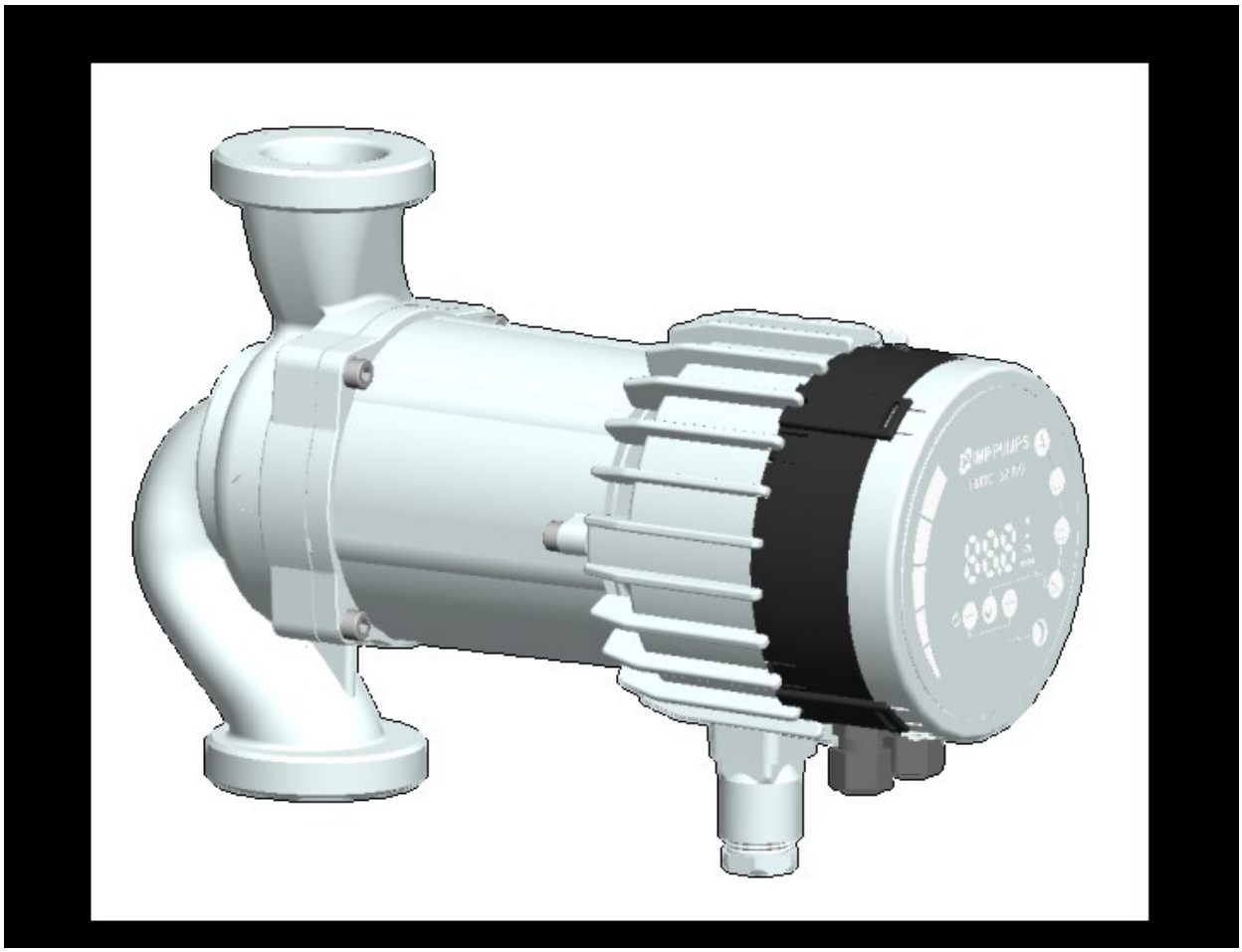
IMPPUMPS
Intelligent Motor Pumps

NMTC module



Installation and operating manual for

- NMT Smart C
- NMT Max C
- NMT Lan C
- NMT Max II C
- NMT Smart II C

EN

7340055, v36, for firmware revision 2.286 +

WARNING!
Prior to installation and commissioning, read these instructions first. Installation and operation must comply with local regulations.

WARNING!
Installation and use of this product requires experience and knowledge of this or similar products. Persons with reduced physical, mental or sensory capabilities must not use this product, unless properly instructed and supervised. Children must not be allowed to play with this product.

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1 SYMBOLS AND CONVENTIONS USED IN THIS DOCUMENT



WARNING!
Denotes that a failure to observe those instructions might cause damage to equipment or pose danger to the user.

NOTE: - Gives additional tips or instructions that might ease the job and ensure proper operation.

NOTE:

- Data in this document are subject to change.
- Actual implementation might differ by pump model and software revision.
- Make sure you are using the right manual for your product. Functionality may differ by firmware revision.
- Verify proper operation after integration.
- Manufacturer cannot be held responsible for problems caused either directly or indirectly by the use of information in this manual.

1.1 ABBREVIATIONS AND CONVENTIONS

Abbreviation	Description
Baud, Baud rate	Serial communication speed, in bits per second including start, parity and stop bits.
BACnet	A Data Communication Protocol for Building Automation and Control Networks.
CRC	Cyclic Redundancy Check, additional bytes used to confirm valid data transmission.
Ethernet	IEEE 802.3, mostly referring to 10BASE-T RJ-45 connector present on board.
H	Differential pressure, often called Head.
I/O	Input/Output.
LED	Light Emitting Diode.
Modbus	A communication protocol used for device automation and remote access.
MS/TP	Master Slave Token Passing, network access control used with BACnet over RS-485.
NMTC	NMT pump Communication module.
Q	Pump flow or flow rate.
RTU	Remote Terminal Unit, network access control used with Modbus.
RS-485	Multi drop serial network wiring, used to transfer data.
TCP	Transmission Control Protocol is a digital data packet handling.
UDP	User Datagram Protocol is a digital data packet handling.
Web interface	HTTP server accessible over Ethernet connector .

This manual assumes that the reader is familiar with commissioning and configuring pumps and relevant networking.

When using relay and analog I/O, compatible external controller and suitable configuration of MODE switch is expected.

2 INTRODUCTION

This manual describes the NMTC module for NMT range of pumps that is either integrated (eg. NMT LAN C, NMT MAX II C) or separately available (NMT Smart C and NMT MAX C).

Purpose of this module is to provide communication interface to the pump.

This module is intended for various remote control applications, including:

- Remote on/off
- Analog 0..10 V voltage control and feedback
- Analog 4..20 mA control and feedback
- PWM control and feedback
- Status relay feedback
- Modbus RTU slave/device (either over RS-485, TCP or UDP)
- Modbus TCP, UDP device
- BACNET MS/TP master
- Web browser access over Ethernet

2.1 SYSTEM DIAGRAM

There are several possible connection configurations. Not all functions can be used simultaneously due to limited amount of outputs, inputs and inlet glands.

Typical configurations	
	- on/off + 0..10 V + relay output - Ethernet + on/off + 0..10 V - Ethernet + on/off + relay output - Modbus RTU + Relay output - Modbus RTU + Ethernet - BACnet MS/TP + on/off - …

2.2 SPECIFICATIONS

The table below is an overview of NMTC specifications. For details, please refer to appropriate sections of this manual.

General data		
Ambient humidity	<95 % relative, non-condensing	Also see appropriate pump data for other ambient specifications.
Power supply and connection	5 V@500 mA supplied by the pump	6-pin connector further extended for display.

RS-485		
Connector type	Screwless terminals	2+1 pins. See section 3.1 Terminals
Data protocol	- Modbus RTU - BACnet MS/TP	Only one at a time. Selectable over Web interface (tab “Network”)
Bus wire configuration	Two-wire + common	Conductors: A, B and COM (Common). See section 3.1 Terminals
Communication transceiver	Integrated, 1/8 of standard load	Connect either via passive taps or daisy chain.
Maximum cable length	1200 m	See section 6.5 Termination
Line termination	Not present	Line termination is not integrated. For low speed/short distance, termination can be omitted. Otherwise, terminate the line externally on both ends.
Supported transmission speeds	Up to 38400 baud	See data for protocol used.
Start bits, data bits	1, 8	Fixed.
Visual diagnostics	LED2	Flashing yellow when data reception detected. Combined (OR) with Ethernet ACT function.
Maximum number of devices	256	1/8 nominal load enables 256 devices, protocol limit might be lower.
Isolation	Common ground (COM) with SET1, SET2 and SET3.	Bus shares common ground with other signals.

Modbus RTU over RS-485		
Slave address	1-247	See section 6.6 Modbus RTU Speed, parity and address. [default=245]
Maximum Modbus packet size	256 bytes	Including address (1) and CRC (2) bytes.
Supported baud rates	1200, 2400, 4800, 9600, 19200, 38400	Settable over Modbus register. Settable over Web interface (tab “Network”). [default=19200]
Stop bits	1 or 2	1 stop bit minimum, up to 2 when parity not enabled [default=1]
Parity bit	Even/odd/none	[default=Even]

BACnet MS/TP over RS-485		
Device MAC address	1-127	Settable over Web interface (tab “Network”) [default=1]
Maximum ADPU size	92 bytes	
Supported baud rates	9600, 19200, 38400	Settable over Web interface (tab “Network”) [default=38400]

Ethernet		
Connector type	RJ-45	10BASE-T, 10Mbit/s connection.
Connection type and services	- Http Web server (port 80) - Firmware update over http - Modbus (port 502)	
Default IP address	192.168.0.245	192.168.0.246 for right twin pump.
Ethernet visual diagnostics	LED1 / LINK	Slowly blinking when module is powered, permanently lid when link established.
	LED2 / ACT	Flashing yellow when data reception detected. Combined (OR) with Modbus data reception.

Modbus over Ethernet		
Server address	192.168.0.245:502	IP address is the same as for pump web server, port is fixed as 502
Device address	245	Default value, can be changed over Modbus
Data format and protocols	• Modbus TCP • Modbus RTU over TCP • Modbus UDP • Modbus RTU over UDP	Protocol is automatically selected according to established connection and received request.

Analog signals (SET1, SET2, SET3)		
Input voltage range	-1..32 VDC	When used as input.
Output voltage source range	0..12 V	When used as voltage output. 5 mA max. Load allowed per output.
Input resistance	~100 kΩ	0.5 mA load is added for most configurations.
Output current sink range	0..33 mA (4-20 mA)	Current sink to COM if configured as current output.
PWM input threshold	~3 V	5 mA current sink added.
PWM input frequency	0..10 kHz	
PWM out frequency	75 Hz	

Relay specifications		
Connection type	Screwless terminals	
Rating	- 230 VAC, 3 A, AC1 - 32 VDC, 3 A	Potential free changeover contact.

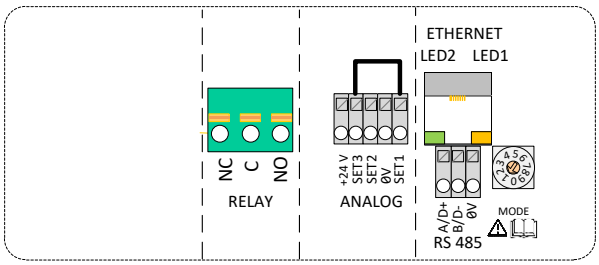
3 MODULE LAYOUT

3.1 TERMINALS

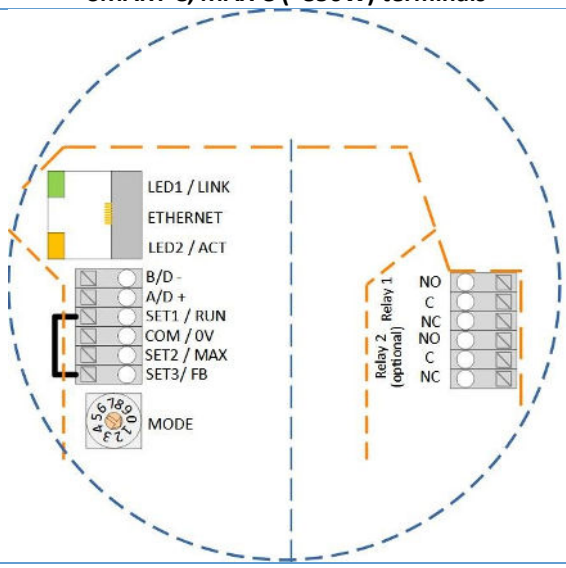
Terminal Designation	Terminal description
MODE	Mode selection rotary switch. Position read at power-on. Used to configure mode of operation for the circuit. See section 4.3 “Module mode selection”.
LED1 / LINK	Slowly blinking when module is powered. Blinking fast on Modbus Error Permanently lid when Ethernet link established.
Ethernet	10BASE-T RJ-45 connector.
LED2 / ACT	Indicates Ethernet activity or RS-485 activity.
B/D-	RS-485 negative data signal.
A/D+	RS-485 positive data signal.
SET1 / RUN	Control signal 1.
COM / 0V	RS-485 common and analog input common return.
SET2 / MAX	Control signal 2.
SET3 / FB	Control signal 3.
+24V	24 V, 50 mA output (only on some models)
NC	Normally closed relay contact. Opens when relay is active.
C	Relay common contact.
NO / OK	Normally open relay contact. Closes when relay is active.

