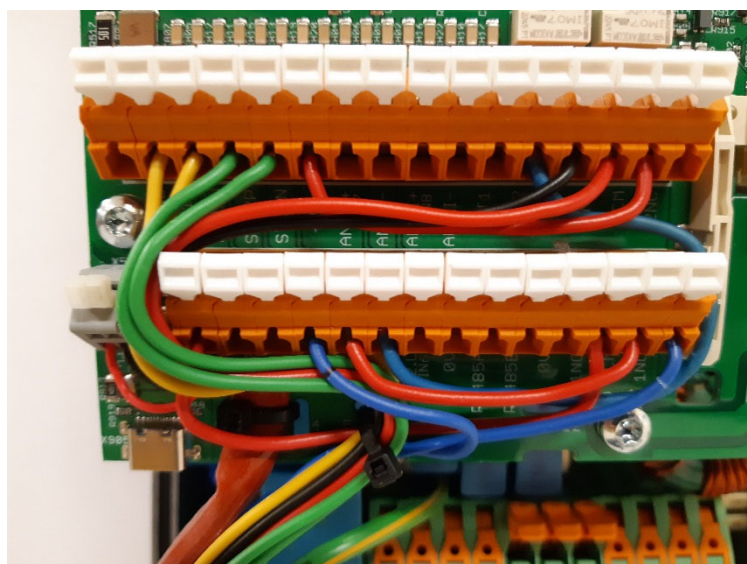


Fig. 3 Signal line wiring.

4.2.1 Signal terminals and their use

Term.	Name	Function	Default function description
1	DIN1	Digital input 1	RUN (Run signal Start/Stop)
2	DIN2	Digital input 2	AN-select (Analog 1 or 2 input setpoint selection)
3	DIN3	Digital input 3	REV (Reverse direction of rotation)
4	DIN4	Digital input 4	SEL-A (Select fixed frequency) (see Table 8)
5	+24V	+24V output/ext. supply	Output voltage for digital inputs or external load (max 200mA)
6	AN1.U (DIN5)	Analog input 1 voltage alt. Digital input 5	Analog setpoint input voltage
7	AN2.U (DIN6)	Analog input 2 voltage alt. Digital input 6	Analog actual value input voltage (process regulator)
8	0V	0V ext. supply	Common signal ground, reference for digital and analog inputs
9	RS485A	RS485 serial port	Serial port
10	RS485B	RS485 serial port	Serial port
11	0V	0V ext. supply	Common signal ground, reference for digital and analog inputs
12	RE1.NO	Relay 1 Normally Open	Fault relay. Potential-free contacts max 1 A, 50 V DC. Terminals 13 and 14 are closed if fault is present, or if inverter is not powered up.
13	RE1.CM	Relay 1 Common	
14	RE1.NC	Relay 1 Normally Closed	
15	PE	Ground / Protective Earth	
16	STO1P	Safe Torque Off, circuit 1	Connect STO1P to STO1N to enable inverter operation.
17	STO1N	Safe Torque Off, circuit 1	When not connected, the Safe Torque Off function is activated.
18	STO2P	Safe Torque Off, circuit 2	Connect STO2P to STO2N to enable inverter operation.
19	STO2N	Safe Torque Off, circuit 2	When not connected, the Safe Torque Off function is activated.
20	+24V	+24V output/ext. supply	Output voltage for digital inputs or external load (max 200mA)
21	AN1.I+ (DIN7)	Analog input 1 current + alt. Digital input 7	Analog setpoint input current, positive
22	AN1.I- (DIN7)	Analog input 1 current - alt. Digital input 7	Analog setpoint input current, negative
23	AN2.I+ (DIN8)	Analog input 2 current + alt. Digital input 8	Analog actual value input current, positive (process regulator)
24	AN2.I- (DIN8)	Analog input 2 current - alt. Digital input 8	Analog actual value input current, negative
25	AOUT1	Analog output 1	Analog output, voltage or current
26	AOUT2	Analog output 2	Analog output, voltage or current
27	0V	0V ext. supply	Common signal ground, reference for digital and analog inputs
28	RE2.NO	Relay 2 Normally Open	Run indication. Potential-free contacts max 1 A, 50 V DC. Terminals 28 and 29 are closed when motor is running.
29	RE2.CM	Relay 2 Common	
30	RE2.NC	Relay 2 Normally Closed	

Table 5. Signal terminals and their use

Terminals 8, 11 and 27 (0V) are internally connected to PE through a 1M Ω resistor. These terminals may vary in terms of potential by up to 100 V from PE. The internal 0V circuit may be connected galvanically to PE via an external jumper wire to terminal 15 (PE). The USB contact is galvanically connected to 0V.

Digital inputs terminals 1 - 4, when configured for positive logic:






Maximum input voltage: 30V
 Switch level: \approx 10V (input voltage *higher* than switch level is considered as active level)
 Impedance: 10k Ω

Digital inputs terminals 1 - 4, when configured for negative logic:

Maximum input voltage: 30V
 Switch level: \approx 9V (input voltage *lower* than switch level is considered as active level)
 Impedance: 10k Ω




Digital inputs terminals 5 - 8, always using positive logic, shared with analog function:

Maximum input voltage: 30V
 Switch level: \approx 10V (input voltage *higher* than switch level is considered as active level)
 Impedance: \approx 100k Ω

-  Digital inputs DIN5 – DIN8 are shared with analog functions. For correct operation they require 24V_{DC} supply. Normally, the digital and analog functions are internally supplied, but if the 24V_{DC} from inverter is used for supplying external loads, the **maximum load must not be exceeded**. Failure to control maximum external load may lead to voltage limiting or shutdown, which could lead to inaccurate or wrong readings of analog and digital inputs.
-  When any of inputs DIN5 – DIN8 are used as digital inputs, they still have the high input impedance of the analog circuit, and it is recommended to always use shielded cables also for digital input configuration.
-  If DIN7 (terminal 21) or DIN8 (terminal 23) is used as a digital input, its corresponding negative peer (terminal 22 or 24 respectively) must be left floating, otherwise applying input voltage level (24V_{DC}) to the pin can damage the current sensing functionality.
-  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.
-  If a Motor Safety Thermistor is to be used, it's recommended to use DIN4, terminal 4. See section 5.12.1.

4.2.2 Safe Torque Off (STO) installation

The Safe Torque Off terminals STO1P – STO1N and STO2P – STO2N provides dual independent input channels for preventing the inverter from generating torque. Activation of Safe Torque Off corresponds to stop category 0 according to EN 60204-1, where the power output of the drive is immediately interrupted and the driven load is brought to an uncontrolled stop. Using dual independent channels makes the installation resistant to single component failures, e.g. involuntary short circuit or error in wiring between inverter and an emergency stop switch. Any such component failure or wiring error will be detected by the inverter and operation will then be inhibited.

-  When Safe Torque Off is activated, the inverter can no longer produce any torque, neither acceleration nor braking. If braking is required, it must be carried out by other measures such as a mechanical brake.
-  Do not use the Safe Torque Off function for hoists, transport mechanisms, suspended loads, or other applications where an uncontrolled stop could lead to additional hazards or risk for personal injuries.
-  Do not use Safe Torque Off as a regular on/off switch for the inverter. Any damages to inverter due to use of Safe Torque Off is not covered by warranty.

⚠ By default, the Safe Torque Off circuitry is internally supplied from 24V_{DC}. If the 24V_{DC} from inverter is used for other external loads (e.g. sensors, relays), the **maximum load must not be exceeded**. Failure to control maximum external load may lead to voltage limiting or shutdown, which at the same time will be detected as activation of Safe Torque Off.

When the Safe Torque Off function is used, terminals STO1P and STO1N shall be routed to one set of potential free contacts, and terminals STO2P and STO2N shall be routed to another set of potential free contacts. Both contact pairs must be operated (opened or closed) at the same time. Safe Torque Off is activated when contacts open. It is sufficient that only one set of contacts open for activating Safe Torque Off, but if a difference of the contact's positions is detected by the inverter, operation will be inhibited until the error is corrected.

When the inverter has detected activation of Safe Torque Off, and the activated contacts has been reset to normal (closed) position, the Safe Torque Off condition must be acknowledged and reset at the inverter. This can be performed by pressing the [ENTER] button on the keyboard, by sending an ack message on a bus connection, or by applying a pulse to any of terminals DIN2 – DIN8 that is configured for *Fault Ack*.

After acknowledging the Safe Torque Off condition, the inverter waits for voltages at motor terminal to settle before a new start is allowed. This may take somewhere from a few seconds up to one minute, depending on inverter size. During this time, the display shows a status that toggles between “*Safe Trq Off*” and “*Wait*”.

If the inverter has detected a Safe Torque Off error the display status will show “*STO Error*”. Turn off power to the inverter and correct the problem. The error condition latch will be reset upon next power up.

One emergency stop switch (with dual opening contacts) must be connected to exactly one inverter. It is not allowed to route one stop switch to several inverters. If the application requires simultaneous interruption of more than one drive unit, the installation must use a safety relay with multiple outputs for routing individual dual circuits to each inverter.

If the Safe Torque Off function is not used, terminal STO1P shall be connected to STO1N, and STO2P to STO2N respectively. Without these connections, Safe Torque Off is activated and inverter will not start.

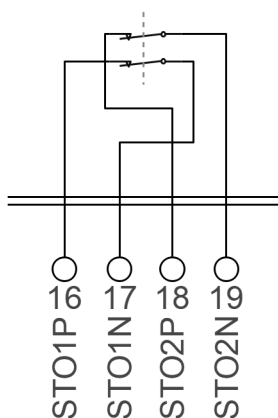


Fig. 4 Safe Torque Off installation with dual channel emergency stop switch

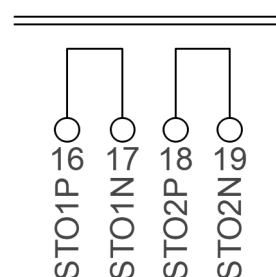


Fig. 5 Installation without Safe Torque Off

4.2.3 Signal terminals configuration

Terminal DIN1 is always used for RUN-signal (Inverter Start/Stop). Terminals DIN2 – DIN8 are configurable for one of several functions. Use the keyboard and display (menu group *Control*) to select function for each DIN terminal. Default settings are listed in Table 3.

