Modbus & Profinet Quick Guide

NFO Sinus Optimal [with Safe Torque Off]

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 connection and setup of communication parameters, please see Operating and Installation Manual.

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 APPLCATIONPROTOCOL SPECIFICATION V1.1b”, available from https://www.modbus.org

Available function codes are:

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

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

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

Default bus master access to Modbus register addresses should be by using the 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 ADI 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 Optimal 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 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.

Below follows a small 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. The table continues on next page.

Parameter Name	ADI	Modbus reg. addr	Type	Scaling/ Coding	Remark
I-rms (output current)	120	03ECh – 03EDh	SINT32	mA (A × 10^3)	Read only
P-out (output power)	121	03F0h – 03F1h	SINT32	W (kW × 10^3)	Read only
PF (output power factor)	122	03F4h	SINT16	1 × 10^3	Read only
Stator Freq (actual)	125	0400h	SINT16	Hz × 10^1	Read only
Control Freq (setpoint)	195	0518h	SINT16	Hz × 10^1	Read only

Parameter Name	ADI	Modbus reg. addr	Type	Scaling/ Coding	Remark
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 × 10^2 (one tick per every 36 s)	Read only
Running Time	40	02ACh – 02ADh	UINT32	h × 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 × 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

Control from terminals and use Modbus to read status and actual values

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

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 Operating and Installation Manual, section 5.

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

Code	Text	Description
0	*Erased*	*Error log was erased*
1	**GND Fail R**	**Ground fail detected during run**
2	**AC Fail**	**Mains power error**
3	**Temp Hi**	**Too high temperature on heat sink**
4	**PTC Temp**	**Motor temperature sensor trip**
5	**Overload**	**Electronic motor overload trip**
6	**Analog Fail**	**Analog input out of range**
7	**DC Low**	**Internal undervoltage warning**
8	**DC High**	**Internal overvoltage warning and trip**
9	**GND Fail S**	**Ground fail detected during stop**

Code	Text	Description
33	*Ext Stby*	*Inverter is ready for run cmd in Auto mode*
34	*Ext Run*	*Inverter is running in Auto mode*
35	*Ext Acc*	*Inverter is accelerating in Auto mode*
36	*Ext Ret*	*Inverter is decelerating in Auto mode*
37	*Bus Stby*	*Inverter is ready for run cmd in Bus mode*
38	*Bus Run*	*Inverter is running in Bus mode*
39	*Bus Acc*	*Inverter is accelerating in Bus mode*
40	*Bus Ret*	*Inverter is decelerating in Bus mode*
41	*PI Reg*	*Process regulator is activated at terminal*
42	*Calibrating*	*Calibrate procedure is ongoing*

Code	Text	Description
10	**Imagn Fail**	**Magnetization current too low or too high**
11	**Cur Low**	**Output current too low**
12	**Cur High**	**Output current too high**
13	**Run Fail**	**Locked rotor / unable to control motor**
14	**Sio Fail**	**Serial communication timeout**
15	**Bus Fail**	**Fieldbus communication timeout**
16	**Tun Fail P**	**Tuning error, parameter value**
17	**Tun Fail M**	**Tuning error, measurement**
18	**RsMeasFail**	**Tuning error, stator resistance**
19	**TuneCnvFail**	**Tuning error, calculation**
20	**Dsp ComErr**	**Internal error, communication**
21	**Cop Restrt**	**Internal error, restart/reboot**
22	**Dsp SysErr**	**Internal error, measurement circuits**
23	**Cop ComErr**	**Internal error, communication**
24	*Stop*	*Inverter is stopped*
25	*Wait*	*Inverter is waiting to become ready*
26	*Brake Ch*	*Brake chopper is operating*
27	*Cur Limit*	*Current limit has been reached*
28	*Tuning*	*Tuning is ongoing*
29	*Sleep*	*Inverter has entered sleep mode*
30	*Final Freq*	*Inverter has reached final frequency*
31	*Accel*	*Inverter is accelerating*
32	*Decel*	*Inverter is decelerating*

Code	Text	Description
43	*Calibr Done*	*Calibrate procedure finished*
44	*BasicTun Ok*	*Basic tuning finished*
45	*Full Tun Ok*	*Full tuning finished*
46	*RsMeas Ok*	*Stator resistance measurement finished*
47	*ParCalc Ok*	*Parameter calculation finished*
48	**Short Circ**	**Short circuit error detected**
49	**DC Low Trip**	**Internal undervoltage trip**
50	**SampleTime**	**Internal error, measurement sample time**
51	**Motor Volt**	**Voltage detected on motor terminals**
52	*Fire Mode*	*Fire Mode is activated*
53	*Not Tuned*	*Tuning has not been performed*
54	*Delay Run*	*Inverter will start after run delay time*
55	*DC Low Ctrl*	*Internal undervoltage regulation active*
56	*DC High Ctrl*	*Internal overvoltage regulation active*
57	*Fact Reset*	*Parameters was reset to factory default*
58	*Cop FwUpdt*	*Firmware update of co-processor*
59	*Dsp FwUpdt*	*Firmware update of DSP*
60	*Gui FwUpdt*	*Firmware update of GUI*
61	**Safe Trq Off**	**Safe Torque Off function activated**
62	**STO Error**	**Safe Torque Off circuit error**
63	*Invalid Status*	*Reserved for internal use*
64	**PI reg Error**	**PI regulator can not reach setpoint**
65	*Not used*	*Reserved for future use*