Terminal layout with factory configuration

LAN C, MAX (>850W) terminals

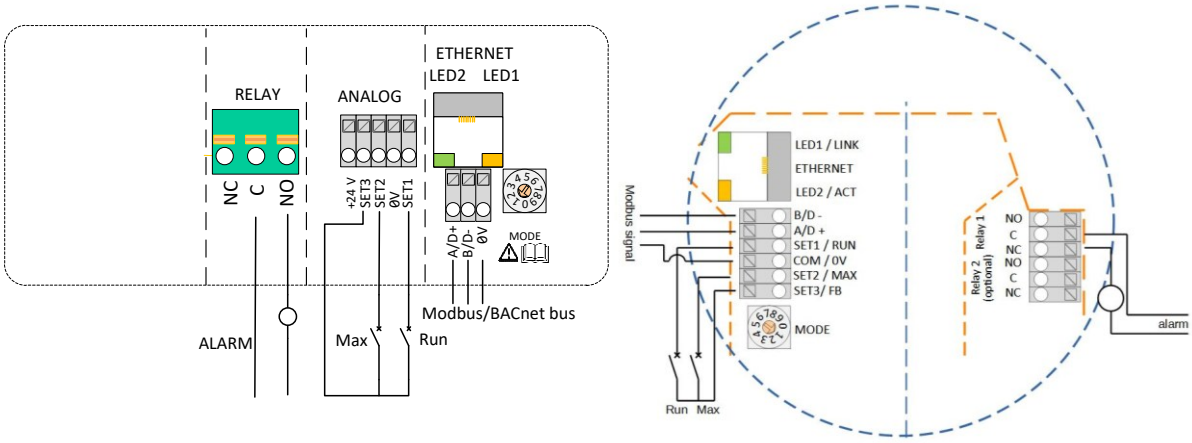


SMART C, MAX C (<850W) terminals

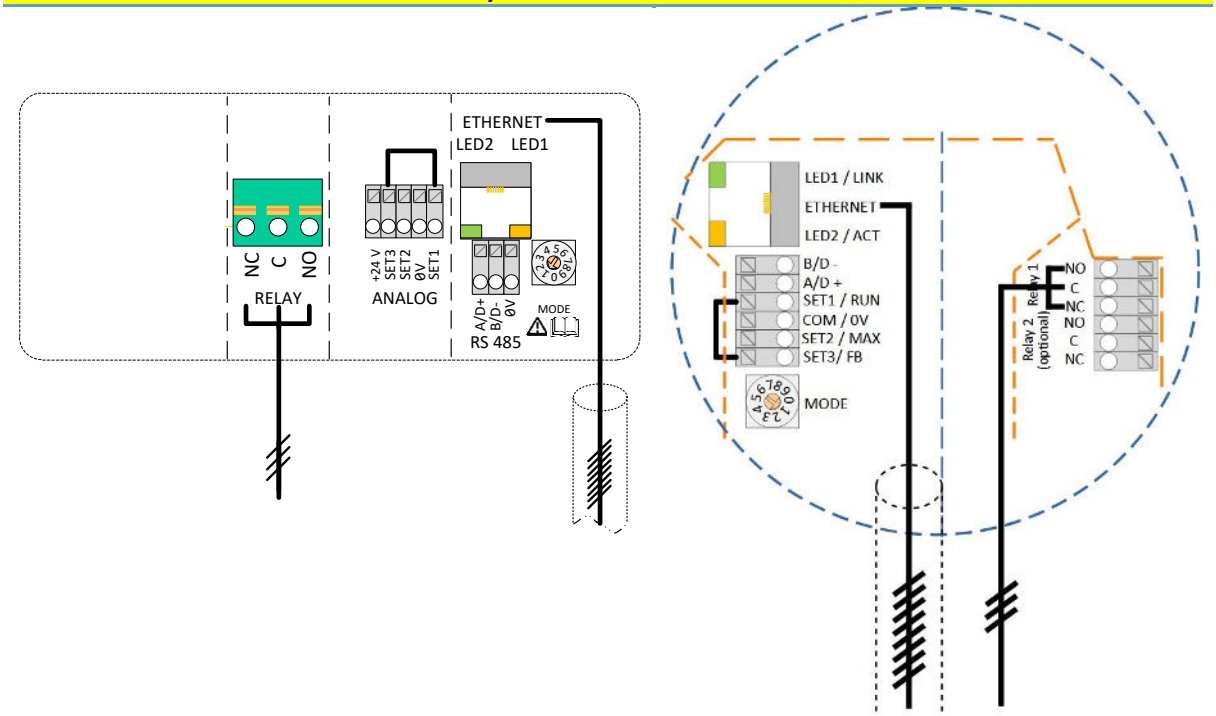


3.2 APPLICATION EXAMPLES

Relay, Analog and RS-485 connection



Relay and Ethernet connection



NOTE: To maintain pump IP (ingress protection), the network cable should be pulled through the gland inlet and then crimped to a connector.

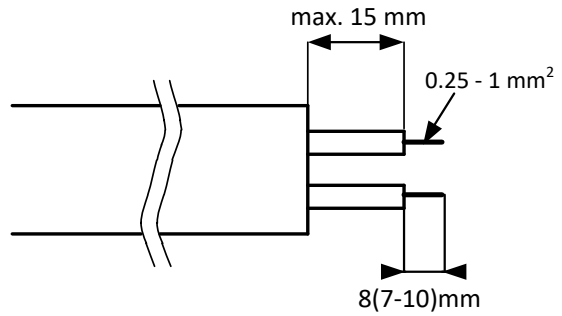
3.3 WIRING CONSIDERATIONS

- All cables connected must be heat-resistant to at least +85 °C.
- All cables connected must be installed in accordance with EN 60204-1.
- All wires to the communications module must be connected to the terminals or cut. No loose wiring permitted.

WARNING!

If voltages over 24 V AC/DC are possible on NO, C, NC terminals:

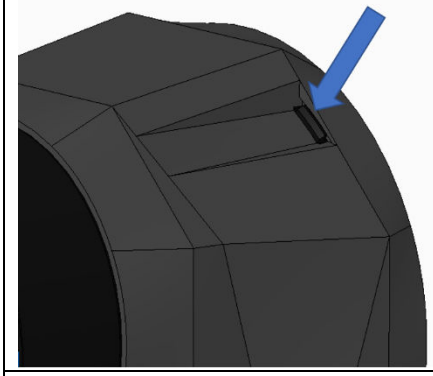
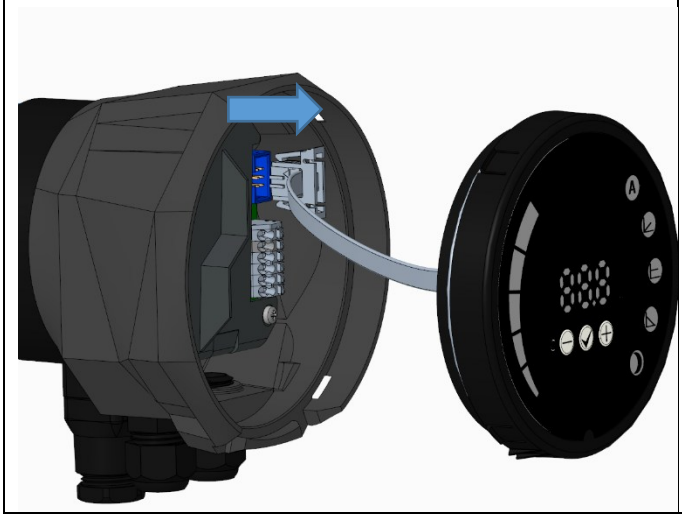
- Wires should be routed so no wire crosses the center barrier.
- Relay cable (NO, C, NC) must be separated from all other wiring with reinforced insulation. Cable outer layer must not be stripped longer than 15 mm. See “Cabling preparation” below.

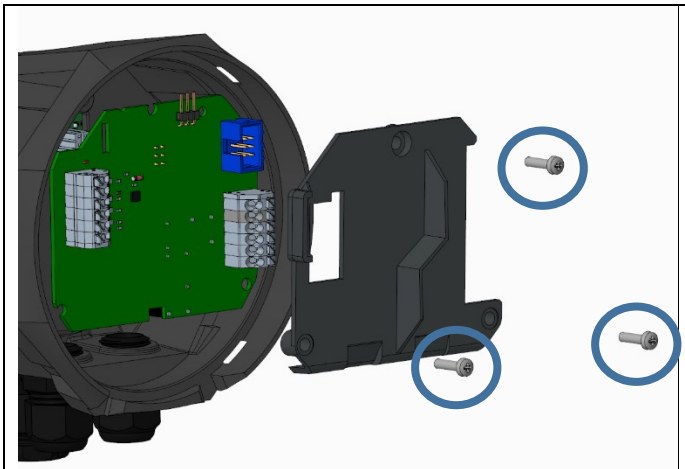
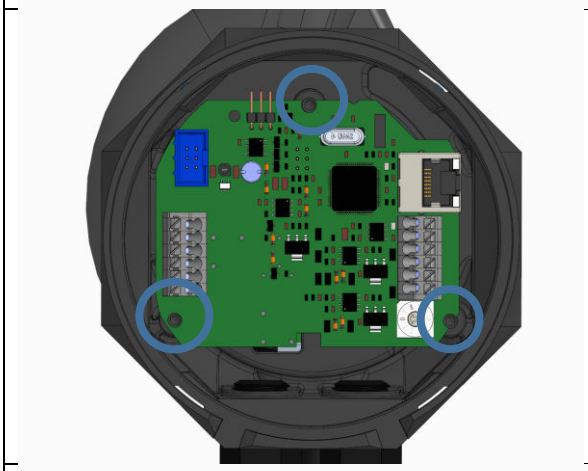
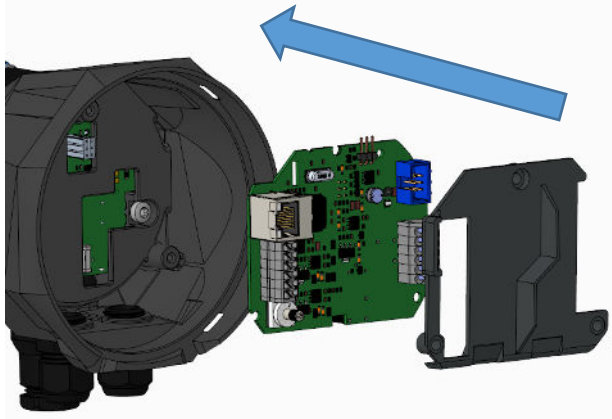
Cabling preparation	
	Cable for the screwless terminals should be prepared as shown on the left.

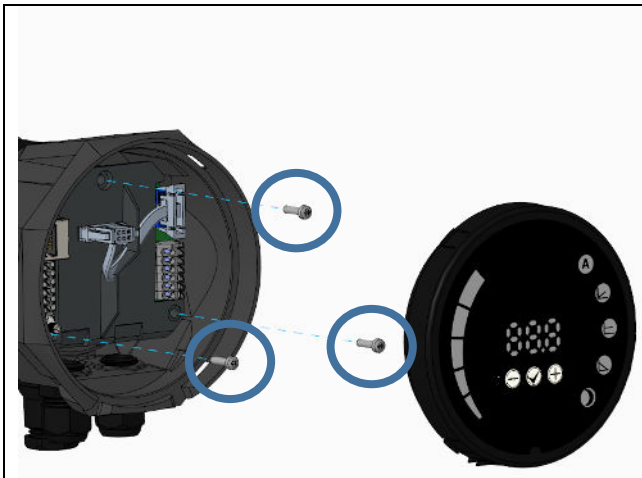
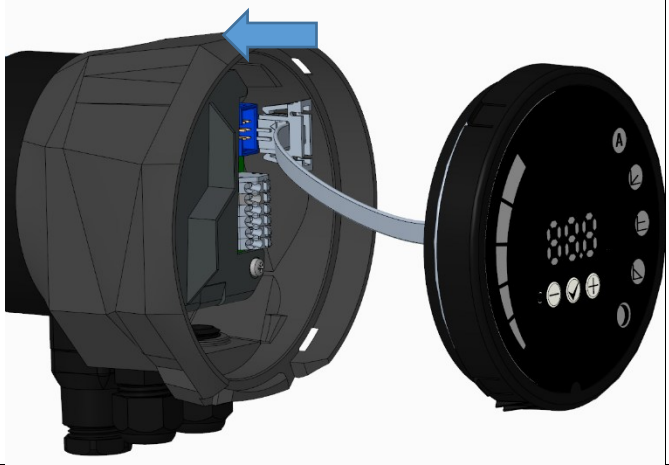
Tools	
	2.4 mm wide flat-bladed screwdriver is needed to press the terminal spring while inserting the cable. Same tool is also used to rotate the Mode switch.