Tip: If the installation uses a PTC sensor for motor overheat detection, it is recommended to use input DIN4 which has a built-in pullup resistor of 1.5k Ω . Any of the other inputs (DIN2, DIN3, DIN5 – DIN8) may also be used for PTC function, but user must then supply an external pullup resistor.

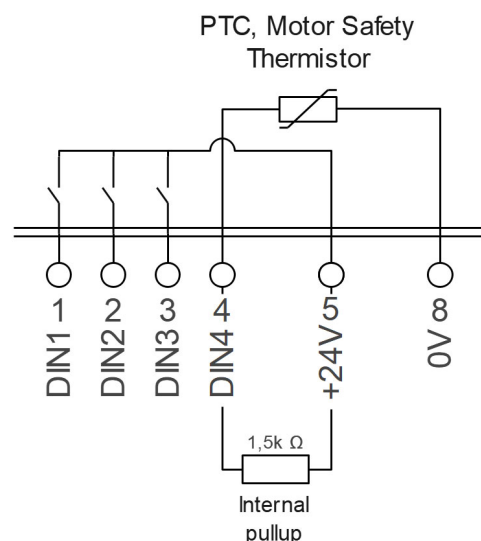


Fig. 6 Use DIN4 for motor protection (positive logic)

4.2.4 Negative logic

The inverter can be configured to operate the digital inputs DIN1 – DIN4 using negative logic. Use the keyboard and display (menu group *Control*) to select positive or negative logic.

NOTE: It's not recommended to use PTC function together with negative logic due to the reverse polarity of external connection to sensor located in motor.

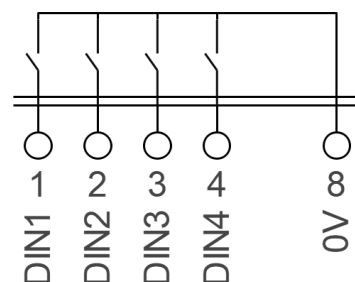


Fig. 7 Connection using negative logic

4.2.5 Analog voltage inputs

The analog voltage inputs accept a ± 10 V_{DC} control signal with reference to a 0V terminal.

Max input voltage: ± 12 V_{DC}

Input resistance: ≈ 100 k Ω .

NOTE: Always use shielded cable for analog voltage inputs due to their high input impedance.

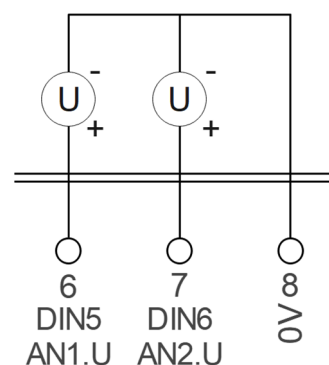


Fig. 8 Analog voltage input configuration

4.2.6 Analog current inputs

The analog current inputs have separate positive and negative terminals (I+ and I-), which allows for easy daisy-chaining of two or more inputs from a single current source. When using a current source to only one receiving unit, the negative input terminal (I-) shall be connected to a 0V terminal.

Max input current: ± 24 mA_{DC}

Max common mode voltage: ± 24 V_{DC}

Input resistance: 100 Ω .

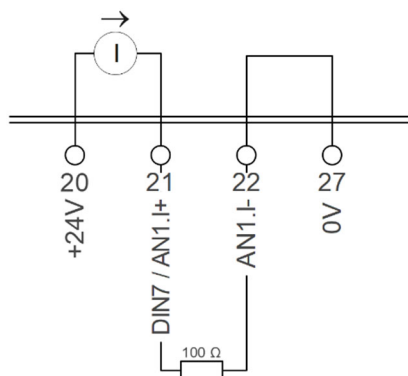


Fig. 9 Analog current single input

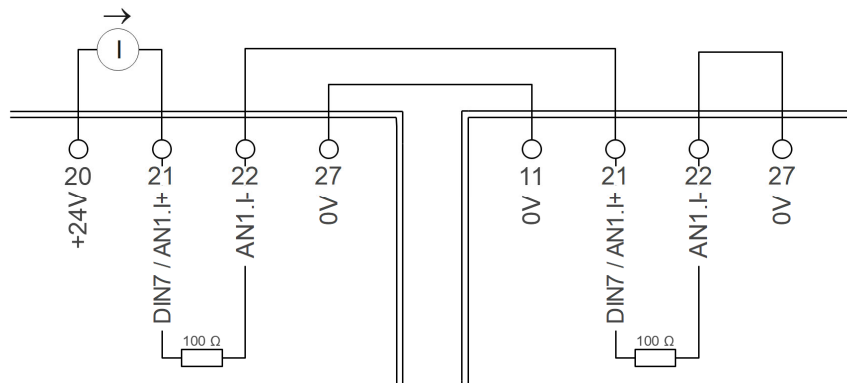


Fig. 10 Analog current input daisy chain connection

4.2.7 Connecting potentiometer

If a potentiometer is to be used as the setpoint source, it shall be connected between the analog voltage output AOUT2 and the selected analog voltage input AIN1.U or AIN2.U, and a 0V terminal. Changing parameter *An Input Type* to *Pot* will automatically configure AOUT2 to supply 10V.

The value of the potentiometer should be between 4,7kΩ and 22kΩ.

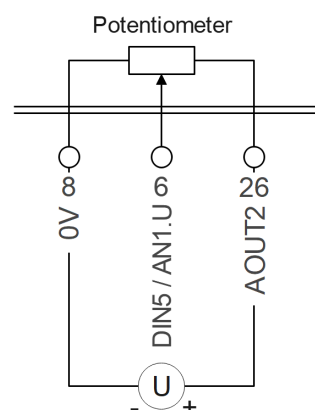


Fig. 11 Connecting potentiometer

4.2.8 Serial channel RS485

The inverter can be controlled via a RS485 serial channel. Connection is made through terminals 9 (RS485.A) and 10 (RS485.B). Termination of the serial channel with 120Ω resistor is available by moving jumper X906 to position "ON".

In theory, it is sufficient to route signals A and B between the communication nodes, but if there is a non-negligible potential difference between nodes, the maximum common mode voltage level may be exceeded and communication could be corrupted. In such cases it is recommended to also route the 0V line for potential equalization.

Shielded cable is recommended for communication.

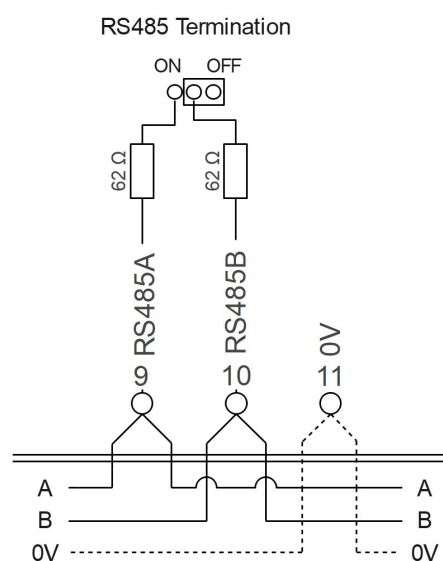


Fig. 12 RS485 connection


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 with a fixed digital or analog setpoint. Motor speed is not compensated for load variations. The electrical frequency is shown on the display. This is factory default.
- Speed regulation of an induction motor with speed calculation with a fixed digital or analog setpoint. Motor speed compensated for load variations. 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.

 Avoid running the inverter with a setpoint of 0 Hz (0 rpm), or very close to zero, other than during start, stop or reversing the direction of rotation. Zero setpoint causes excessive heating of motor windings and may lead to damage of motor or inverter. To avoid involuntary use of setpoint close to zero, the factory default setting is 10 Hz for a zero analog signal.

5.2 Keyboard and display

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



Fig. 13 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 [↑] or [↓]. 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 flowchart of Fig. shows how to reach different screens, examples of appearance and explanation of text:

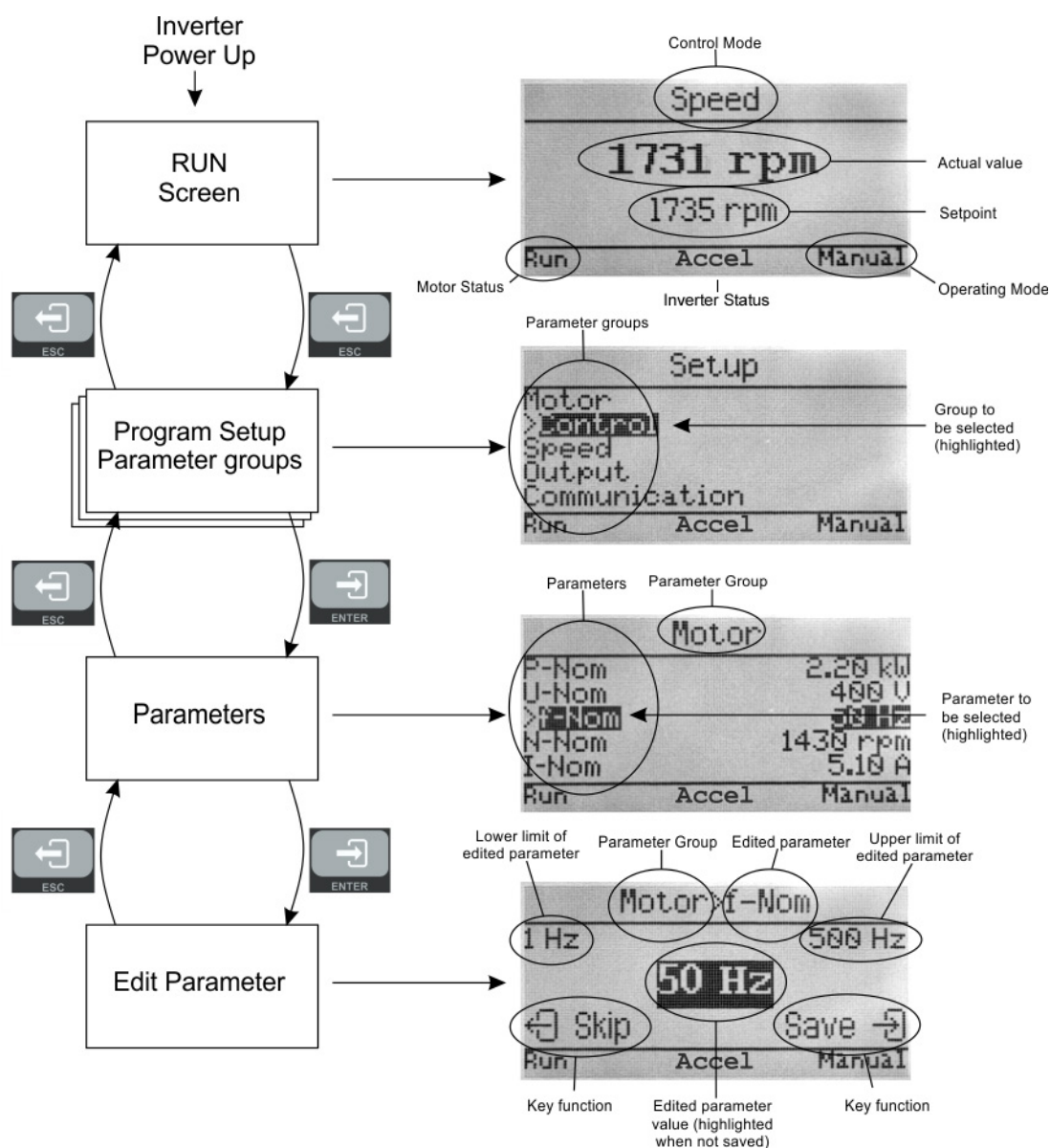


Fig. 14 Programming flowchart and screen examples with explanations

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 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. Note that all applications may not be available in all inverter models.

Application	Description
Fluid / 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 for agriculture application

5.5 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 7.

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.

5.5.1 Full tuning

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 $\cos \varphi$.
3. Start the autotuning by selecting the *Tuning* command and pressing [↑].
4. When asked *Full*, press [ENTER] (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 windings 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.

5.5.2 Basic tuning

A simplified form of calculating parameters can be carried out by pressing [$\hat{\uparrow}$] again in point 3 as above. The display then reads *Basic*. Press [ENTER] to start. This calculation procedure only measures the motor stator resistance and then uses that as the basis for calculating the other motor parameters.

5.5.3 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 [$\hat{\uparrow}$] three times in point 3. The display will now show *Calc*, press [ENTER] to run calculations.

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

P-Nom	U-Nom	f-Nom	N-Nom	I-Nom	cos φ	R-stat	R-rot	L-main	Sigma	I-magn	I-limit
2.2 kW	400 V	50 Hz	1455 rpm	4.75 A	0.78	3.00 Ω	2.00 Ω	400 mH	0.080	1.80 A	5.80 A
5.5 kW	400 V	50 Hz	1460 rpm	11.1 A	0.81	1.00 Ω	0.70 Ω	160 mH	0.080	4.10 A	13.3 A
11 kW	400 V	50 Hz	1465 rpm	21.5 A	0.83	0.45 Ω	0.30 Ω	80 mH	0.080	7.90 A	25.8 A
18.5 kW	400 V	50 Hz	1470 rpm	35.0 A	0.85	0.20 Ω	0.15 Ω	40 mH	0.080	12.8 A	42.0 A

Table 7. Default nominal motor data and motor parameters

Table 7 shows default values for nominal data and motor parameters. Please note that these parameters cannot be measured from the motor terminal.

5.6 Operating modes

The inverter has five operating modes, *Inhibit*, *Manual*, *Auto*, *Bus* and *Fire*. 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. shows how to switch between *Manual* and *Auto* modes:

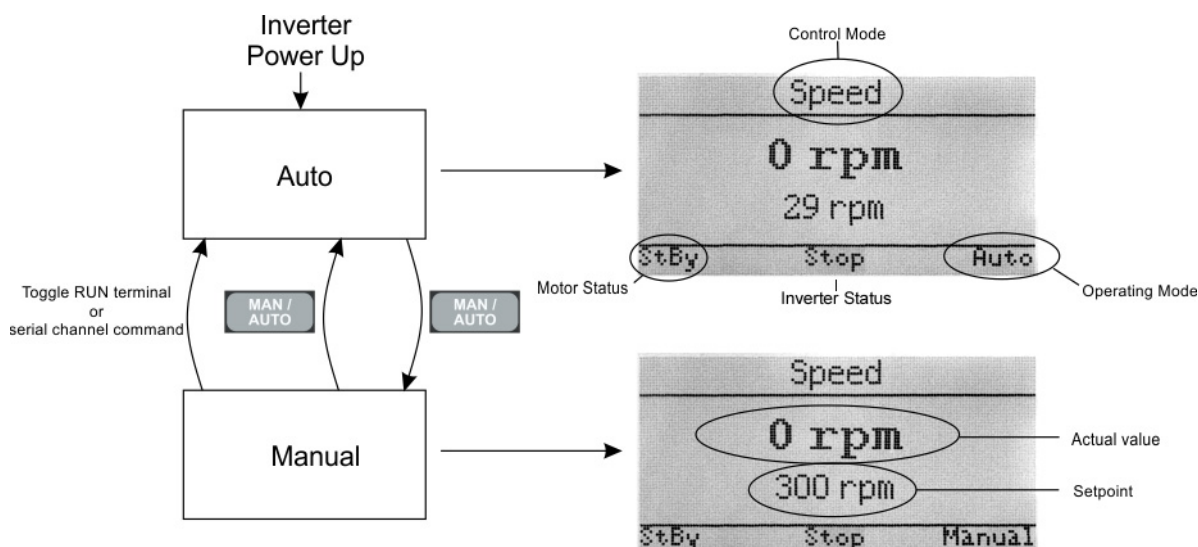


Fig. 15 Flowchart switching between modes and screen examples

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

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



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

5.6.1 Manual Mode

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

The setpoint and actual value are shown on the screen. The setpoint is increased by pressing [↑], and decreased by pressing [↓].

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

5.6.2 Auto Mode

You can switch to *Auto* mode at any time by pressing [MAN/AUTO]. If terminal 1 (DIN1) is active the motor starts. *Auto* mode can also be reached by toggling terminal 1 (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 in question, see 5.9.1, 5.10.1 and 5.11.1.

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

Terminal: It enables the setpoint source to be selected from the digital input signal terminals as in Table 8. Setpoint sources can be changed while inverter is running and apply immediately.

Analog 1 input has the lowest priority, and is used for setpoint if no other select signals are active. Next level of priority are any of the Fix1 – Fix7 setpoints, which are selected with a combination of Select A, B and C signals.

The Analog Select signal has priority over Select A, B, C, and when active it selects the Analog input 2 for setpoint.

Highest priority is the PI-reg input, which activates the process regulator, please see section 5.11.

Function	Direction	Select A	Select B	Select C	Analog select	PI reg
Analog 1 Forward	0	0	0	0	0	0
Analog 1 Reverse	1	0	0	0	0	0
Fix-1 F	0	1	0	0	0	0
Fix-1 R	1	1	0	0	0	0
Fix-2 F	0	0	1	0	0	0
Fix-2 R	1	0	1	0	0	0
Fix-3 F	0	1	1	0	0	0
Fix-3 R	1	1	1	0	0	0
Fix-4 F	0	0	0	1	0	0
Fix-4 R	1	0	0	1	0	0
Fix-5 F	0	1	0	1	0	0
Fix-5 R	1	1	0	1	0	0
Fix-6 F	0	0	1	1	0	0
Fix-6 R	1	0	1	1	0	0
Fix-7 F	0	1	1	1	0	0
Fix-7 R	1	1	1	1	0	0
Analog 2 Forward	0	x	x	x	1	0
Analog 2 Reverse	1	x	x	x	1	0
PI Reg F	0	x	x	x	x	1
PI Reg R	1	x	x	x	x	1

Table 8. Digital input control to select setpoint source. (0 = inactive, open, 1 = active, closed)

Analog 1 F or Analog 2 F: runs clockwise with analog setpoint. The analog signal range and input type is selected using parameter *Analog Input Type* from the *Control* parameter group as in Table 9. The analog input value is then scaled between the lowest setpoint (*An Min Freq* or *An Min Speed*) and the highest setpoint (*Ain Max Freq* or *Ain Max Speed*).

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.

Analog 1 R or Analog 2 R: as *Analog F*, but running counter-clockwise.

PI reg F (PI reg R): Use the PI regulator output as setpoint, clockwise or counter-clockwise rotation.

Parameter <i>Ain Type</i>	Analog value	Input terminal (AN1)	Input terminal (AN2)
0-20 mA	Current 0-20mA	21 (+) and 22 (-)	23 (+) and 24 (-)
4-20 mA	Current 4-20mA	21 (+) and 22 (-)	23 (+) and 24 (-)
+/-20 mA	Current +/- 20mA	21 (+) and 22 (-)	23 (+) and 24 (-)
0-10 V	Voltage 0-10V	6 (+) and 0V	7 (+) and 0V
2-10 V	Voltage 2-10V	6 (+) and 0V	7 (+) and 0V
+/-10 V	Voltage +/- 10V	6 (+) and 0V	7 (+) and 0V
Pot	Potentiometer (0-10V)	10V at 26, viper to 6, and 0V	10V at 26, viper to 7, and 0V

Table 9. Settings for analog inputs AIN1 and AIN2.