Control inverter using DriveControl/DriveStatus

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

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

Drive control bit field description:

Bit	Name	Description
0	Switch on	Run command (run signal must be active)
1	Not used	(value echoed to drive status bit 4)
2	Not used	(value echoed to drive status bit 5)
3	Enable	Enable command (must precede Run cmd)
4	Not used	-
5	Not used	-
6	Not used	-
7	Fault ack	Fault acknowledge on 0 to 1 transition

Bit	Name	Description
8	Not used	-
9	Not used	-
10	Not used	-
11	Not used	-
12	Not used	-
13	Not used	-
14	Bus control cmd	PLC takes control (must precede Enable)
15	Not used	-

Drive status bit field description:

Bit	Name	Description
0	Ready	Ready to receive enable command
1	Switched on	Inverter output stage is active
2	Enabled	Enabled, ready to receive run command
3	Fault active	Fault condition active (may require ack)
4	Not used	(returns value of drive control bit 1)
5	Not used	(returns value of drive control bit 2)
6	Disabled	Run signal not present on terminal DIN1
7	Alarm active	Alarm condition active (not require ack)

Bit	Name	Description
8	Not used	-
9	Control from bus	Inverter is in bus mode
10	Setpoint reached	Output frequency has reached setpoint
11	Limit active	Inverter has reached current limit
12	Sleep active	Output is suspended in sleep mode
13	Stopmode brake	Inverter will brake/ramp to stop
14	Reverse	Actual rotation is reverse
15	Stopping	Inverter is decelerating towards a stop

An example of communication could be that bus master sets the Bus control command bit and then waits for inverter to respond with Control from bus bit in status. Then bus master sets the Enable bit and waits for inverter to respond with Enabled. Now the bus master may start the motor using the Switch on command bit, and inverter will respond with Switched on. When bus master clears the Switch on bit, inverter will decelerate towards a stop. When fully stopped, the Switched on bit will be cleared and inverter is now ready for a new start command. For other status bits and their meaning, see table above.

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)		
Slot	**ADI**	**Description**
1	1	Profidrive Status word
2	2	Profidrive Actual frequency (or speed)
3	3	Profidrive Control word
4	4	Profidrive Setpoint frequency (or speed)

Extended telegram parameters (available from version 5120)			
Slot	**ADI**	**Description**	
5	22	Actual rotor speed in rpm	
6	120	Motor current RMS in mA	(32 bit)
7	121	Output power RMS in Watts	(32 bit)
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)

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 (when in Speed mode). A negative number corresponds to reverse rotation. Maximum range is -24576 – +24576 ($\pm$ 150Hz or $\pm$ 3 $\times$ Nnom).

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

Profidrive control bit field description:

Bit	Name	Description
0	Switch on	Run command (run signal must be active)
1	Not used	(value echoed to drive status bit 4)
2	Not used	(value echoed to drive status bit 5)
3	Enable	Enable command (must precede Run cmd)
4	Not used	-
5	Not used	-
6	Not used	-
7	Fault ack	Fault acknowledge on 0 to 1 transition

Bit	Name	Description
8	Not used	-
9	Not used	-
10	PLC control	PLC takes control (must precede Enable)
11	Not used	-
12	Not used	-
13	Not used	-
14	Not used	-
15	Not used	-

Profidrive status bit field description:

Bit	Name	Description
0	Ready	Ready to receive enable command
1	Operating	Inverter output stage is active
2	Enabled	Enabled, ready to receive run command
3	Fault active	Fault condition active (may require ack)
4	Not used	(returns value of drive control bit 1)
5	Not used	(returns value of drive control bit 2)
6	Disabled	Run signal not present on terminal DIN1
7	Alarm active	Alarm condition active (not require ack)

Bit	Name	Description
8	Not used	-
9	Control requested	Inverter is in bus mode
10	Setpoint reached	Output frequency has reached setpoint
11	Limit active	Inverter has reached current limit
12	Sleep active	Output is suspended in sleep mode
13	Stopmode brake	Inverter will brake/ramp to stop
14	Reverse	Actual rotation is reverse
15	Stopping	Inverter is decelerating towards a stop

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

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

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