3.4 MODULE INSTALLATION

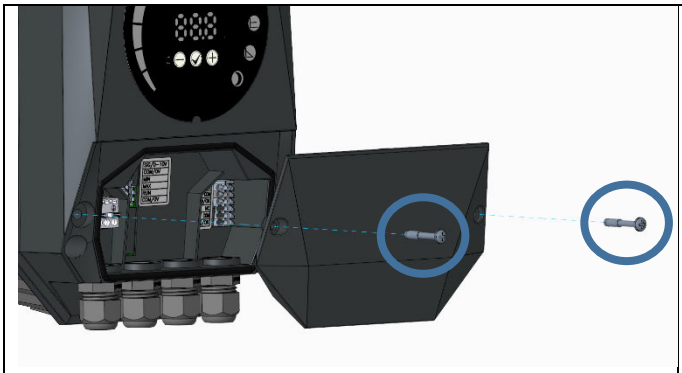
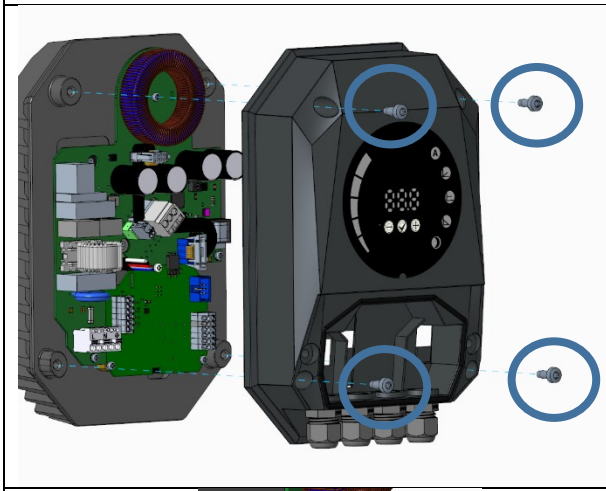
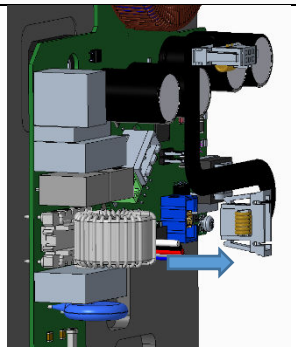
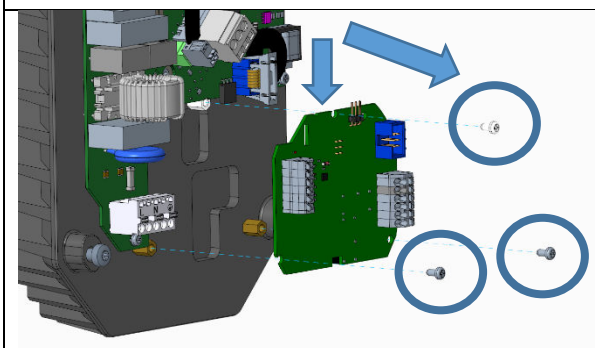
3.4.1 NMT SMART II PUMP MODELS

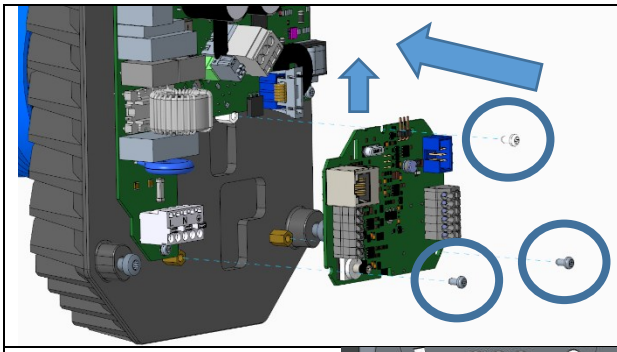
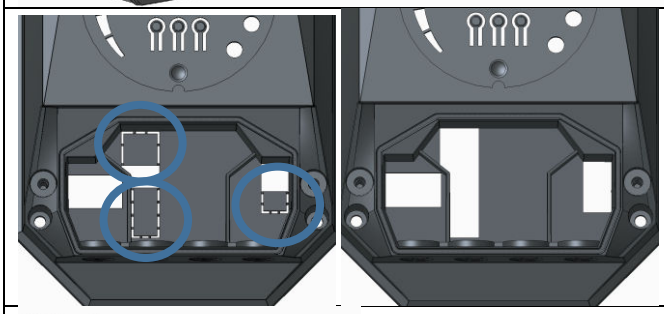
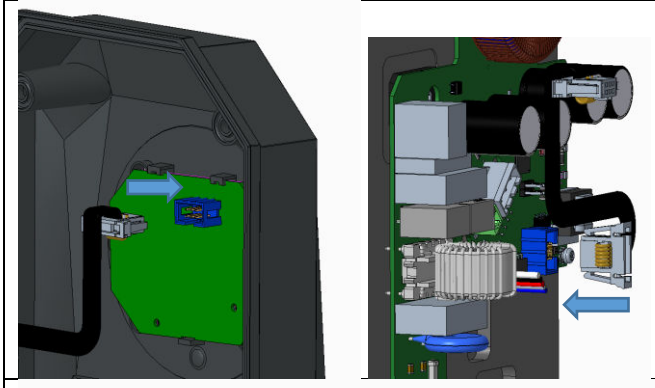
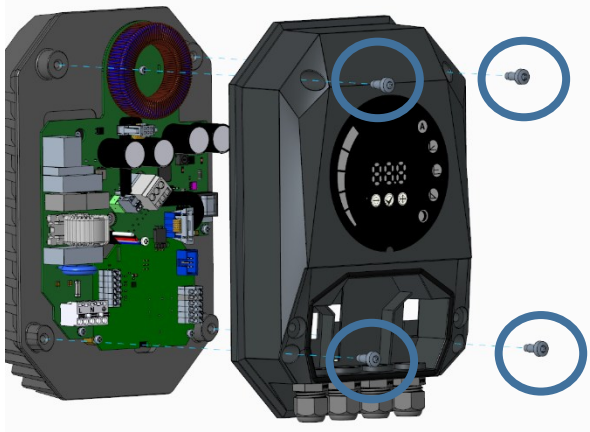
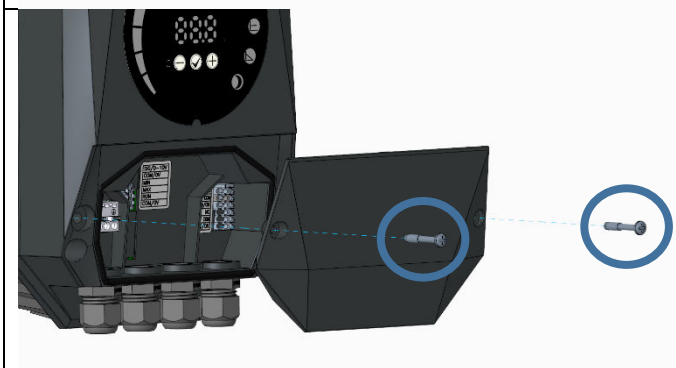
	**WARNING!** Before performing any work on the module, make sure that the pump and module electricity supply has been switched off and that it cannot be accidently switched on. . Locate the hooks, to detach the display
	Press two top hooks on the top and bottom of the display panel. Use flat tip screwdriver if needed and simultaneously pull display panel away from the pump.
	Disconnect display panel cable to ease access to the module wiring. Wiring can now be connected.

	Unscrew the 3 philips head screws to remove the cover.
	Place NMTC board inside the pump. Make sure that 6 pin head and the 3 screw holes are aligned.
	Place cover on board

	Screw the 3 philips head screws to place the cover.
	Reconnect the display cable and display.
	Make sure that the hooks are aligned. Push the display back to the NMTC module.

3.4.2 NMT MAX II PUMP MODELS

	**WARNING!** Before performing any work on the module, make sure that the pump and module electricity supply has been switched off and that it cannot be accidently switched on. . Unscrew the Philips head screws holding the front cover of the pump
	Unscrew 4 hex screws holding the electronics box.
	Disconnect display panel cable to easy electronics box removal
	Unscrew the 3 philips head screws to remove the cover and slide down the electronics, to remove them.

	Place NMTC board, by sliding in to the three pin header. Make sure that 3 screw holes are aligned. Screw the 3 philips head screws to mount the board.
	Remove the plastics on the cover so that the new board will fit
	Reconnect the display cable and display.
	Screw back the 4 hex screws holding the electronics housing
	Connect all the cables to the NMTC module and screw back the cover

3.4.3 NMT MAX AND SMART PUMP MODELS

Only for NMT Smart and NMT MAX pump models.

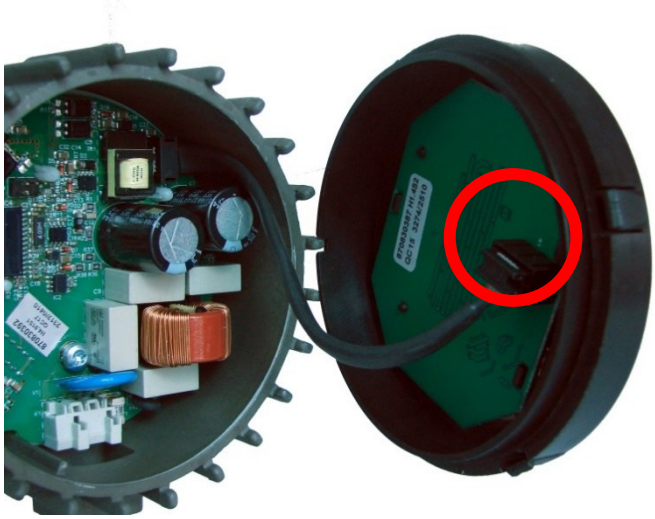
Installing the module



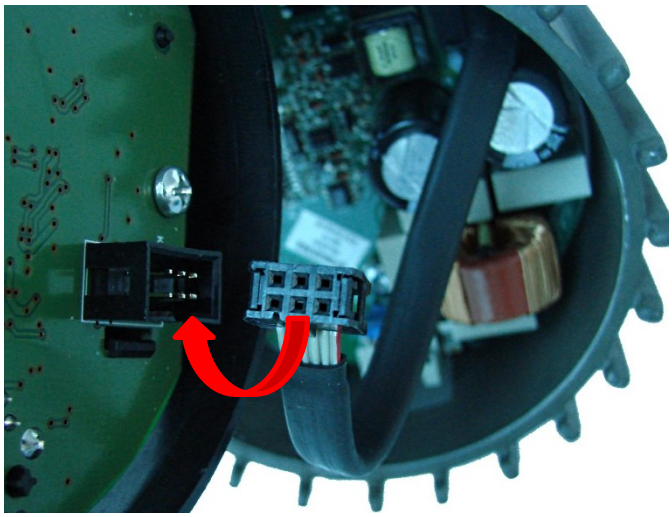
WARNING!

Before performing any work on the module, make sure that the pump and module electricity supply has been switched off and that it cannot be accidently switched on.

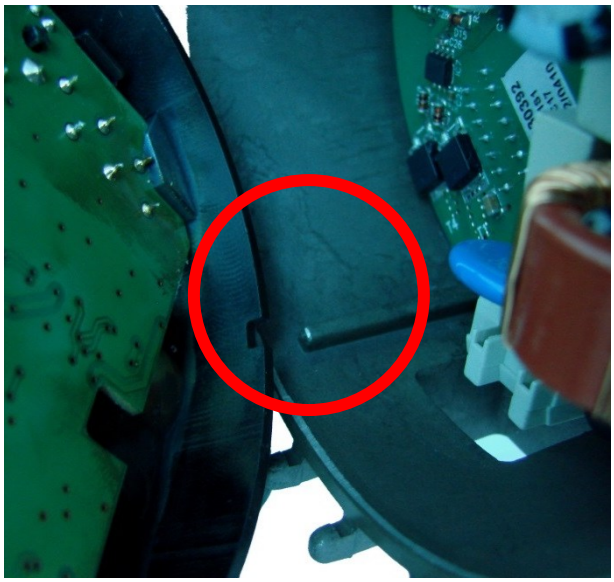
Press two top hooks on the display panel. Use flat tip screwdriver if needed and simultaneously pull display panel away from the pump.



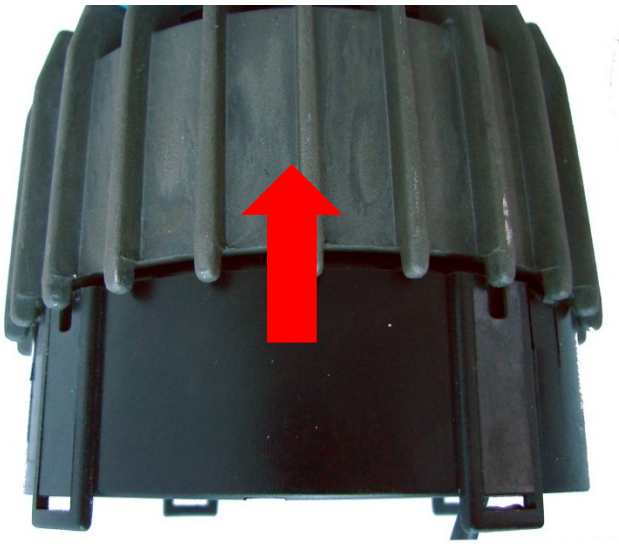
Disconnect display panel cable to ease access to the module wiring. Wiring can now be connected.



Connect the NMTC module with power electronics.



Make sure that the position tab and position slot are aligned.



Push the NMTC module back to the heat sink

3.5 CONNECTING THE MODULE WIRING

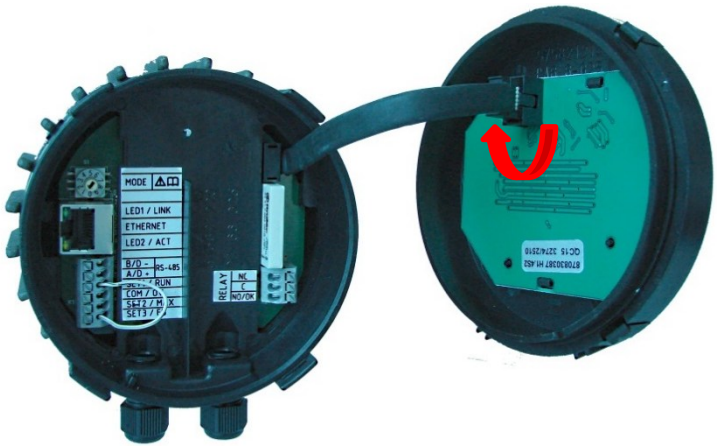
NOTE: Only for NMT Smart and NMT MAX pump models.

Opening the cover



WARNING!
Before performing any work on the module, make sure that the pump and module electricity supply has been switched off and that it cannot be accidently switched on.

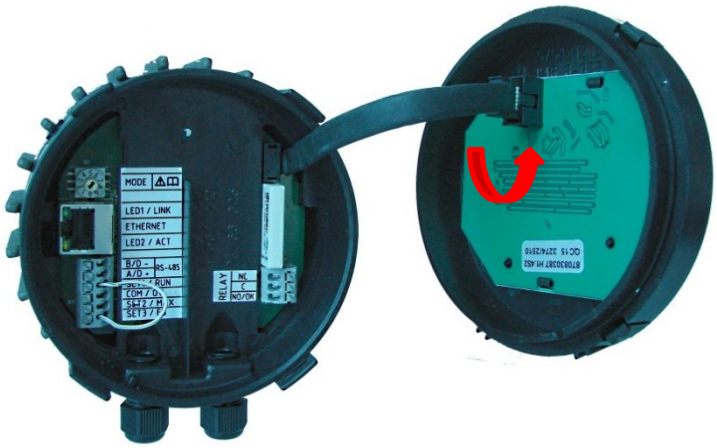
Press two top hooks on the display panel (Use flat tip screwdriver if needed) and simultaneously pull display panel away from the pump.