5.6.3 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

5.6.4 Fire Mode

The inverter can be setup to operate in a way where it runs at a specified setpoint, overrides other control signals and disregards alarm or fault conditions that normally would lead to a stop. Please see section 5.8.16 Fire Mode Configuration for information on how to enable fire mode.



User must be aware that when Fire Mode is enabled, the inverter can start without an active RUN signal.



To safely inhibit start when Fire Mode is enabled, the installation must include the Safe Torque Off function, and the emergency stop switch must be activated.



When Fire Mode is active, the inverter disregards several self-protective functions and will run for as long as possible, even if it could lead to permanent failure of the inverter.



Any damages to the inverter caused by using Fire Mode is not covered by warranty.

5.7 Parameter specifications

5.7.1 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	Urms	Motor Temp	Display Par 1	Operate Time	COP 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	An Input 1 Type	FixFrq2	FixSpd2	FixReg2	Relay 2 Mode	RS485 baud	Pout	COP Temp	Display Par 3	Brake Time	GUI Version	Reset Time
N-Nom	Alt Accel Time	Pwr On Delay	An 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 Time	Run Delay	DIN2 Function	FixFrq4	FixSpd4	FixReg4	AnOut 1 Mode	RS485 timeout	DC Link	Heat Sink 2	Bklight Timeout	DC Low Time	Serial Number	Temp Hi
cos φ		Stop Delay	DIN3 Function	FixFrq5	FixSpd5	FixReg5	AnOut 1 Type	RS485 autostop	Brake Chop	Heat Sink 3	Menu readonly	Start Count		PTC Temp
Tuning		DC Brake	DIN4 Function	FixFrq6	FixSpd6	FixReg6	AnOut 1 Max	RS485 failsafe	Stator Freq	Heat Sink 4	Show freq in %	Alarm Count		Over load
R-stator		Kp Speed	DIN5 Function	FixFrq7	FixSpd7	FixReg7	AnOut 2 Mode	USB bustype	Rotor Freq	Fan 1 Volt		STO Run Cnt		Analog Fail
R-rotor		Ti Speed	DIN6 Function	An Min Freq	An Min Speed	Setpoint Min Val	AnOut 2 Type	USB addr	Control Freq	Fan 2 Volt		STO Stby Cnt		PI reg Fail
L-main		Sleep Freq	DIN7 Function	An Max Freq	An Max Speed	Setpoint Max Val	AnOut 2 Max	USB timeout	Rotor Speed	Fan 3 Volt		STO Err Cnt		DC Low
Sigma		Bypass Freq	DIN8 Function			Actual Min Val	Analog 1 Out	USB autostop	Control Speed	Fan 4 Volt		Firemd Count		DC High
I-magn		Bypass Bandw	DIN1-4 Logic			Actual Max Val	Analog 2 Out	ABCC interface	Actual Torque	EXT 24V		Output Energy		GND Fail
I-limit		Boost Time	Fire Mod Setpoint			Setpoint Min Lim		ABCC bustype	Control Torque	USB 5V		Total Energy		Short Circuit
Pole Count		Boost Level	Fire Mod Type			Setpoint Max Lim		ABCC addr	Actual Reg					Imagn Fail
T-nom			Limit ManSetp			Reg Amp		ABCC timeout	Setpoint Reg					Current Low
Tuned status						Reg Kp		ABCC autostop	AnIn1 U					Current High
						Reg Ti		Auto Reset	AnIn1 I					Current Limit
						Reg MinFreq			AnIn2 U					Run Fail
						Reg MaxFreq			AnIn2 I					
						Reg Unit			Keybrd					
						Off Limit			Terminal					
						On Limit			Function					
						Off/On Delay								

Table 10. Parameter groups and parameters.

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

5.7.2 Parameter table

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



Parameters and their default values may change without notice. Please find latest version of manual at www.nfodrives.se

Name	Description	Default value	Range	Type ^[1]
Motor				
P-Nom	Nominal motor power	Table 7	0.18 – 30 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 – 6000 rpm	Standby
I-Nom	Nominal motor current		0.5 – 55 A	Standby
cos φ	Nominal motor cos φ		0.5 – 1.0	Standby
Tuning	Tuning command	Measured during tuning		Standby
R-stator	Motor stator resistance			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				
Accel Time	Acceleration time from 0 to f-Nom Hz	25.0 s ^[2]	0.5 - 100.0 s	Stby/Run
Decel Time	Deceleration time from f-Nom to 0 Hz	30.0 s ^[2]	0.5 - 100.0 s	Stby/Run
Ramp Brkpoint	Breakpoint for alternate Accel/Decel	35 Hz ^[2]	0 - 50.0 Hz	Stby/Run
Alt Accel Time	Alternate Acceleration time from 0 to f-Nom Hz	15.0 s ^[2]	0.5 - 100.0 s	Stby/Run
Alt Decel Time	Alternate Deceleration time from f-Nom to 0 Hz	20.0 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	<i>Brake</i> = motor brakes according to <i>Deceleration Ramp</i> <i>Release</i> = motor is released.	Brake	Brake Release	Stby/Run
Energy Save	<i>OFF</i> = Function is disabled. <i>ON</i> = 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
Boost Time	Current boost time, from start	5 s	0 – 100 s	Stby/Run
Boost Level	Current boost level	50%	0 – 100%	Stby/Run
Control				
Control Mode	<i>Frequency</i> = speed control with frequency estimation <i>Speed</i> = speed control with rpm estimation <i>PI-Reg</i> = process regulator	Frequency	Frequency Speed PI-Reg	Standby
Auto Start	<i>OFF</i> = Inverter awaits transition on RUN after power applied. <i>ON</i> = 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 Input 1 Type	Type of input range used for analog input 1	0-10V	0-20mA, 0-10V 4-20mA, 2-10V +/-20mA, +/-10V Pot	Stby/Run
Analog Input 2 Type	Type of input range used for analog input 2	0-10V	see above	Stby/Run
DIN2 Function	Selecting the function for terminal DIN2	Analog Select	An.Sel, Reverse, PI-reg, Select.A, Select.B, Sel.C, PTC Temp, Fault Ack, Fire Mode, Fix Inc, Fix Dec, No Function	Stby/Run
DIN3 Function	Selecting the function for terminal DIN3	Reverse	see above	Stby/Run
DIN4 Function	Selecting the function for terminal DIN4	Select A	see above	Stby/Run
DIN5 Function	Selecting the function for terminal DIN5	Analog In 1 U	see above	Stby/Run
DIN6 Function	Selecting the function for terminal DIN6	Analog In 2 U	see above	Stby/Run
DIN7 Function	Selecting the function for terminal DIN7	Analog In 1 I	see above	Stby/Run
DIN8 Function	Selecting the function for terminal DIN8	Analog In 2 I	see above	Stby/Run
DIN1-4 Logic	Selecting active high or active low level for terminals DIN1-DIN4	Active High	Active High, Active Low	Stby/Run
FireMode Setp	Select which setpoint source to use when Fire Mode is active	Fix 5	Table 12	Stby/Run
FireMode Type	Enable/Disable Fire Mode and select if it shall be activated when external contacts closes or opens	Disabled	Disabled, Closed Contact, Open Contact	Stby/Run

Limit Manual Setpoint	Limit manual mode setpoint for the selected control mode using values from Analog Input Min and Max settings.	ON	OFF ON	Stby/Run
Frequency				
Op Mode	Setpoint source, frequency	Terminal	Table 12	Stby/Run
Fix Freq 1	Fixed frequency 1	10.0 Hz	0.0-150.0 Hz	Stby/Run
Fix Freq 2	Fixed frequency 2	20.0 Hz	0.0-150.0 Hz	Stby/Run
Fix Freq 3	Fixed frequency 3	30.0 Hz	0.0-150.0 Hz	Stby/Run
Fix Freq 4	Fixed frequency 4	40.0 Hz	0.0-150.0 Hz	Stby/Run
Fix Freq 5	Fixed frequency 5	50.0 Hz	0.0-150.0 Hz	Stby/Run
Fix Freq 6	Fixed frequency 6	60.0 Hz	0.0-150.0 Hz	Stby/Run
Fix Freq 7	Fixed frequency 7	70.0 Hz	0.0-150.0 Hz	Stby/Run
An Min Freq	Lowest frequency when running with analog setpoint.	10.0 Hz	+/-150.0 Hz	Stby/Run
An Max Freq	Highest frequency when running with analog setpoint.	50.0 Hz	+/-150.0 Hz	Stby/Run
Speed				
Op Mode	Setpoint source, speed	Terminal	Table 13	Stby/Run
Fix Speed 1	Fixed speed 1	300 rpm	0-4500 rpm	Stby/Run
Fix Speed 2	Fixed speed 2	600 rpm	0-4500 rpm	Stby/Run
Fix Speed 3	Fixed speed 3	900 rpm	0-4500 rpm	Stby/Run
Fix Speed 4	Fixed speed 4	1200 rpm	0-4500 rpm	Stby/Run
Fix Speed 5	Fixed speed 5	1500 rpm	0-4500 rpm	Stby/Run
Fix Speed 6	Fixed speed 6	1800 rpm	0-4500 rpm	Stby/Run
Fix Speed 7	Fixed speed 7	2100 rpm	0-4500 rpm	Stby/Run
An Min Speed	Lowest speed when running with analog setpoint.	300 rpm	+/-4500 rpm	Stby/Run
An Max Speed	Highest speed when running with analog 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
Setp Min Val	Value at min. input signal from setpoint input	0.0	-2000.0 - 2000.0	Stby/Run
Setp Max Val	Value at max. input signal from setpoint input	200.0	-2000.0 - 2000.0	Stby/Run
Actual Min Val	Value at min. input signal from actual value input	0.0	-2000.0 - 2000.0	Stby/Run
Actual Max Val	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	Amplifier sign 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
Reg Min Freq	Frequency setpoint at minimum regulator output	10.0 Hz	0.0-150.0 Hz	Stby/Run
Reg Max Freq	Frequency setpoint at maximum regulator output	50.0 Hz	0.0-150.0 Hz	Stby/Run
Reg Unit	Regulator units	kPa	Table 14	Stby/Run
Turn Off Limit	Turn off motor when actual value below off limit	0.0	-2000.0 - 2000.0	Stby/Run
Turn On Limit	Turn on motor when actual value above on limit	0.0	-2000.0 - 2000.0	Stby/Run
Off/On Delay	Reaction time for stopping and restarting during regulating	2 s	1 – 10 s	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 is in <i>Alarm</i> or <i>Fault</i> state <i>Fault</i> = Inverter is in <i>Fault</i> state (relay ignores <i>Alarm</i> conditions) <i>Ready</i> = Inverter in Standby, Running or Stopping (accept Run) <i>Curr Lim</i> = Current limit reached <i>STO active</i> = Indicate Safe Torque Off activation <i>Fire active</i> = Indicate Fire Mode activation <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 STO active Fire active 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 Out 1 Mode	<i>Disable</i> = Function disabled <i>Frequ</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 Frequ Speed Torque Irms Prms PF Setpoint	Stby/Run