Disconnect display panel cable to ease access to the module wiring.

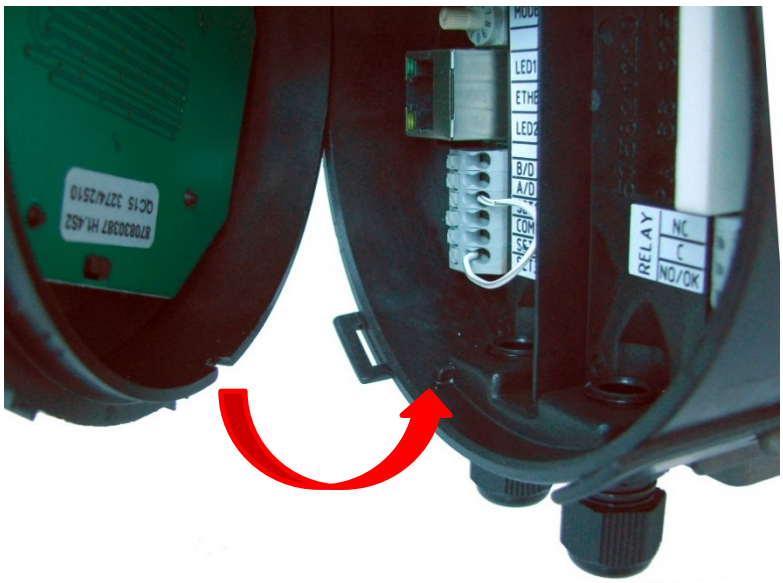
Wiring can now be connected.

Closing the cover



WARNING!
Before performing any work on the module, make sure that the pump and module electricity supply has been switched off and that it cannot be accidently switched on.

Reconnect display panel cable.



Make sure that the position tab and position slot are aligned.



Make sure that the hooks are aligned.

Push the display back to the NMTC module.

4 CONTROL MODES AND PRIORITIES

4.1 PRIORITY OF SETTINGS

Several signals will influence the pump operation. For this reason, settings have priorities as shown in the table below. If two or more functions are active at the same time, the one with highest priority will take precedence.

Priority	Pump control panel & Ethernet settings	External signals[1]	Modbus control
1	Stop (OFF)		
2	Night mode active[2]		
3	Max. RPM (Hi)		
4		Min. curve[4]	
5		Stop (Run not active)	
6		Max. curve[4]	Stop[3]
7		Set point setting[4]	Set point setting[3]
8	Set point setting[4]		

Examples:

- Stop on the pump display panel will stop the pump, regardless of external set point.
- If External Run input is inactive, the pump cannot be started over Modbus, but can be set to max RPM on the display panel.

4.2 CONTROL VARIABLES

Pump will respond to external controls according to selected pump operating mode. Consult proper pump operating manual for explanation.

Symbol	Regulation mode	Module set point controls:
	Auto mode	- (RUN only)
	Proportional pressure	Maximum head
	Constant pressure	Maximum head
	Constant speed	Speed (RPM)
	Combined[5]	- (Web interface only)
	Night mode[6]	- (RUN only)

[1] Not all inputs are available in all modes.
[2] External and Modbus Stop signals become active in night mode. Due to possible confusion, use of night mode is discouraged while using external control.
[3] Only available when pump is bus controlled.
[4] Not available when pump is bus controlled.
[5] Multiple limits can be set. Not available on all pumps.
[6] Night mode is not independent regulation mode.

4.3 MODULE MODE SELECTION



WARNING!
Before performing any work on the module, make sure that the pump and module electricity supply has been switched off and that it cannot be accidently switched on.

There is a mode selection rotary switch in the terminal box. It can be rotated by gently inserting a screwdriver into the arrow mark on top and rotating the switch to desired value. This enables manual configuration according to table below. For advanced configuration, place rotary switch to position 0 and configure module over network.

Mode switch position	Function	Description
0	Web configuration	Terminal functions are configured over Web interface. SET pins and relay functionality can be configured to any custom function.
1	Mode 1 (2-10V control)	SET1 = RUN input SET2 = MAX input SET3 = FB (10.5 V) output, can be used to supply RUN and MAX inputs. See section “4.5 Mode 1”.
2	Mode 2 (0-10V control)	SET1 = RUN input SET2 = SPEED input SET3 = FB (10.5 V) output, can be used to supply RUN and SPEED inputs. See section “4.6 Mode 2”.
3	Mode 3 (PWM Solar)	SET1 = PWM-in (0 % = Pump OFF) SET2 = PWM-out status SET3 = FB (10.5 V) output, can be used to supply SET1 and SET2 bias. See section “4.7 Mode 3, 4 ”
4	Mode 4 (PWM Heating)	SET1 = PWM-in (100 % = Pump OFF) SET2 = PWM-out status SET3 = FB (10.5 V) output, can be used to supply SET1 and SET2 bias. See section “4.7 Mode 3, 4 ”
5	RESERVED	Reserved for future or customer specific use.
6	Show relay configuration	LED1 and LED2 will show relay configuration. See section “5. Relay output”.
7	Change relay configuration	Relay configuration will be increased (0->1, 1->2, 2->0) when power is turned on. LED1 and LED2 will show current relay configuration. See section “5. Relay output”.
8	Twin reset to factory	Same as Mode 9, with exception of: module IP address is set to 192.168.0.246 Twin IP address is set to 192.168.0.245
9	Reset to factory	This mode will set communication interface to default values. Main purpose is to restore default settings. **NOTE:** • SET1, SET2, SET3 will output test voltages of 10 V, 7 V and 5 V respectively. RS-485 port is actively driven. Relay will cycle. • Make sure that external controllers will not be harmed by conditions above, otherwise disconnect.

4.4 MODE 0 (CUSTOM CONFIGURATION)

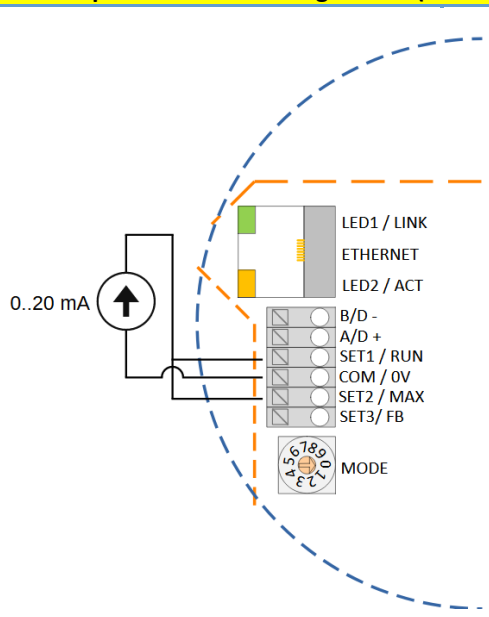
Mode 0 allows for full custom configuration of all SET terminal pins and Relay functionality, via the Web interface.

The SET functions available are:

- No Function (pin is disabled)
- Run Input 2-3V
- Max input 0-10V
- Max input 2-10V
- Run input 4-6mA
- Max input 0-20mA
- Max input 4-20mA
- Feedback output 10.5V
- Flow output 2-10V
- Flow output 4-20mA
- RPM output 0-10 V
- RPM output 4-20 mA
- Error output 10-0V
- Error output 20-0 mA
- PWM heating input
- PWM solar input
- PWM flow + Error output

For all voltage-controlled functions (0-10V and 2-10V) see chapters 4.5 – 4.7 (MODE 1-4) for examples of usage and wiring.
All Current-controlled functions (0-20 mA, 4-20mA and 4-6mA) are functionally identical to voltage-controlled functions, with the difference that a direct current source (DC) is required for pump control. If the selected function is an output, the pump will act as a current source.

Mode 0 example connection configuration (MAX input 0-20mA + RUN input 4-6mA)



4.4.1 CURRENT INPUTS

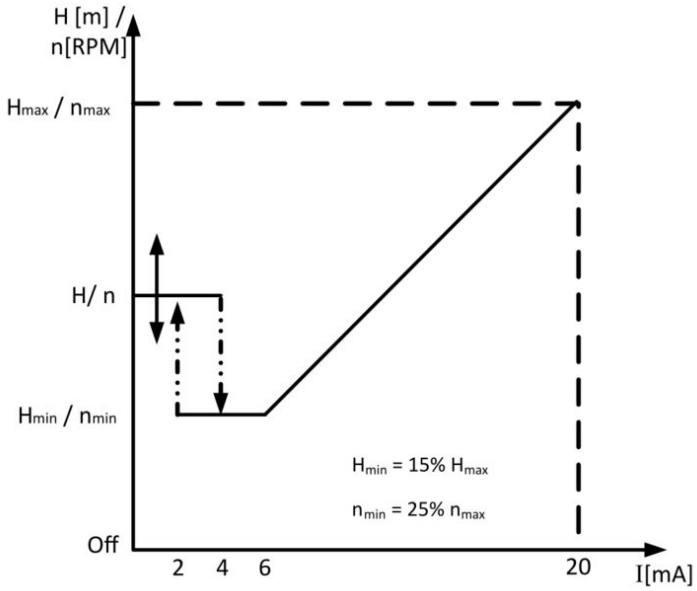
RUN current	MAX current	Function
< 4mA	< 2mA	Pump stopped
> 6mA	< 2mA	Internal regulation
< 4mA	4..20mA	Minimum curve
> 6mA	4..20mA	

Figure 1: External 4..20 mA transfer curve for Mode 1

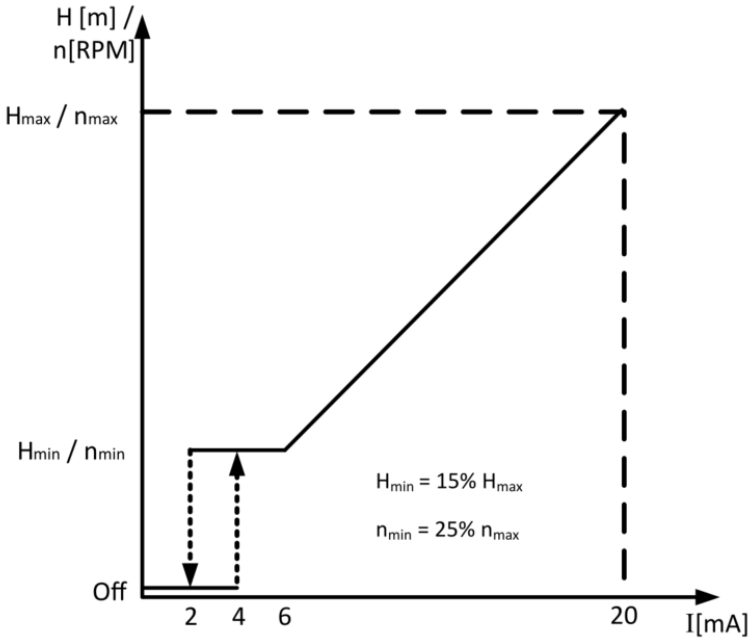
0..20 mA (RUN+MAX)	

Figure 2: External 0..20 mA transfer curve for Mode 1

4.4.2 FEEDBACK OUTPUT

The feedback output provides a constant voltage source, that allows the user to set any voltage-controlled input-function such as “RUN 2-3V” or “Max input 0-10V” to a fixed state, without the need for an external voltage source. Simply connect the “Feedback output” SET pin with a short wire to the SET pin with the selected function.

4.4.3 FLOW & RPM OUTPUT

The Flow and RPM output functions allow for real-time monitoring of the pumps, by outputting the % value of the pumps current RPM speed compared to its maximum allowed RPM, or its current measured flow rate compared to its maximum-rated flow rate. See Figure 3 in chapter 4.6 (Mode 2) for expected output curve.

4.4.4 ERROR OUTPUT

The error output function enables remote monitoring of the pump for any errors.
When the pump displays an error code, the output on the SET pin is set to either 10V or 20mA, depending on the selected configuration. Conversely, if the pump is operating normally, the output will remain at 0V or 0mA.

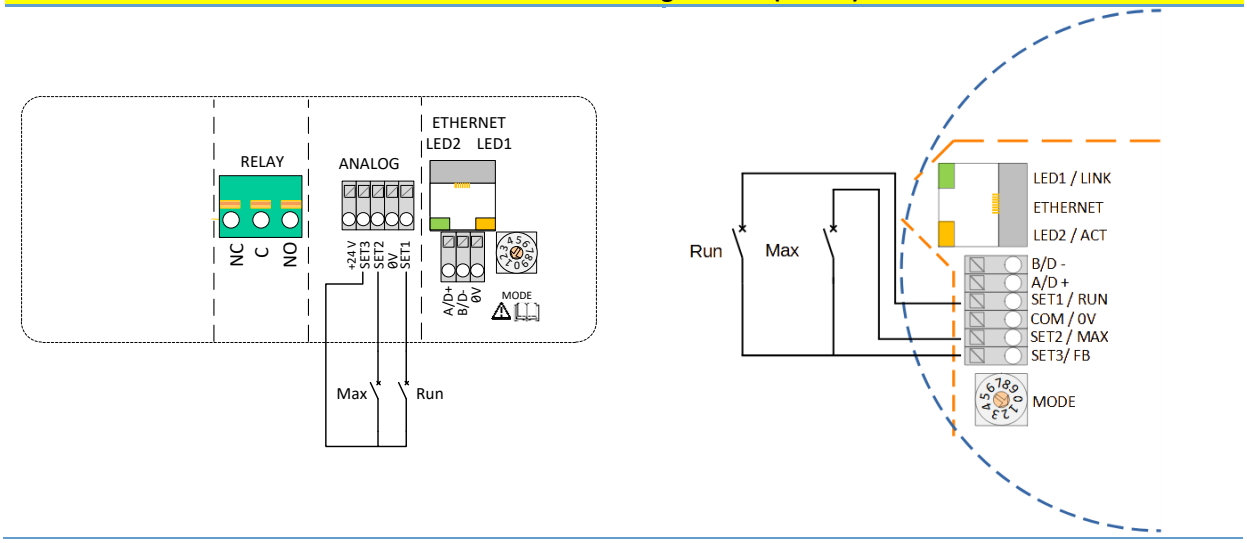
4.5 MODE 1 (2..10V)

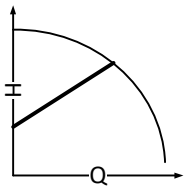
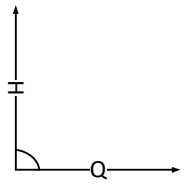
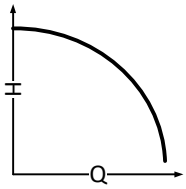
Mode 1 is most often used mode of operation. It has 2 pre-prepared inputs that can be used for either digital control or with analog control voltages. Additional 10.5V output provides voltage feedback for analog or digital control.

Terminal designation	Signal function
SET1 / RUN	RUN input. Signal load 0.5 mA.
COM / 0V	Common ground for voltage input.
SET2 / MAX	MAX input. Signal load 0.5 mA
SET3 / FB	10.5 V feedback voltage for SET1 and SET2.

4.5.1 DIGITAL (SWITCH) CONTROL

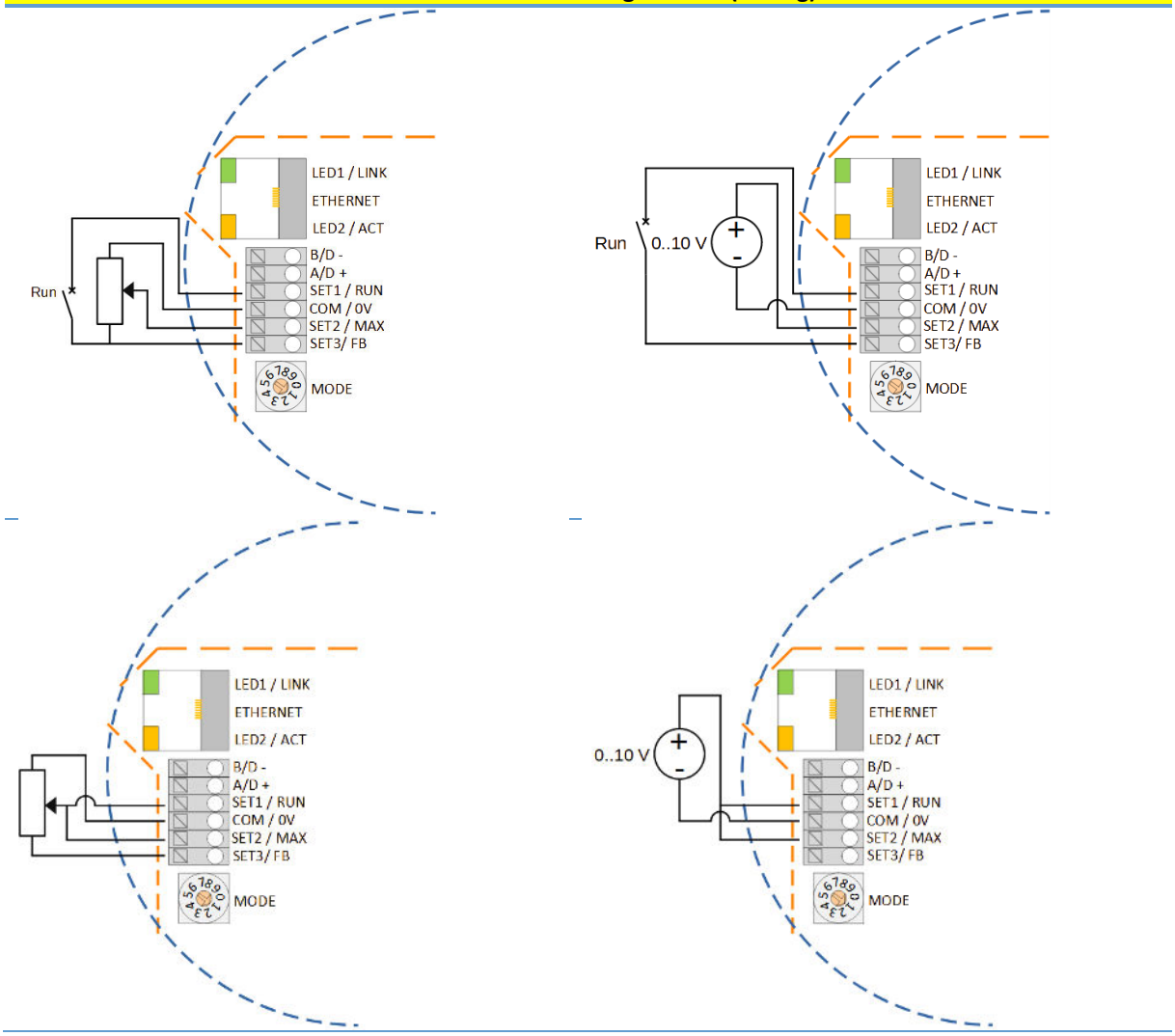
Mode 1 connection configurations (switch)

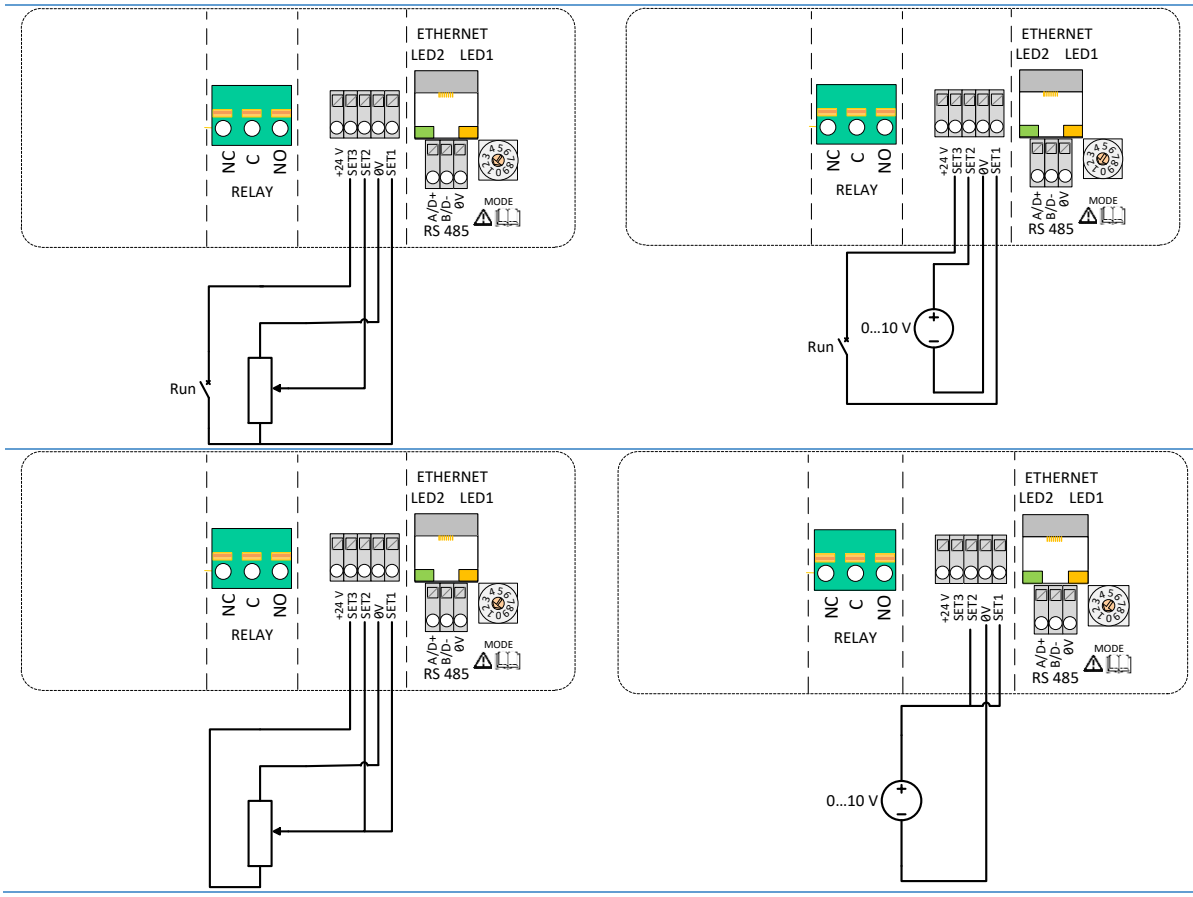


Contact position		Function	Description
RUN	MAX		
		Stop the pump	The pump is stopped
		Start the pump	The pump will run with internal set point 
		Minimum curve	The pump will run with minimal speed for selected regulation mode 
		Maximum curve	The pump will run with maximum speed form selected regulation mode 

4.5.2 ANALOG CONTROL

Mode 1 connection configurations (analog)




ETHERNET
LED2 LED1
NC C NO
RELAY
+24 V
SET3
SET2
0V
SET1
A/D+
B/D-
0V
RS 485
MODE
Run
0...10 V

ETHERNET
LED2 LED1
NC C NO
RELAY
+24 V
SET3
SET2
0V
SET1
A/D+
B/D-
0V
RS 485
MODE
0...10 V

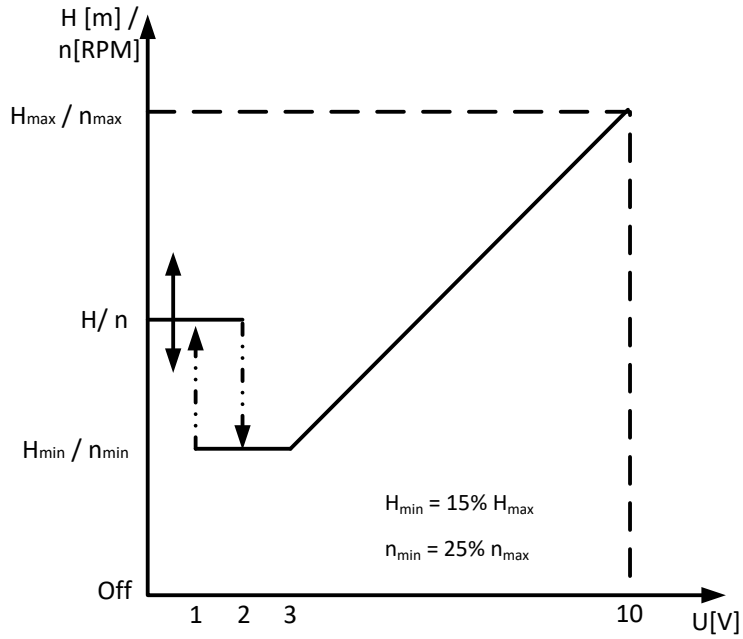
RUN voltage	MAX voltage	Function
< 2 V	< 1 V	Pump stopped
> 3 V	< 1 V	Internal regulation
< 2 V	2..10 V	Minimum curve
> 3 V	2..10 V	

Figure 4: External 2..10 V transfer curve for Mode 1

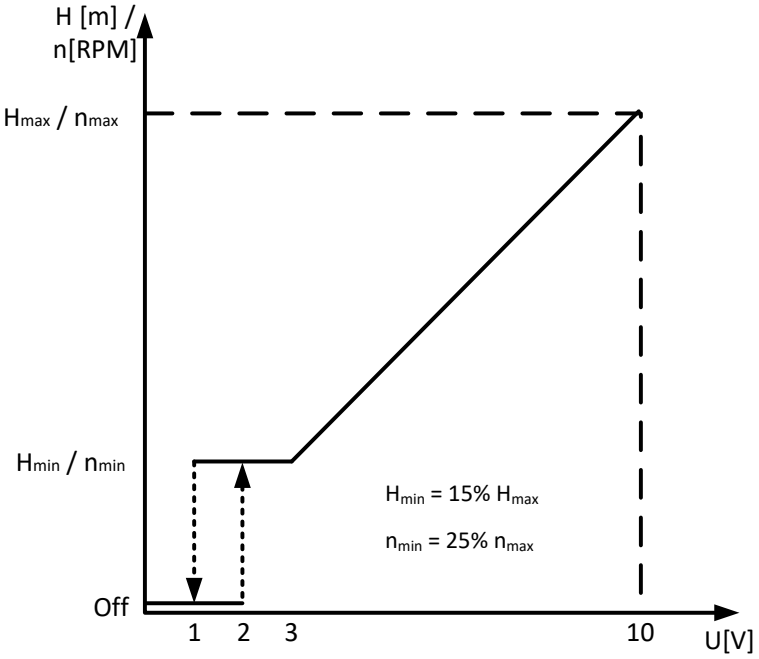
0..10 V (RUN+MAX)		