Analog Out 1 Type	Output type for analog output 1	+/-10V	0-20mA, 0-10V 4-20mA, 2-10V +/-20mA, +/-10V	Stby/Run
Analog Out 1 Max	Scale factor for analog output 1 (Output voltage when reaching nominal value of selected mode)	10.00V	0 - 10.00 V	Stby/Run
Analog Out 2 Mode	See options for Analog 1 Output Mode	Disable	see Analog 1 Output Mode	Stby/Run
Analog Out 2 Type	Output type for analog output 2	+/-10V	see Analog 1 Output Type	Stby/Run
Analog Out 2 Max	Scale factor for analog 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				
Urms	Motor voltage (RMS)	V		Read
Irms	Motor current (RMS)	A		Read
Pout	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</i> mode)	Hz		Read
Rotor Speed	Rotor speed actual value	rpm		Read
Control Speed	Rotor speed setpoint (<i>Speed</i> mode)	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 Reg	Actual value process regulator	As per parameter <i>Unit</i>		Read
Setpoint Reg	Setpoint value process regulator	As per parameter <i>Unit</i>		Read
Analog In 1 U	Actual input voltage	V		Read
Analog In 1 I	Actual input current	mA		Read
Analog In 2 U	Actual input voltage	V		Read
Analog In 2 I	Actual input current	mA		Read
Keyboard In	Bitmask input of keyboard	-		Read
Terminal In	Bitmask input of terminals (DIN1..8)	-		Read
Function In	Bitmask input of active function	-		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 Timeout	Illumination dimmer timeout	2 min	0 – 60 min	Stby/Run
Menu Read Only	OFF: No activation of read only mode ON: Activate readonly mode (require PIN code to deactivate)	OFF	OFF ON	Stby/Run
Show freq in %	Rescale 0 – 50 Hz to 0 – 100% for setpoint and actual frequency	OFF	OFF / ON	Stby/Run
Counters				
Operate 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 been running with low DC (seconds)	s		Read
Start Count	Number of motor starts	-		Read
Alarm Count	Number of logged alarms or faults	-		Read
STO Run Cntr	Number of Safe Torque Off occurrences during Run	-		Read
STO Stby Cntr	Number of Safe Torque Off occurrences during Standby	-		Read
STO Err Cntr	Number of Safe Torque Off error occurrences	-		Read
Fire Mode Cntr	Number of Fire Mode occurrences	-		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 Number	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			Stby/Run
Temp Hi	Heatsink overheating			Stby/Run
PTC Temp	Motor overheating			Stby/Run
Overload	Electronic motor overload protection			Stby/Run
Analog Fail	Analog setpoint input signal out of range			Stby/Run
PI reg Fail	PI regulator unable to reach setpoint			Stby/Run
DC Low	Voltage in DC link too low			Read
DC High	Voltage in DC link too high			Read
GND Fail	Fault in motor or motor wiring			Read
Short Circuit				Read
Imagn Fail				Read
Current Low				Read
Current High				Read
Current Limit	Motor overcurrent			Read
Run Fail	Rotor locked, start failure			Read

Table 11. 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, etc. are available depending on selected application.
- [3] Available in future versions.
- [4] Value for indicative purpose only as measurement has limited accuracy.

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 from zero to 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 output current allows. An acceleration time set too low leads to the inverter limiting the output current, which results in an extended acceleration time.

During deceleration, the inverter can only brake so much that it still is able to handle the motor's surplus energy. To extend the inverter's capability of steep deceleration, a brake chopper resistor can help handle the surplus energy.



External braking resistance must be fitted if the deceleration time is low, compared to the inertia of the driven load. Avoid setting deceleration ramp any shorter than necessary.



The external braking resistance or the brake chopper circuit can become overheated or damaged, if the braking energy is too high. Avoid setting deceleration ramp any shorter than necessary.

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.

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 braking 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 or frequency 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, while the integral part (*Ti-speed*) handles fine-tuning the final speed.

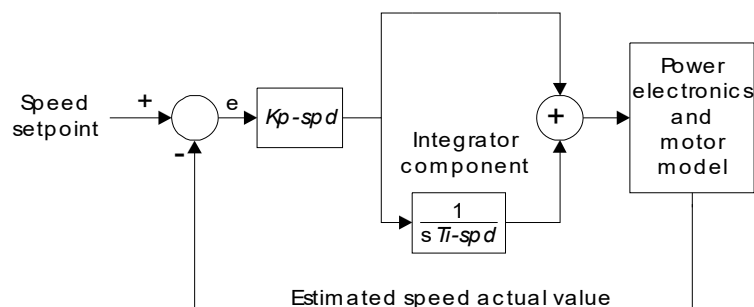


Fig. 16 Speed regulator

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.

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 (*Frequ* 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. analog 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..

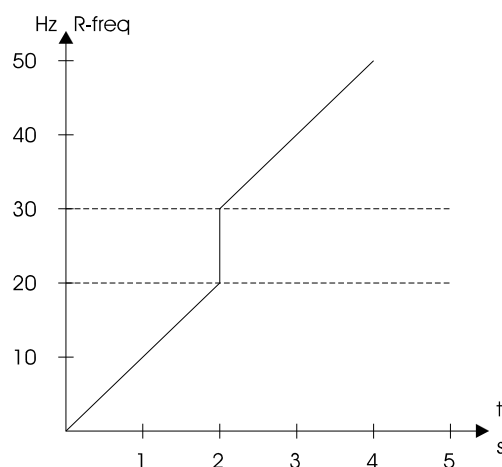


Fig. 17 Acceleration with frequency bypass

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 5.18.

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 4.2.5 and 4.2.6.

5.8.14 DIN selectable functions

The digital inputs DIN2 through DIN8 can be configured for different functions, as per table below. DIN1 is always used for RUN signal and can not be configured for other functions. Inputs DIN1 – DIN4 can be configured for either positive or negative logic. Inputs DIN5 – DIN8 are shared with analog function (analog is default setting).

Function	Description
Analog	Input is used for analog Voltage or Current (only available for DIN5 – DIN8)
An Select	Select analog 2 channel for setpoint (overrides analog 1 and any selected Fix setpoint)
Reverse	Change direction of rotation to reverse
PI-reg	Activate PI-reg function directly from terminal
Select A	Together, the Select C, B and A inputs form a binary number 001 to 111 (1 through 7) that selects one of the Fixed setpoints Fix1 – Fix7 of either Frequency, Speed or PI-reg mode. Select C equals 4, B equals 2 and A equals 1. Any combination of one, two or three of the Select signals may be used, e.g. inputs Select C and A can be used to select Fix 1, 4 or 5.
Select B	
Select C	
PTC Temp	Connect to motor temperature sensing thermistor (DIN4 has built in pull-up resistor)
Fault Ack	Generate acknowledge of fault condition
Fire Mode	Activation of Fire Mode. Configure for either closing contacts or opening contacts
Fix1 Inc	A pulse increments value of Fix1 by 1 Hz in Frequency Mode or 30 rpm in Speed Mode
Fix1 Dec	A pulse decrements value of Fix1 by 1 Hz in Frequency Mode or 30 rpm in Speed Mode
No Function	The input has no function

5.8.15 Digital potentiometer (Increment / Decrement)

The DIN functions **Fix1 Inc** and **Fix1 Dec** can be used together to form a functionality where digital (on/off) pulses are used to either increment or decrement the setpoint value. The functionality operates on the Fix1 value of Fix Freq1, Fix Speed1 and Fix Reg1 respectively, depending on what Mode is selected.

To use the digital potentiometer function, select OpMode = Fix 1F (or Fix1R for reverse) of the desired Mode, and configure the desired DINs (terminal inputs) to Fix1 Inc and Fix1 Dec respectively.

The increment and decrement is limited to the values of *An Max Freq* and *An Min Freq* (default 50 Hz and 10 Hz), or the corresponding Max and Min of the selected Mode. The limit can be disabled by turning off the parameter *Limit Manual Setpoint*, located in the *Control* group.

5.8.16 Fire Mode configuration

The inverter can be setup to operate in a way where it runs at a specified setpoint, overrides other control signals and disregards alarm or fault conditions that normally would lead to a trip.