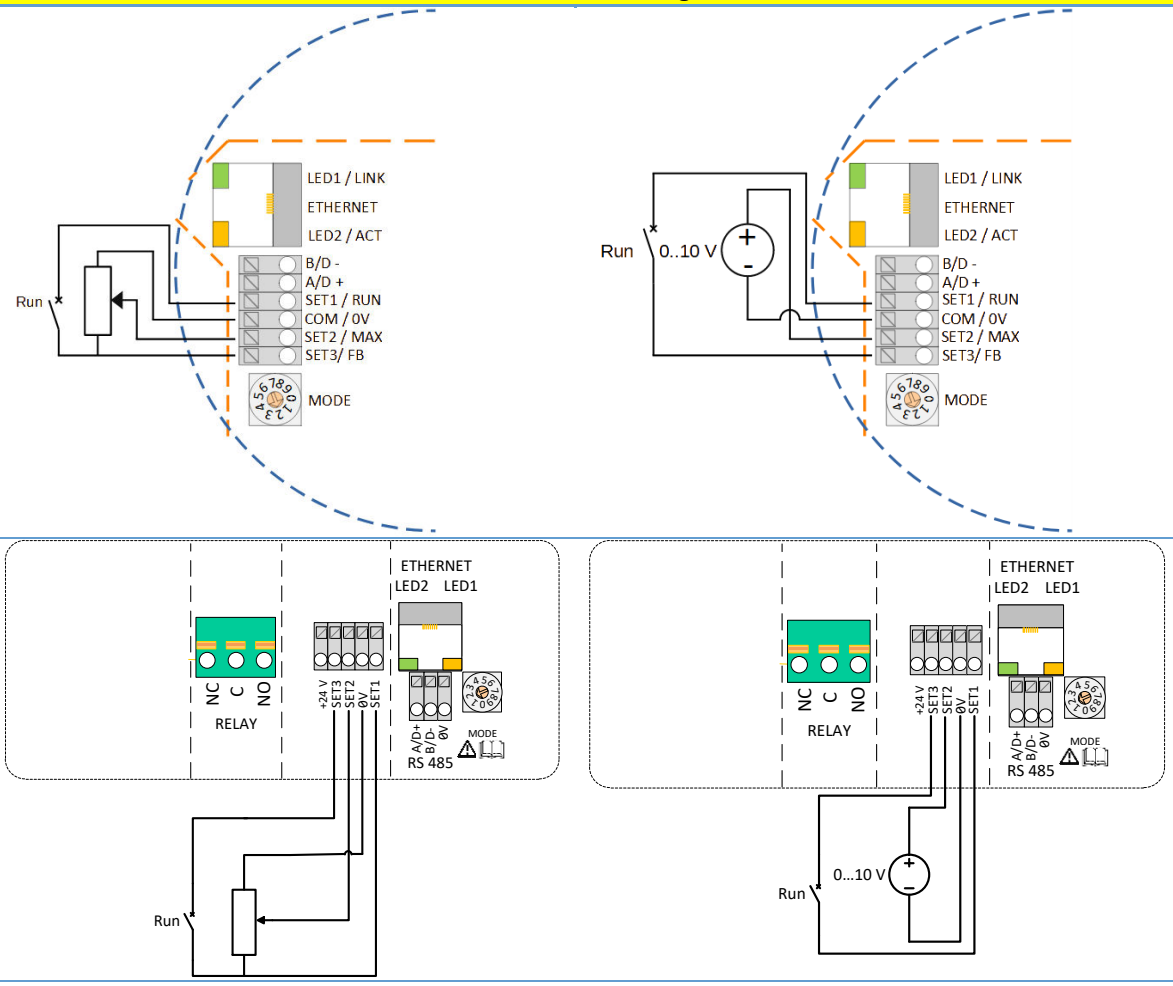
Figure 5: External 0..10 V transfer curve for Mode 1

4.6 MODE 2 (0..10V)

Mode 2 is used for external 0..10 V voltage control.

Terminal designation	Signal function
SET1 / RUN	RUN input. Signal load 0.5 mA.
COM / 0V	Common ground for voltage input.
SET2 / MAX	SPEED input. Signal load 0.5 mA
SET3 / FB	10.5 V feedback voltage for SET1 and SET2.

Mode 2 connection configurations



RUN voltage	MAX voltage	Function
< 2 V	0..10 V	Pump stopped.
> 3 V	0..10 V	

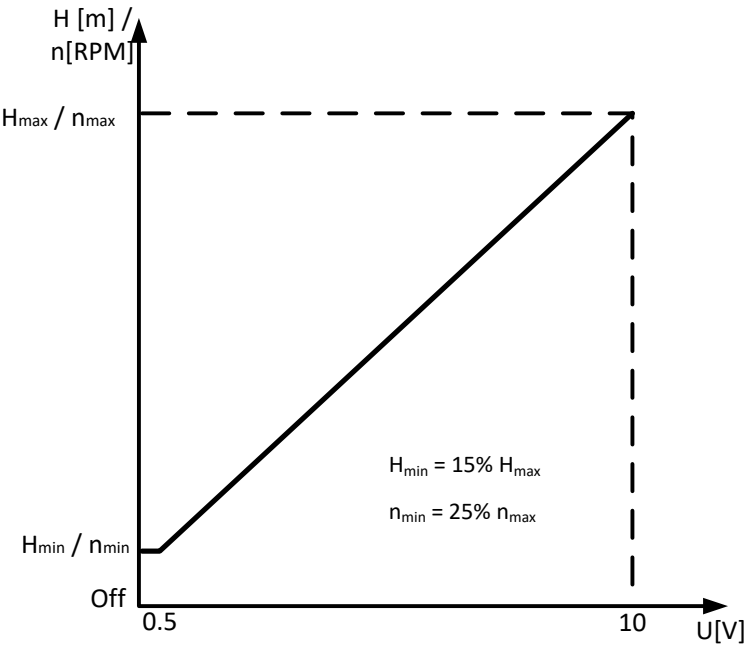


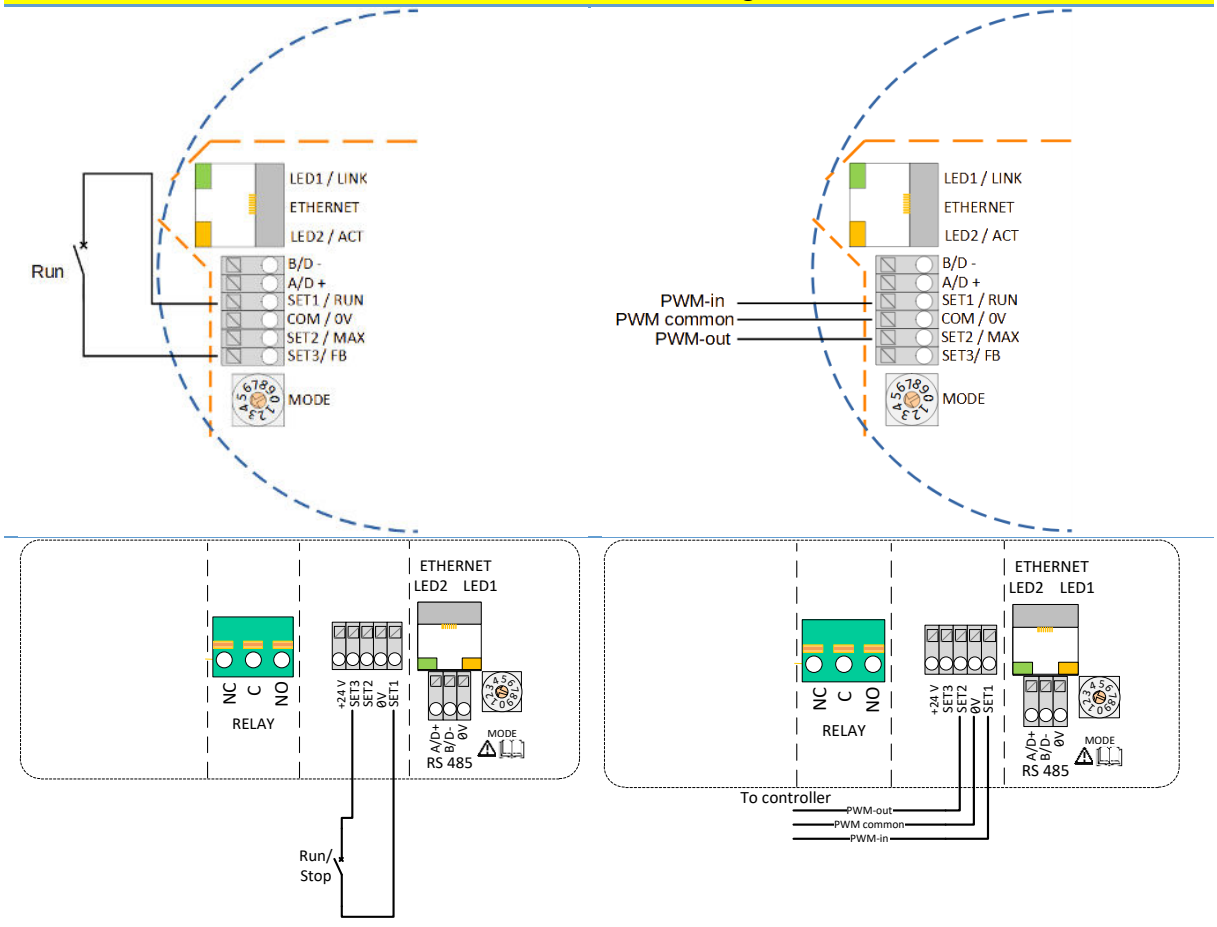
Figure 6: External 0..10 V transfer curve for Mode 2

4.7 MODE 3, 4 (PWM)

Mode 3 and 4 is used for PWM control and feedback according to IEC 60469-1. The difference between these two modes is in response to PWM-in signal. Mode 3 stops the pump when signal is missing or at 0 % while Mode 4 applies full power. See transfer curves in Figure 7 and Figure 8.

Terminal designation	Signal function
SET1 / RUN	PWM-in (PWM input) Signal frequency: 100 Hz – 10000 Hz (1000 Hz nominal) Signal load: 5 mA (4 – 6 mA, internally limited) Signal amplitude: 3.3 – 24 V (threshold at approx. 3V)
COM / 0V	Common ground for signals
SET2 / MAX	PWM-out (PWM output) Signal frequency: 75 Hz (±1 Hz) Signal drive: Open drain, (100 ohm, 20 mA internal current limit) Signal amplitude: 0 – 24 V Signal polarity: Active high (0% - pulled to COM, 100% -open)
SET3 / FB	FB (10.5 V) output, can be used to supply SET1 and SET2 bias.

Mode 3, Mode 4 connection configurations



4.7.1 MODE 3 (SOLAR)

SET1 (PWM-in)	function
< 7 %	Standby (pump stopped)
12..15 %	Minimum setpoint
15..95 %	Pump setpoint increases linearly with input
> 95 %	Maximum setpoint

0..100 %

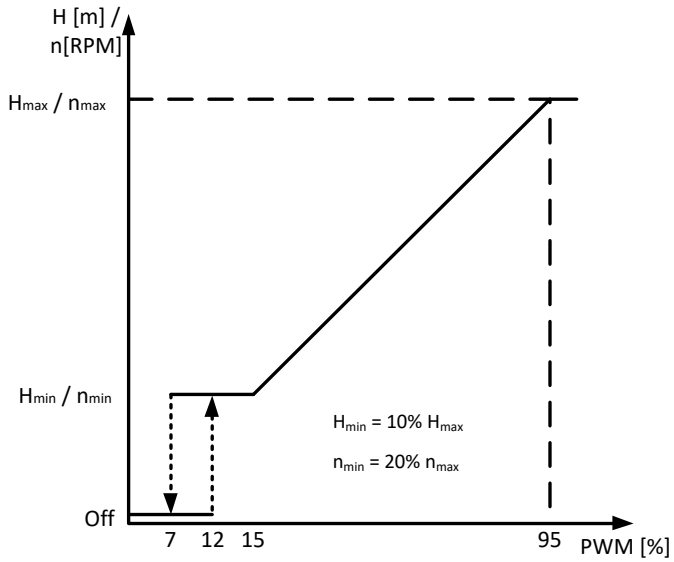


Figure 7: PWM solar transfer curve

4.7.2 MODE 4 (HEATING)

SET1 (PWM-in)	MODE 4 (HEATING) function
< 5 %	Pump at maximum speed
5..85 %	Pump setpoint decreases linearly with input
85..88 %	Minimum setpoint
> 93 %	Standby (pump stopped)
0..100 %	

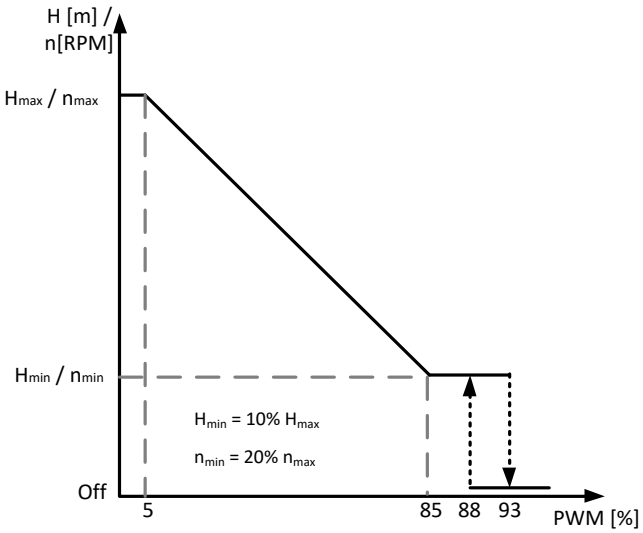


Figure 8: PWM heating transfer curve

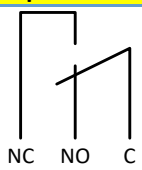
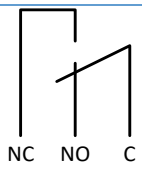
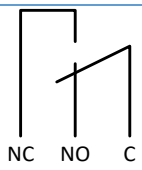
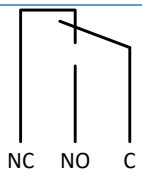
4.7.3 PWM OUTPUT

SET2 (PWM-out)	Status
0 %	PWM output interface in short circuit
2.5 %	Pump in standby and ready
5 %	Normal operation, no flow
5..75 %	Normal operation, flow indication
75 %	Normal operation, maximum nominal flow
80 %	Error is present, performance might be reduced
85 %	Error is present, pump is still functional, but might be stopped
90 %	Error is present, pump is stopped
95 %	Error is present, pump is stopped, permanent failure, will not restart
100%	PWM output interface is open circuit or pump is not powered

5 RELAY OUTPUT

Terminal designation	Terminal description
MODE	Mode selection rotary switch. Used to show and configure mode of operation for relay.
LED1 / LINK	Slowly blinking when module is powered, permanently lid when link established[7].
LED2 / ACT	Flashing when data reception detected. Combined (OR) with RS-485 data reception[7]
NC	Normally closed relay contact. Opens when relay is active.
C	Relay common contact.
NO / OK	Normally open relay contact. Closes when relay is active.

The module contains one or two status relays, used to signal pump operation or malfunction. See table below for functionality.

Relay configuration	Output status	Description	Relay position	LED status[7] LED 1	LED 2
0	Error [default for Relay 1]	Only active when the pump is powered up and detects a problem with operation.			
1	Ready [default for Relay 2]	The relay signal is active when the pump is ready for operation.			
2	Operation	The relay signal is active as long as the pump is operating. If the pump comes to a stop or an error occurs, relay will deactivate.			
	-	Relay output not active.			

Relay configuration number can be modified by either the web interface, Modbus register 012 (relay 1), 017(relay 2) or the Mode switch.

[7] When mode Mode 6 or Mode 7 is selected, LED1 and LED2 will show relay configuration. See section "4.3 Module mode selection"

LED is on 

LED is off 

6 RS-485 BUS

6.1 RS-485 RELATED INTERFACE

Designation	Description
MODE	Can be used to reset network configuration
LED2 / ACT	Indicates Ethernet or RS-485 activity.
B/D-	RS-485 negative data signal.
A/D+	RS-485 positive data signal.
COM/0V	RS-485 common and analog input common (ground).

6.2 SERVICES

- Modbus RTU
- BACnet MS/TP [default]

NOTE: Selectable over Web interface. Only single protocol can run at a time.

6.3 BUS TOPOLOGY

RS-485 Connection can be made in either daisy chain style (if cabling allows such a connection) or a limited length passive tap. Schematic example in figure below.

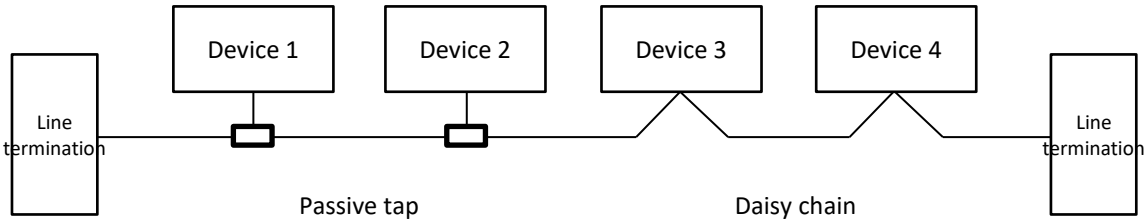


Figure 9: Example of network

Up to 32 single load devices can be connected to one RS-485 system without using a repeater. As this module is a 1/8 load device, up to 256 modules can be connected to the bus. Repeaters can be used to extend the maximum transmission distance and increase device count if needed.

6.4 CONNECTION TO RS-485

A screened, twisted-pair cable should be used. The cable screen should be connected to the COM terminal and connected to safety ground at one point.

NOTE: In some cases, better performance is achieved if no COM connection is made. Device can operate with 2 wire connection.

6.5 TERMINATION

NMTC module contains neither termination nor bias circuitry. RS-485 wiring should be externally terminated if needed.
For short wiring and/or low baud rate, interface can operate without termination. However, it is recommended that termination (100-150 ohm resistor) is added on both ends of bus wiring. There are wiring length limits regarding to speed and termination:

Maximum speed [baud]	Maximum cable length [m]
38400	1200, terminated cable
9600	1200
19200	500
38400	250

NOTE: Any branch/derivative cable is considered unterminated. Keep them short, below 250m combined for maximum speed and reliability.

6.6 MODBUS RTU SPEED, PARITY AND ADDRESS

By default, each device is set to 19200-E-1 (even parity), address 245. Properly set registers in section “8.5 NMTC control register” to configure each device before connecting it to existing network. Optionally power each device one by one, configuring the settings before adding another one.

6.7 BACNET MS/TP SPEED AND ADDRESS

By default, each device is set to 38400 baud, MAC 1.
Use web interface to modify RS-485 configuration.

7 ETHERNET BUS

7.1 ETHERNET RELATED INTERFACE

Terminal designation	Description
MODE	Can be used to reset network configuration
LED1 / LINK	Slowly blinking when module is powered, permanently lid when link established.
Ethernet	10BASE-T RJ-45 connector.
LED2 / ACT	Indicates Ethernet or RS-485 activity.

7.2 SERVICES

- Http server on port 80
- Modbus server on port 502

7.3 BUS TOPOLOGY

Ethernet connection topologies

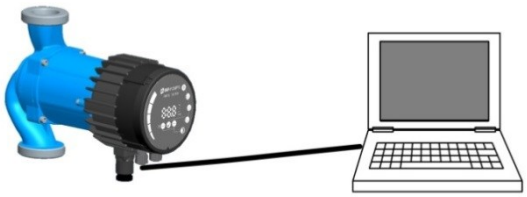


Figure 10: connecting to a computer with a cross-over cable

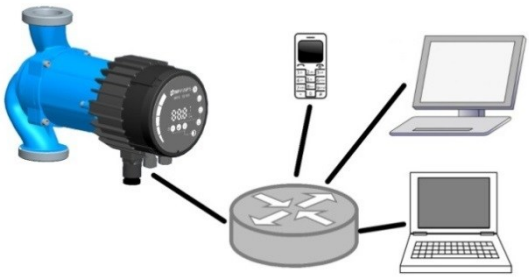


Figure 11: connecting to a network via router

7.4 CONNECTING TO PUMP AD-HOC

When connecting directly with the computer, a crossover cable must be used to connect with the pump. The pump can then be accessed at IP address “192.168.0.245” or “nmtpump” if NBNS is enabled. Alternative addresses are “192.168.0.246” or “nmtpump2” for left twin.

The computer must be set up to have a dynamic IP address or be in the same subnet range.

7.5 CONNECTING TO PUMP VIA ROUTER

When connecting via a router, a patch cable must be used to connect with the pump. The pump can then be accessed by typing IP address “192.168.0.245” or “nmtpump” or “192.168.0.246” or “nmtpump2” if it’s a left twin pump in to your web browsers address bar.
The computer must be set up to have a dynamic IP address.

7.6 PUMP CONFIGURATION OVER ETHERNET

See chapter “9. HTTP server”.

8 MODBUS

8.1 MODBUS RELATED INTERFACE

Modbus can operate over either RS-485 or Ethernet bus.

- See chapter “6. RS-485 bus” for RS-485 bus wiring details.
- See chapter “7. Ethernet bus” for Ethernet wiring details.

8.2 MODBUS RTU OVER RS-485

NMTC is a Modbus RTU slave.

Typically, only one master device is connected to the serial bus, and one or several slaves are also connected to the bus. Slaves do not communicate with each other and will never transmit data without receiving a proper request from the master device.

8.3 MODBUS OVER ETHERNET

Modbus device is available at port 502. Default address is thus 192.168.0.245:502

Supported protocols are:

- Modbus TCP
- Modbus RTU over TCP
- Modbus UDP
- Modbus RTU over UDP

Protocol is automatically recognized according to received packet and no additional configuration is needed.

NOTE: Device ID equals slave address. Controller requests must match this value [245 by default].

8.4 REGISTER OVERVIEW

NMTC Modbus RTU registers are grouped in the following register blocks:

Start address	Register block	Readable/Writeable	Description
001	NMTC configuration	R/W	Configuration of the NMTC module.
021	NMTC status	R	Status registers for the NMTC module.
101	Pump control	R/W	Pump control registers.
201	Pump status	R	Status data from the pump.
301	Pump data	R	Measured data from the pump.

All addresses contain 16 bit (one Word) registers. Some are bit interpreted while others are combined for a 32 bit value.

NOTE: All register addresses are 1-based. Address 001 is thus transmitted over bus as 0x0000.

8.5 NMTC CONTROL REGISTERS

Registers in this block are read with either function codes 0x03 or 0x04. They can be written as holding registers with function codes 0x06 and 0x10.

NOTE: All values in this block are stored in nonvolatile memory immediately after write.

NOTE: See section "4.3 Module mode selection" and use Mode 8 or 9 to restore default settings if you cannot access the controller after writing to these registers.

Address	Register name	Range	Resolution	Description
001	SlaveDelay	0..10000	1 ms	Delay in milliseconds for slave reply. This delay will be added to every Modbus reply [default = 0].
002	RESERVED			
003	ModbusAddress	1..247	1	Modbus slave/device address [default = 245].
004	BitRate	0..5	1	RS-485 transmission speed enumeration. 0 = 1200 baud 1 = 2400 baud 2 = 4800 baud 3 = 9600 baud 4 = 19200 baud [default] 5 = 38400 baud 6 = 57600 baud (optional)
005.. 008	RESERVED			
009	Parity	0..2	1	Parity setting to be used for communication. 0 = No parity 1 = Even parity [default] 2 = Odd parity
010	StopBits	1..2	2	Stop bits used for communication. 2 stop bits will only be used when “Parity” is set to 0. 1 = 1 stop bit [default] 2 = 2 stop bits
011	RESERVED			
012	Relay1Control	0..2	1	Configures module relay 1 output. 0 = indicates fault 1 = indicates pump ready 2 = indicates pump operation See section “5 Relay output”.
013	ErrorDelay	0..30	1	Error codes and error outputs (relay, register 201.10) will be delayed by ErrorDelay seconds.
014	SET1Type		1	Configuration for SET1 terminal. 0 = "NO FUNCTION" 1 = "RUN input 2-3V" 2 = "MAX input 0-10V" 3 = "MAX input 2-10V" 4 = "RUN input 4-6 mA" 5 = "MAX input 0-20 mA" 6 = "MAX input 4-20 mA" 7 = "FB output 10.5V" 8 = "FLOW output 2-10V" 9 = "FLOW output 4-20 mA" 10 = "RPM output 2-10V" 11 = "RPM output 4-20 mA" 12 = "ERROR output 10-0V" 13 = "ERROR output 20-0 mA" 14 = "PWM SOLAR input" 15 = "PWM HEATING input" 16 = "PWM FLOW+ERR output"
015	SET2Type		1	Configuration for SET2 terminal. See enumeration for register 014
016	SET3Type		1	Configuration for SET3 terminal. See enumeration for register 014

Address	Register name	Range	Resolution	Description
017	Relay2Control	0..2	1	Configures of relay 2 output. 0 = indicates fault 1 = indicates pump ready 2 = indicates pump operation See section “5 Relay output”.

8.6 NMTC STATUS REGISTERS

Registers in this block are read with either function codes 0x03 or 0x04. They are read-only. This block can be used for various kinds of fault finding.

Address	Register name	Resolution	Description
021..022	RESERVED		
023	SoftwareVersion		Module software version
024..029	RESERVED		
030	ProductVersion		Product version [32x for NMTC module, x denotes hardware revision]
031	RESERVED		
032	SoftwareVersion		Module software version

8.7 PUMP CONTROL REGISTERS

Registers in this block are read with either function codes 0x03 or 0x04. They can be written as holding registers with function codes 0x06 and 0x10.

Address	Register name	Range	Description
101	ControlReg	b0: RemoteAccess	Control bit that sets local or remote control. Setting this bit will enable pump control over Modbus. 0 = Local 1 = Remote (controlled by Modbus master).
		b1: OnOffReq	Control bit that switches the pump on or off. 0 = Off (stop) 1 = On (start).
		b2..3: RESERVED	-
		b4:	Control bit saves values in register block as default. 0 = No save 1 = Save as default. This value will be reverted back to 0 when set.
		b5..15: RESERVED	-
102	AltControlMode		Alternative Control mode. Use of register 108 is preferred. Sets the control mode enumeration. 0 = ConstantRPM 1 = ConstantRPM 3 = ConstantHead 4 = ConstantHead 5 = ConstantHead 6 = ProportionalHead 128 = AutoHeadMode **NOTE:** values outside this range reserved.
103	OperationMode		RESERVED
104	SetPoint	0.. 10000	Sets desired pump set point. 0 will stop the pump. 10000 will set the pump to maximum output for desired mode. Values outside of valid range will cause the pump to operate with front panel set values.
105	RelayControl	0..2	Configures relay output. 0 = indicates fault 1 = indicates pump ready 2 = indicates pump operation See section “5 Relay output”.
106..107	RESERVED		
108	ControlMode	0..3	Sets the pump control mode. 0 = AutoHeadMode (Automatic head mode) 1 = ProportionalHead (Head proportional to flow) 2 = ConstantHead (Head is kept constant) 3 = ConstantRPM (Speed is kept constant) **NOTE:** values outside this range reserved. See section “4.2 Control variables” for exact parameter to be controlled.

8.8 PUMP STATUS REGISTERS

Registers in this block can be read by means of function codes 0x03 and/or 0x04. They are read-only.

Address	Register name	Description
201	StatusReg	
	b0..b5: RESERVED	-
	b6: Rotation	Indicates if the pump is rotating (running) or not. 0 = No rotation 1 = Rotation.
	b7: RESERVED	
	Bit 8: AccessMode	Indicates if the pump is locally or remotely controlled. 0 = Local (a source with higher priority controls the pump) 1 = Remote (controlled by Modbus master).
	Bit 9: IsOn	Indicates if the pump is on or off. 0 = Off 1 = On It not necessarily indicate rotation as an error might stop the pump.
	Bit 10: Error	Indicates if there is a problem with proper operation. 0 = No problem 1 = Error present. Pump might still run.
	Bit 11: RESERVED	-
	Bit 12: RESERVED	-
	Bit 13: NearMaxSpeed	Indicates if the pump is running near maximum speed. 0 = No 1 = Yes. This flag is set when power or speed is over 95% of rated maximum.
	Bit 14: RESERVED	-
	Bit 15: NearMinSpeed	Indicates if the pump is running near minimum speed. 0 = No 1 = Yes. This flag is set when speed falls below 1/3 of rated maximum.
202	RESERVED	(TBD)
203	ControlMode	Indicates the actual control mode. 0 = ConstantRPM 1 = ConstantRPM 3 = ConstantHead 4 = ConstantHead 5 = ConstantHead 6 = ProportionalHead 128 = AutoHeadMode.
204	RESERVED	
205	ErrorCode1	Current first error code. 0 - when pump is operating without problems. This value will always be non-zero when there is an error present. See section “11.1 Error codes” for code details.