The parameters used for configuring Fire Mode consists of

1. Selecting which DIN terminal that shall be used for activation from an external contact
2. Selecting the desired setpoint
3. Enabling Fire Mode function by selecting if it shall be activated when contacts closes or opens

By factory default, no input terminal is configured for Fire Mode. Default setpoint is using the frequency value from Fixed Frequency 5 (default 50 Hz), and the Fire Mode function is disabled (neither closed nor open contacts).

When Fire Mode is activated, it requires no RUN signal to start. It is sufficient to receive the correct level of open or closed contact of the configured DIN terminal. If RUN signal was already active when Fire Mode was entered, the inverter will continue to operate but switch to the selected Fire Mode setpoint. Releasing the RUN signal has no effect when inverter is in Fire Mode.

If Fire Mode is active and user presses the [MAN/AUTO] button, the inverter will remain in Fire Mode and continue to run with the Fire Mode setpoint. If Fire Mode is active and user presses [STOP] the inverter will shut off output and enter Manual Mode. User may now start again by pressing the [START] button, and the inverter will return to Fire Mode.

If the inverter operates in Bus Mode (e.g. controlled by external Modbus master or by Profibus/Profinet) when Fire Mode is activated, the inverter will leave Bus Mode and enter Fire Mode. When in Fire Mode, the bus master can not take control over the inverter.

When Fire Mode is active, the Operating Mode shown to the lower right of the display will read "Fire", and the inverter status will continuously toggle between "Fire Mode" and the relevant actual status. Any of the two relay output contacts can be configured for indication when Fire Mode is active.

If the Fire Mode condition is removed (DIN terminal becomes inactive), or if Fire Mode is disabled by changing a related parameter, the inverter will return to Auto Mode and operate according to valid control signals.



User must be aware that when Fire Mode is enabled, the inverter can start without an active RUN signal.



To safely inhibit start when Fire Mode is enabled, the installation must include the Safe Torque Off function, and the emergency stop switch must be activated.



When Fire Mode is active, the inverter disregards several self-protective functions and will run for as long as possible, even if it could lead to permanent failure of the inverter.



Any damages to the inverter caused by using Fire Mode is not covered by warranty.

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 motor's 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 8
Analog 1 F	Analog input 1 clockwise.
Analog 1 R	Analog input 1 counter-clockwise.
Analog 2 F	Analog input 2 clockwise.
Analog 2 R	Analog input 2 counter-clockwise.
Fix-1 F	Frequency from parameter Fix Freq 1, clockwise.
Fix-2 F	Frequency from parameter Fix Freq 2, clockwise.
Fix-3 F	Frequency from parameter Fix Freq 3, clockwise.
Fix-4 F	Frequency from parameter Fix Freq 4, clockwise.
Fix-5 F	Frequency from parameter Fix Freq 5, clockwise.
Fix-6 F	Frequency from parameter Fix Freq 6, clockwise.
Fix-7 F	Frequency from parameter Fix Freq 7, clockwise.
Fix-1 R	Frequency from parameter Fix Freq 1, counter-clockwise.
Fix-2 R	Frequency from parameter Fix Freq 2, counter-clockwise.
Fix-3 R	Frequency from parameter Fix Freq 3, counter-clockwise.
Fix-4 R	Frequency from parameter Fix Freq 4, counter-clockwise.
Fix-5 R	Frequency from parameter Fix Freq 5, counter-clockwise.
Fix-6 R	Frequency from parameter Fix Freq 6, counter-clockwise.
Fix-7 R	Frequency from parameter Fix Freq 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.

5.9.2 Analog frequency setpoint range

When using frequency regulation, parameters *Ain Min Freq* and *Ain Max Freq* sets the frequency range in which the inverter is to operate when an analog input is designated as setpoint source. *Ain Max Freq* applies at maximum input signal and *Ain Min Freq* 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 *Ain Min Frq* to the negative value of *Ain Max 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 8
Analog 1 F	Analog input 1, clockwise.
Analog 1 R	Analog input 1, counter-clockwise.
Analog 2 F	Analog input 2, clockwise.
Analog 2 R	Analog input 2, counter-clockwise.
Fix-1 F	Speed from parameter Fix Speed 1, clockwise.
Fix-2 F	Speed from parameter Fix Speed 2, clockwise.
Fix-3 F	Speed from parameter Fix Speed 3, clockwise.
Fix-4 F	Speed from parameter Fix Speed 4, clockwise.
Fix-5 F	Speed from parameter Fix Speed 5, clockwise.
Fix-6 F	Speed from parameter Fix Speed 6, clockwise.
Fix-7 F	Speed from parameter Fix Speed 7, clockwise.
Fix-1 R	Speed from parameter Fix Speed 1, counter-clockwise.
Fix-2 R	Speed from parameter Fix Speed 2, counter-clockwise.
Fix-3 R	Speed from parameter Fix Speed 3, counter-clockwise.
Fix-4 R	Speed from parameter Fix Speed 4, counter-clockwise.
Fix-5 R	Speed from parameter Fix Speed 5, counter-clockwise.
Fix-6 R	Speed from parameter Fix Speed 6, counter-clockwise.
Fix-7 R	Speed from parameter Fix Speed 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 Speed 1 - Fix Speed 7*, with the range 0 - 9000rpm. However, the maximum speed depends on 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 Analog speed setpoint range

Parameters *Ain Min Speed* and *Ain Max Speed* indicate the RPM range in which the inverter is to work when an analog input is designated as setpoint source. *Ain Max Speed* applies at maximum analog input signal and *Ain Min Speed* at minimum input signal. The settings apply for both rotational directions.

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

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*.

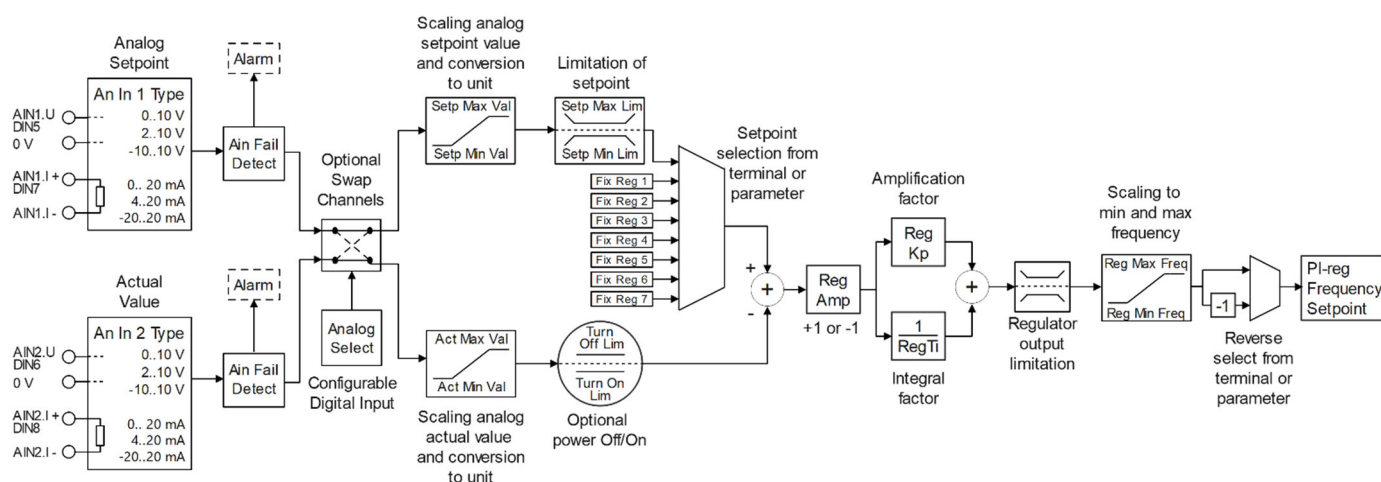


Fig. 18 Process regulator overview

The process regulator unit (default kPa) is selected using the parameter *Unit* and applies for both setpoint and actual value, see Table 14. The regulator's actual value is by default taken from Analog Input 2, either voltage or current. The scaling of the actual value is controlled by parameters *Actual Min Val* och *Actual Max Val* which translates the minimum and maximum signal level from the actual value input corresponding to the selected unit.

For best accuracy of the regulator, it is recommended to select a unit that results in regulator values not being too low, e.g. rather use kPa (or mbar) than bar if the system operates on low pressures.

The regulator generates an output signal in the form of a setpoint (frequency or speed) in the range limited by parameters *Ain Min Freq* and *Ain Max Freq*, or *Ain Min Speed* and *Ain Max Speed*, depending on the control mode chosen. When using *Control Mode = PI-Reg* the parameters used for scaling min and max frequency are *Reg Min Freq* and *Reg 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 Val* and *Setpoint Max Val*. With parameters *Setpoint Min Limit* and *Setpoint Max Limit*, it is possible to limit the range of the setpoint value. Both An In1 and An In2 can be configured for voltage or current input individually, 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 *Turn Off Limit* or *Turn 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.

Reaction time (delay) for Off/On function is controlled by parameter Off/On Delay which has a default value of 2 s.