206	ErrorCode2	Second error code. Non-zero when there is more than one error. See section “11.1 Error codes” for code details.
207	ErrorCode3	Third error code. Non-zero when there is more than two errors. See section “11.1 Error codes” for code details.
208	ControlMode	Indicates the actual control mode. 0 = AutoHeadMode (Automatic head mode) 1 = ProportionalHead (Head proportional to flow) 2 = ConstantHead (Head is kept constant) 3 = ConstantRPM (Speed is kept constant). **NOTE:** values outside this range reserved. See section “4.2 Control variables” for exact parameter to be controlled.

8.9 PUMP DATA REGISTERS

Registers in this block can be read by means of function codes 0x03 and/or 0x04. They are read-only.

Modbus address	Register name	Range	Resolution	Description
301	Head		0.01 m	Pump head estimation in meters of water column.
302	Flow		0.1 m^3/h	Pump flow estimation.
303	Efficiency		0.01 %	Estimated pump efficiency.
304	Speed		1 rpm	Motor speed.
305	Frequency		0.1 Hz	Motor frequency [100.0 Hz for 3000 rpm and 4 pole motor].
306..307	RESERVED			
308	ActualSetPoint	0..10000	0.01 %	Indicates actual set point of the pump. (-1 for internal pump regulation). tbd
309..311	RESERVED			
312 313	PowerHI PowerLO	$0..2^{32}$	1 W	Total power consumption of the system.
314..317	RESERVED			
318	CircuitTemp	-5500.. 16000	0.01 °C	Power electronics hotspot temperature.
319	MotorTemp	-5500.. 16000	0.01 °C	Motor compartment temperature.
320..321	RESERVED			
322	LiquidTemp	-5500.. 16000	0.01 °C	Liquid temperature.
323..326	RESERVED			
327 328	OperationTimeHI OperationTimeLO		1 hour	Total operation time (above zero speed) of the pump.[8]
329 330	TotalPoweredTimeHI TotalPoweredTimeLO		1 hour	Total power-on time of the module.[8]
331	RESERVED			
332 333	EnergyHI EnergyLO		1 kWh	Total energy consumption of the system.[8]

[8] Not available on all models.

9 HTTP SERVER

The communications module has a built in web server which allows you to access your pump directly to an existing Ethernet connection. Direct connection to a computer is also possible with a cross over cable.
The web server uses HTML pages to set/view:

- Regulation mode settings
- Regulation parameters (power, RPM, head, flow, efficiency)
- Relay settings
- External control inputs
- Current and previews error
- Pump statistics (power consumption, run time and other).

9.1 WEB SERVER

Pump responds as a web server on port 80. See chapter “7. Ethernet bus” for Ethernet configuration details.

Pump configuration is possible via HTML pages that offer different options:

1. **Overview** (default page when you connect to the pump, web page OVERVIEW) displays pump operation summary like:
   - Operating mode
   - Power consumption
   - Head
   - Estimated flow
   - RPM
   - Estimated efficiency
   - Priority set point
   - Mode switch position
   - Input/output status
   - Replay status
   - Error code
   - Twin pump status
   - Night mode status
   - Motor temperature
   - Heat sink temperature
   - Number of restarts.
2. **Pump settings** (web page PUMP) is meant to provide regulation and control (input and output) settings. It has control over:
   - Operation mode
   - Head limit(depending on pump mode)
   - RPM limit (depending on pump mode),
   - Ratio between head and flow HQ (depending on pump mode)
   - Input/output control
   - Relay control
   - Error delay

Setting can be saved to permanent memory by pressing the SAVE button.

3. **Network settings** (web page NETWORK) provide a way to change network configuration:
   - NetBIOS name - is a local network name service. Instead of ‘192.168.0.245’ you can for example use 'http://nmtpump'. Default: nmtpump.

- IP address - is a pump network address. The pump is seen as http server on this address, default: 192.168.0.245.
- DHCP server - provides lease for "point to point" connection (cross-over cable to computer for example). Will disable itself if another DHCP server is found.
- DHCP client – will automatically acquire DHCP address from the network when enabled.
- Gateway – not used
- Subnet mask - sets subnet address range that is on the same subnet and can be reached directly. The rest of communication goes over the gateway, default: 255.255.255.0.
- Twin pump - will connect two pumps for alternating operation. When two pumps are configured for twin mode, they will switch about once per day. Setting this field to nonexistent IP will disable this option! Set it so the first pump references the second and vice versa. Default: 192.168.0.246.
- RS-485 field – select either Modbus or BACnet and relevant network parameters.

Setting can be saved to permanent memory by pressing the SAVE button.

4. **Log** (web page LOG) displays possible previous and current errors.

5. **MORE** (web page MORE) has link to additional manuals and tools that might be available. Has an option to update NMTC module software via provided file.

9.2 XML DATA

Pump data available at /pump.xml

10 BACNET

10.1 INTRODUCTION

IMP Pumps NMTC module with BACnet support

Document date: 14 June 2021
Product name: NMTC Module
Product model number: 321
Application software: 2.286_BACNET
Application firmware revision: 2.286_BACNET
BACnet protocol revision: 19

10.2 PRODUCT DESCRIPTION

NMTC module enables BACnet MS/TP communication with compatible pumps. Module is either integrated into the pump or installed into the pump as an add-on.

BACnet Standardized Device Profile (Annex L):

☐ BACnet Operator Workstation (B-OWS)
☐ BACnet Advanced Operator Workstation (B-AWS)
☐ BACnet Operator Display (B-OD)
☐ BACnet Building Controller (B-BC)
☐ BACnet Advanced Application Controller (B-AAC)
☑ BACnet Application Specific Controller (B-ASC)
☐ BACnet Smart Sensor (B-SS)
☐ BACnet Smart Actuator (B-SA)

BACnet Interoperability Building Blocks Supported (Annex K):

Name	BACnet BIBB
ReadProperty	DS-RP-B
WriteProperty	DS-WP-B

Device management services:

Name	BACnet BIBB
Who-is/I-am	DM-DDB-A DM-DDB-B
Who-has/I-have	DM-DOB-B

NOTE: Segmentation is not supported.
NOTE: Dynamically creatable objects are not supported.

10.3 DATA LINK LAYER OPTIONS

☑MS/TP master (Clause 9), baud rate(s):

Baud Rate
9600
19200
38400 [default]

Configuration over Web interface (see tab “Net”)
To reset to default, see chapter “ 4.3 Module mode selection”

☐ BACnet IP, (Annex J)
(CURRENTLY NOT IMPLEMENTED)

10.4 DEVICE ADDRESS BINDING

Is static device binding supported? (This is currently necessary for two-way communication with MS/TP slaves and certain other devices.) ☐ Yes ☑ No

10.5 NETWORKING OPTIONS

None

10.6 NETWORK SECURITY OPTIONS

☑ Non-secure Device - is capable of operating without BACnet Network Security

10.7 CHARACTER SETS SUPPORTED

☑ ISO 10646 (UTF-8) ☐ IBM™/Microsoft™ DBCS ☐ ISO 8859-1
☐ ISO 10646 (UCS-2) ☐ ISO 10646 (UCS-4) ☐ JIS X 0208 ☑ ANSI X3.4

10.8 SUPPORTED BACNET INTEROPERABILITY BUILDING BLOCKS

Data sharing services:

Name	BACnet BIBB
ReadProperty	DS-RP-B
ReadPropertyMultiple	DS-RPM-B
WriteProperty	DS-WP-B
WritePropertyMultiple	DS-WPM-B
SubscribeCOV	DS-COV-B

Device management services:

Name	BACnet BIBB
Who-is/I-am	DM-DDB-A DM-DDB-B
Who-has/I-have	DM-DOB-B
DeviceCommunicationControl	DM-DCC-B

NOTE: **Segmentation is not supported.**

Object types supported	
• Device	• Binary output
• Analog input	• Binary input
• Analog output	

NOTE: **Dynamically creatable objects are not supported.**

10.9 ANALOG INPUTS (OBJECT TYPE 0)

NOTE: **Values are read-only**

Instance	Object Name	Unit	Description
AI.0	ActualSetPoint	%	Currently active Setpoint - 100% represents maximum - Pump performance depending on Control Mode - <0% indicates user control
AI.1	ActualOperatingMode	-	Current pump operating mode - Mirrors AO.1 when remotely controlled - See AO.1 for possible values
AI.2	Head	ft (H_2O)	Estimated pump head
AI.3	Flow	GPM	Estimated flow
AI.4	Power	W	Electrical power of the pump
AI.5	Speed	RPM	Motor speed
AI.6	MotorTemperature	°F	Medium or motor temperature
AI.7	HeatsinkTemperature	°F	Controller temperature
AI.8	HMax	ft (H_2O)	Maximum pump head
AI.9	QMax	GPM	Maximum pump flow
AI.10	PMax	W	Rated pump power
AI.11	RPMMax	W	Maximum motor speed
AI.12	OperatingHours	h	Time active (not implemented = 0)
AI.13	EnergyConsumed	kWh	Total electrical energy (not implemented = 0)
AI.14	ActiveErrorCode	-	Currently active error. 0 = pump is operating without problems. This value will always be non-zero when there is an error present. See section “11.1 Error codes” for code details.

10.10 ANALOG OUTPUTS (OBJECT TYPE 1)

Instance	Object Name	Unit	Description
AO.0	BusSetPoint	%	Requested Setpoint - 100% represents maximum - 0% stops the pump - Set B0.0 to enable
AO.1	BusOperatingMode	-	Requested pump operating mode - 0: Auto mode (only on/off)

	- 1: Proportional pressure, setpoint controls peak head - 2: Constant pressure, setpoint controls head - 3: Constant RPM, setpoint controls speed. - Other values reserved - Set B0.0 to enable

10.11 BINARY INPUTS (OBJECT TYPE 3)

NOTE: Values are read-only

Instance	Object Name	Unit	Description
BI.0	RemoteAccessActive	-	Indicates remote control 0 = Local 1 = Remote (Bus control).
BI.1	NearMinimumSpeed	-	Indicates if the pump is running near minimum speed. 0 = No 1 = Yes. This flag is set when speed falls below 1/3 of rated maximum.
BI.2	NearMaximumSpeed	-	Indicates if the pump is running near maximum speed. 0 = No 1 = Yes. This flag is set when power or speed is over 95% of rated maximum.

10.12 BINARY OUTPUTS (OBJECT TYPE 4)

Instance	Object Name	Unit	Description
BO, 0	RemoteAccessEnable	-	Control bit that sets local or remote control. Setting this bit will enable pump control over BACnet. 0 = Local 1 = Remote
BO, 1	ResetFaults	-	Setting to 1 will try to clear any pending faults (not needed as faults are auto cleared) 0 = No reset 1 = Trigger reset
BO, 2	SaveConfiguration	-	Write analog outputs to non-volatile memory. After next power cycle, pump will start with saved configuration. 0 = No reset 1 = Trigger save

11 FAULT FINDING

11.1 ERROR CODES

The following codes will show up on display panel and on the appropriate Modbus/BACnet registers to help you diagnose the cause of improper operation.

Error code	Description	Probable cause / solution
E1x	*Load errors*	
E10 (drY)	Low motor load	Pump is running dry. Add water or vent the system.
E11	High motor load	Motor might be faulty or viscous medium is present.
E2x	***Protection active***	
E22 (hot)	Inverter temperature protection	Due to high ambient temperature, pump is running with under 2/3 of rated power.
E23	Inverter temperature protection	Pump stopped due to high ambient temperature.
E24	Motor overcurrent	This is unexpected during normal operation. Rotor might be locked or inverter is faulty.
E25	Overvoltage	Supply voltage is too high. Insure supply voltage matches nameplate ratings.
E26	Undervoltage	Line voltage is too low for proper operation.
E27	PFC Overcurrent	This is unexpected during normal operation. If condition persists, inverter or PFC choke might be faulty.
E3x	*Pump errors*	
E31	Software motor protection active	Pump power was reduced to protect motor from overheating. Caused by high medium temperature combined with high load.
E4x	***Device specific error codes***	
E40	General inverter error	Inverter did not pass self-test and is faulty.
E42 (LEd)	LED faulty	One of the display segment diodes is faulty (open/short).
E43 (con)	Internal communication fault	There is power present, but internal communication bus not as expected. Cabling between power circuit, communication module and display might be faulty.
E44	DC link current offset	PFC or DC link current zero value out of tolerance. If persistent after power cycle, Inverter needs replacement.
E45	Motor temperature sensor faulty	Invalid motor temperature.
E46	Inverter temperature sensor faulty	Invalid inverter temperature.
E47	Voltage reference outside limits	Internal reference out of tolerance. Inverter faulty.
E48	Internal 15V supply outside limits	15 V supply out of tolerance. Inverter faulty.
E49	Test load does not match	Reference load test failed.
E5x	***Motor error codes***	
E51	Motor parameters out of range	Motor does not behave as expected. Motor might be damaged or disconnected.
E52	Thermal protection active	Motor temperature is too hot to operate. Might be caused by high motor temperature or motor failure.
E53	Invalid model selected	Pump model not valid or incompatible with drive. Inverter was not properly matched to pump model.