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

Parameter <i>Unit</i> and <i>Sense Unit</i> 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, mbar

Table 14 Process regulator units

Parameter <i>Ain Type</i> settings	Analog value	Input terminal (AN1)	Input terminal (AN2)
0-10V	Voltage 0-10V	6 (+) , 0V	7 (+) , 0V
2-10V	Voltage 2-10V	6 (+) , 0V	7 (+) , 0V
+/-10V	Voltage +/- 10V	6 (+) , 0V	7 (+) , 0V
0-20mA	Current 0-20mA	21 (+) , 22 (-)	23 (+) , 24 (-)
4-20mA	Current 4-20mA	21 (+) , 22 (-)	23 (+) , 24 (-)
+/-20mA	Current +/-20mA	21 (+) , 22 (-)	23 (+) , 24 (-)

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	Analog input 1, clockwise.
Analog 1 R	Analog input 1, counter-clockwise.
Analog 2 F	Analog input 2, clockwise.
Analog 2 R	Analog 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

Function	Direction	Select A	Select B	Select C	Analog select
Analog 1 Forward	0	0	0	0	0
Analog 1 Reverse	1	0	0	0	0
Fix-1 F	0	1	0	0	0
Fix-1 R	1	1	0	0	0
Fix-2 F	0	0	1	0	0
Fix-2 R	1	0	1	0	0
Fix-3 F	0	1	1	0	0
Fix-3 R	1	1	1	0	0
Fix-4 F	0	0	0	1	0
Fix-4 R	1	0	0	1	0
Fix-5 F	0	1	0	1	0
Fix-5 R	1	1	0	1	0
Fix-6 F	0	0	1	1	0
Fix-6 R	1	0	1	1	0
Fix-7 F	0	1	1	1	0
Fix-7 R	1	1	1	1	0
Analog 2 Forward	0	x	x	x	1
Analog 2 Reverse	1	x	x	x	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 $\text{Reg Amp} * \text{Max Ain} / \text{Act Max}$. *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. Connect the thermistor between any of the configurable terminal DIN2 – DIN8 and a 0V terminal. It's recommended to use DIN4 since that terminal has a built in pullup resistor of 1.5kΩ. Make sure to configure the selected DIN terminal for PTC function.

Configuration of the PTC fault reaction is carried out under *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*. 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.

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 12, 13 and 14 (see Fig). With selected function active, the relay is activated (contacts 12-13 closed and 13-14 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 13-14). 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 28, 29 and 30 (see Fig). With selected function active, the relay is activated (contacts 28-29 closed and 29-30 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 supply both voltage and current signals, and are selectable 0-10V, 2-10V, $\pm 10V$, 0-20mA, 4-20mA or $\pm 20mA$ using the *Analog Out Type* parameter. Analog outputs are at terminals 25 (AOUT1) and 26 (AOUT2). Both are related to any of the 0V terminals. To scale the output, use parameter *An Out Max* to select current (mA) and/or voltage (V) at nominal actual value. Parameter *An Out Mode* in parameter group *Output* selects which parameter to control the output function.

 **If parameter *An In Type* is set to *Pot*, AOUT2 will always deliver 10V irrespective of *An Out 2 Mode*.**

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

To reset all user parameters to a factory default state, perform the following operation: Power off inverter and wait for it to black out. Press and hold buttons [↑] and [↓]. Power on inverter and keep pressing the buttons. After about 1-2 sec., when text “NFO Sinus Optimal” appears, momentarily press STOP button and then release the other two. Now press ENTER to proceed with reset, or press ESC to cancel. To reset all parameters except those included in parameter group motor, press and hold STOP and then press ENTER.

The inverter parameters can also be reset to default factory settings by 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.

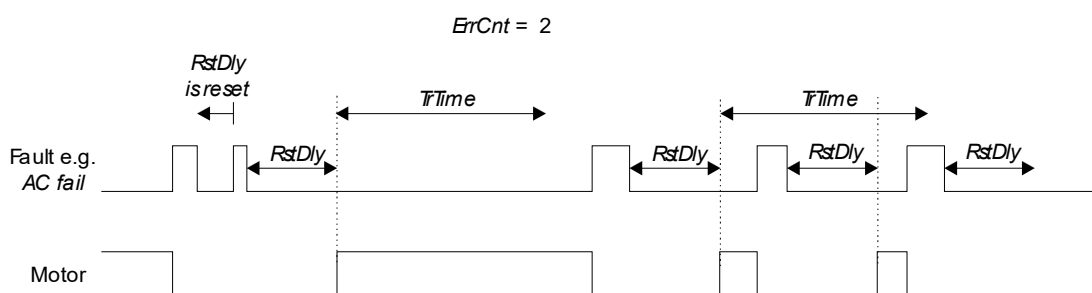


Fig. 19 Typical fault situation

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 [\uparrow] or [\downarrow] 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

If *Alarm* is selected for a particular fault, and the fault condition occurs while inverter is in Standby, a new start will be inhibited until the fault condition is removed. If the RUN signal is active when fault condition is removed, the inverter will start.

Fault message	Possible fault types	Default setting		Fault description, other fault parameters	Source of fault, action	
		Type of fault	Error Count			
Safe Trq Off	Safe Torque Off condition always inhibits inverter and is not controlled by parameters			Safe Torque Off function activated	Deactivate Emergency stop button	
STO Error				Error in Safe Torque Off circuit	Check wiring and external equipment	
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	2	Inverter heat sink temperature too high.	Wait until inverter has cooled down. Check inverter is installed so air can circulate sufficiently. Check ambient temperature is not too high.	
PTC Temp	Fail Alarm Indication Disable	Fail	2	If using PTC function, the motor is overheated, thermistor input limit exceeded.	Let motor cool down.	
Overload	Fail Alarm Indication Disable	Fail	2	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					
Analog Fail	Fail Alarm Indication Disable	Indication	2	Analog setpoint input signal outside range.	Open or short circuit in signal line to analog setpoint or <i>Ain Type</i> not set correctly.	
PI reg Fail	Fail Alarm Indication Disable	Disable	2	PI regulator is unable to reach setpoint, even at full throttle	The driven equipment is incorrect, or due to some other external circumstance, e.g. water supply error, etc.	
DC Low / 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 Circuit	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	2	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.
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
Tun Fail M	Fail	Fail	0	Measurement error during tuning	The motor data that has been entered is not correct with respect to the connected motor. Some of the motor properties are unknown or the motor is incompatible with the inverter
Tun Fail P	Fail	Fail	0	Parameter error during tuning	The motor data or the properties of the motor results in values that are out of range
Rs Meas Fail	Fail	Fail	0	Error when measuring the stator resistance of the motor	The motor data or the properties of the motor results in values that are out of range Motor is not connected properly The motor, the cables, or the inverter is damaged.

Table 18. Fault messages

5.18.3 Acknowledge fault

Faults can be acknowledged in a couple of 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)
- By configuring a DIN terminal to *Fault Ack* and applying a low to high transition on that terminal

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 C 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 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 parameter's 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 parameter base address. If bus master makes an illegal register address access, the inverter will reply with a Modbus error code.

For bus master access to units with firmware up to and including version 5114, the number of registers to read or write in each transmission is internally limited to the number of registers used by the parameter in question, i.e. maximum four consecutive registers (if parameter is 64 bits).

From version 5115 and onwards, the master may access up to 16 consecutive ADI's (up to 64 registers) in each RTU mode read/write transmission (or maximum 4 ADI's in ASCII mode). For read operations, the slave will pad the reply data with 0000 for locations originating from unused addresses. For write operations, the slave will disregard data that allocates to unused register addresses.

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. 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 Please note that the parameters are always accessed using their Modbus register address, while the ADI number is used only for reference to the parameter in documentation or when using other communication methods than Modbus.

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 3 = Bus 2 = Auto 4 = Fire	
SMODE (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

Table 19. Example of accessible parameters

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>	33	<i>Ext Stby</i>	<i>Inverter is ready for run cmd in Auto mode</i>
1	GND Fail R	Ground fail detected during run	34	<i>Ext Run</i>	<i>Inverter is running in Auto mode</i>
2	AC Fail	Mains power error	35	<i>Ext Acc</i>	<i>Inverter is accelerating in Auto mode</i>
3	Temp Hi	Too high temperature on heat sink	36	<i>Ext Ret</i>	<i>Inverter is decelerating in Auto mode</i>
4	PTC Temp	Motor temperature sensor trip	37	<i>Bus Stby</i>	<i>Inverter is ready for run cmd in Bus mode</i>
5	Overload	Electronic motor overload trip	38	<i>Bus Run</i>	<i>Inverter is running in Bus mode</i>
6	Analog Fail	Analog input out of range	39	<i>Bus Acc</i>	<i>Inverter is accelerating in Bus mode</i>
7	DC Low	Internal undervoltage warning	40	<i>Bus Ret</i>	<i>Inverter is decelerating in Bus mode</i>
8	DC High	Internal overvoltage warning and trip	41	<i>PI Reg</i>	<i>Process regulator is activated at terminal</i>
9	GND Fail S	Ground fail detected during stop	42	<i>Calibrating</i>	<i>Calibrate procedure is ongoing</i>
10	Imagn Fail	Magnetization current too low or too high	43	<i>Calibr Done</i>	<i>Calibrate procedure finished</i>
11	Cur Low	Output current too low	44	<i>BasicTun Ok</i>	<i>Basic tuning finished</i>
12	Cur High	Output current too high	45	<i>Full Tun Ok</i>	<i>Full tuning finished</i>
13	Run Fail	Locked rotor / unable to control motor	46	<i>RsMeas Ok</i>	<i>Stator resistance measurement finished</i>
14	Sio Fail	Serial communication timeout	47	<i>ParCalc Ok</i>	<i>Parameter calculation finished</i>
15	Bus Fail	Fieldbus communication timeout	48	Short Circ	Short circuit error detected
16	Tun Fail P	Tuning error, parameter value	49	DC Low Trip	Internal undervoltage trip
17	Tun Fail M	Tuning error, measurement	50	SampleTime	Internal error, measurement sample time
18	RsMeasFail	Tuning error, stator resistance	51	Motor Volt	Voltage detected on motor terminals
19	TuneCnvFail	Tuning error, calculation	52	<i>Fire Mode</i>	<i>Fire Mode is activated</i>
20	Dsp ComErr	Internal error, communication	53	<i>Not Tuned</i>	<i>Tuning has not been performed</i>
21	Cop Restrt	Internal error, restart/reboot	54	<i>Delay Run</i>	<i>Inverter will start after run delay time</i>
22	Dsp SysErr	Internal error, measurement circuits	55	<i>DC Low Ctrl</i>	<i>Internal undervoltage regulation active</i>
23	Cop ComErr	Internal error, communication	56	<i>DC High Ctrl</i>	<i>Internal overvoltage regulation active</i>
24	<i>Stop</i>	<i>Inverter is stopped</i>	57	<i>Fact Reset</i>	<i>Parameters was reset to factory default</i>
25	<i>Wait</i>	<i>Inverter is waiting to become ready</i>	58	<i>Cop FwUpdt</i>	<i>Firmware update of co-processor</i>
26	<i>Brake Ch</i>	<i>Brake chopper is operating</i>	59	<i>Dsp FwUpdt</i>	<i>Firmware update of DSP</i>
27	<i>Cur Limit</i>	<i>Current limit has been reached</i>	60	<i>Gui FwUpdt</i>	<i>Firmware update of GUI</i>
28	<i>Tuning</i>	<i>Tuning is ongoing</i>	61	Safe Trq Off	Safe Torque Off function activated
29	<i>Sleep</i>	<i>Inverter has entered sleep mode</i>	62	STO Error	Safe Torque Off circuit error
30	<i>Final Freq</i>	<i>Inverter has reached final frequency</i>	63	<i>Invalid Status</i>	<i>Reserved for internal use</i>
31	<i>Accel</i>	<i>Inverter is accelerating</i>	64	PI reg Error	PI regulator can not reach setpoint
32	<i>Decel</i>	<i>Inverter is decelerating</i>	65	<i>Not used</i>	<i>Reserved for future use</i>

Table 20. Inverter status codes

6.1.2 Control inverter using MODE/SMODE/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 SMODE to send a start or stop command. 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 (in Frequency mode), or Input Speed Setpoint register (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.

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 concurrently using Profibus, Profinet or any other Anybus CompactCom (fieldbus) module.

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	-

Table 21. Drive control bit field description

Bit	Name	Description	Bit	Name	Description
0	Ready	Ready to receive enable command	8	Fire Mode active	Inverter operates in fire mode
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

Table 22. Drive status bit field description

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:

Telegram 1 parameters (available in all firmware versions)			Extended telegram parameters (available from version 5120)		
Slot	ADI	Description	Slot	ADI	Description
1	1	Profidrive Status word	5	22	Actual rotor speed in rpm
2	2	Profidrive Actual frequency (or speed)	6	120	Motor current RMS in mA (32 bit)
3	3	Profidrive Control word	7	121	Output power RMS in Watts (32 bit)
4	4	Profidrive Setpoint frequency (or speed)	8	122	Power factor in % $\times 10^1$
			9	123	Internal DC bus voltage in Volts
			10	125	Actual stator frequency in Hz $\times 10^1$
			11	233	Energy counter in Watthours (32 bit)

Table 23. Profidrive Telegram parameter slots

Some external systems may number slots starting on 0, but the order of parameters is 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 (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.

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	-

Table 24. Profidrive control bit field description

Bit	Name	Description	Bit	Name	Description
0	Ready	Ready to receive enable command	8	Fire Mode active	Inverter operates in fire mode
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

Table 25. Profidrive status bit field description

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. 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. Resistor is connected to internal power DC voltage and must be of class II construction.



External braking resistance must be fitted if the deceleration time is low, compared to the inertia of the driven load. Avoid setting deceleration ramp 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 5.4.

Furthermore, the motor nameplate data shall be entered in the inverters' setup, and a tuning of the motor shall be performed. See section 5.5.

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 [\uparrow] and [\downarrow] 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 analog and digital input combination.



The digital inputs 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 5 (+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 analog setpoint 0 – 10 V resulting in 10 – 60 Hz frequency.

- Connect analog control signal between terminal 6 (AIN1.U) and terminal 8 (0V).
- Check that parameter *Ain 1 Type* in parameter group *Control* is set to *0-10 V*.
- Check that parameter *DIN5 function* in parameter group *Control* is set to *Analog Input*.
- Set parameter *An Min Freq* in parameter group *Frequency* to 10Hz.
- Set parameter *An Max Freq* in parameter group *Frequency* to 60Hz.
- Start motor by connecting terminal 1 (DIN1, Run signal) to terminal 5 (+24V).
- Stop motor by disconnecting terminal 1 and terminal 5.

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.

- Set parameter *Control Mode* in parameter group *Control* to *PI-reg*.
- Connect actual value signal between terminal 7 (AIN2.U) and terminal 8 (0V).
- Check that parameter *An In 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*.

- If necessary, adjust regulator amplification using parameter Reg Kp in parameter group PI-reg.
- If necessary, adjust regulator integration time using parameter Reg Ti in parameter group PI-reg.
- Start motor by connecting terminal 1 (DIN1, Run signal) to terminal 5 (+24V).
- Stop motor by disconnecting terminal 1 and terminal 5.

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 a 0 – 300 kPa pressure sensor.

- Set parameter *Control Mode* in parameter group *Control* to *PI-reg*.
- Connect actual value signal between terminal 7 (AIN2.U) and terminal 8 (0V).
- Connect setpoint value signal between terminal 6 (AIN1.U) and terminal 8 (0V) (or use terminal 11 or 27).
- Check that parameter *An In 2 Type* in parameter group *Control* is set to *0-10V*.
- Check that parameter *An In 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 *Min Freq* and *Max Freq* in parameter group *PI-reg*.
- Set actual value from sensor at 0V (0 kPa) using parameter *Actual Min Val* in parameter group *PI-reg*.
- Set actual value from sensor at 10V (300 kPa) using parameter *Actual Max Val* in parameter group *PI-reg*.
- Set setpoint value from sensor at 0V (0 kPa) using parameter *Setpoint Min Val* in parameter group *PI-reg*.
- Set setpoint value from sensor at 10V (300 kPa) using parameter *Setpoint Max Val* in parameter group *PI-reg*.
- If necessary, adjust regulator amplification using parameter RegKp in parameter group PI-reg.
- If necessary, adjust regulator integration time using parameter RegTi in parameter group PI-reg.
- Start system by connecting terminal 1 (DIN1, Run signal) to terminal 5 (+24V)
- Stop motor by disconnecting terminal 1 and terminal 5.

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 a digital input configured for PI-reg. 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*, e.g. as in section 9.3.4.
- Set parameter *Control Mode* in parameter group *Control* to *Frequency*.
- Connect an analog control signal to terminal 6 (AIN1.U) and terminal 8 (0V) that gives the desired night time (low frequency) setting.
- Connect a time relay or other contact between one DIN-terminal (configured for PI-reg) and a +24V source. When the DIN terminal is active, PI-reg is activated. When the DIN is not active, the inverter selects the night time setup frequency.

9.3.7 Ventilation control with both analog and fixed setpoints

For ventilation installations, it is sometimes necessary to let an external signal or time relay contact override the control setpoint. For example, during forced ventilation, or reduced ventilation at night time, the fan should speed up (or down) to a maximum or pre-defined setpoint. This example sets up for normal conditions 10 – 40 Hz using analog input 4 – 20 mA as setpoint, and changes to 50Hz when activation occurs.

- Connect analog control signal to terminal 21 (AIN1.I+). Connect terminal 22 (AIN1.I-) to terminal 27 (0V).
- Connect activation signal to DIN4 (default configured for function Select A).
- Set parameter *An In 1 Type* in parameter group *Control* to *4-20 mA*.
- Set parameter *Op Mode (Setp Source)* in parameter group *Frequency* to *Terminal*.
- Set parameter *Fix Freq1* in parameter group *Frequency* to 50Hz.
- Set parameter *An Min Freq* in parameter group *Frequency* to 10Hz.
- Set parameter *An Max Freq* in parameter group *Frequency* to 40Hz.
- Start motor by connecting terminal 1 (DIN1, Run signal) to terminal 5 (+24V).
- Activate preset frequency by connecting terminal 4 (default configuration Select A) to terminal 5 (+24V).

9.3.8 Ventilation control with analog setpoint and Fire Mode

For ventilation installations including requirement of a prioritized ventilation or smoke evacuation program, the NFO Sinus Optimal offers the Fire Mode function. When Fire Mode is activated, the unit uses the specified Fire Mode setpoint, and disregards any fault conditions that during normal operation would lead to a shut down.

This example sets up for normal conditions 10 – 50 Hz using analog input 0 – 10 V as setpoint, and changes to 60Hz if Fire Mode is activated by a closing contact signal.

- Connect analog 0 – 10V control signal to terminal 6 (AIN1.U [DIN5]) and terminal 8 (0V).
- Choose a terminal (e.g. DIN2 – DIN4, DIN6 – DIN8) and connect fire alarm indication signal to the selected DIN terminal. This example assumes that a +24V level on terminal will activate Fire Mode. Please note that AIN1.U [DIN5] is already in use as analog input and can't be selected also for digital input.
- Configure the selected DIN for Fire Mode. Configuration is set up in the Control Menu
- Complete the Fire Mode setup by setting *Fire Mode Type* in *Control* menu to *Closed Contact* (i.e. closing contacts at the fire alarm equipment will put out +24V signalling voltage to the terminal).
- Set parameter *An In 1 Type* in parameter group *Control* to *0-10 V*.
- Set parameter *Fire Mode Setp* in parameter group *Control* to *Fix 6 F*.
- Set parameter *Op Mode (Setp Source)* in parameter group *Frequency* to *Terminal*.
- Set parameter *Fix Freq 6* in parameter group *Frequency* to 60Hz.
- Set parameter *An Min Freq* in parameter group *Frequency* to 10Hz.
- Set parameter *An Max Freq* in parameter group *Frequency* to 50Hz.
- Start motor in normal run mode by connecting terminal 1 (DIN1, Run signal) to terminal 5 (+24V).
- Activate Fire Mode by connecting the chosen terminal to a +24V source (from fire alarm contacts).