USER MANUAL

HEAT3

DUAL MODE HEATING POWER SUPPLY

PREVAC

OPERATING MANUAL

English translation

HEAT3

DUAL MODE HEATING POWER SUPPLY

Document no. 1035724

Rev. 1

October 2019

Firmware version 4.6

Precision and Vacuum Technology

PREVAC

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1 INTRODUCTION

Please read this manual carefully to ensure the optimum operating conditions and safety of the user. This user manual handbook contains important information about functionality, installation, start-up and operation of the HEAT3 device.

1.1 INFORMATION ABOUT VERSION - RELEASE NOTE

Information about HEAT3 device version can be found at *www.prevac.eu*, in the *DOWNLOAD* tab. There is information about any possible changes in subsequent versions of the device or software.

1.2 INTENDED TO USE

HEAT3 is designed for heating a sample on a sample holder under clean UHV-conditions. The HEAT3 delivers two methods of sample heating:

1. Resistance heating method. The heating element is located close to the sample which becomes hot. This method is best suited for low temperature heating, up to a few hundred degrees.

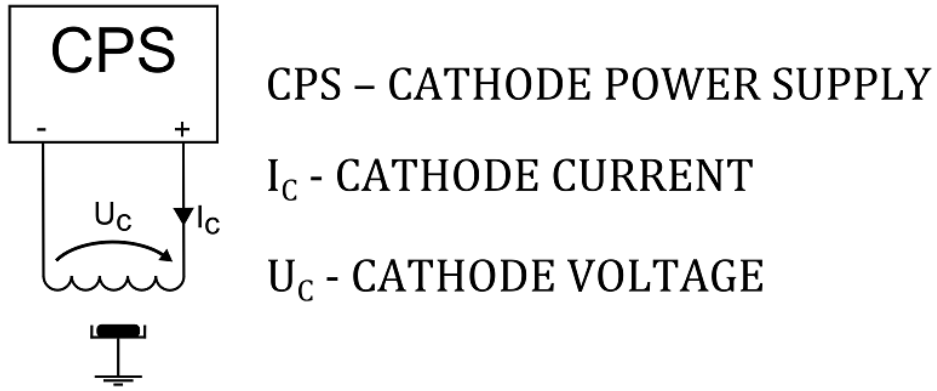


Figure 1.1: Overview of the resistance heating method

2. Electron bombardment heating method. The heater is located close to the sample again. The sample is at ground potential and the heater is raised to a high voltage (negative potential). In this method, the heater is used to generate electrons which are accelerated to the more positive (ground) potential where the sample is located. Electron bombardment heats the sample. This method is best suited for high temperature heating, up to 2000°C.

Temperature ramp control and cathode current ramp control protect the filament against deformation and overheating of the sample. The HEAT3 has a built-in PID controller which stabilizes the temperature at the desired level. The device can work in Auto mode (with temperature control) or Manual mode (without temperature control). Temperature can be controlled by 2 methods using AUTO mode:

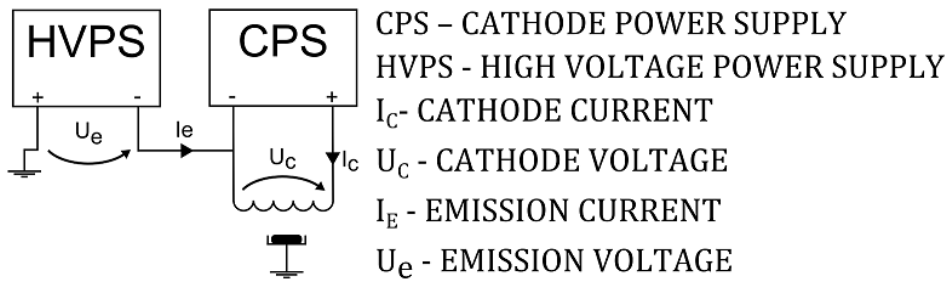


Figure 1.2: Overview of the electron bombardment heating method

1. Resistance heating method (RES MODE). Whereby temperature is stabilized by controlling the cathode current.
2. Electron bombardment heating method (EB MODE). Whereby temperature is stabilized by controlling the high voltage that sets the electron energy.

The HEAT3 can be delivered with four types of thermocouples suited to specific sample holder type. Thermocouple ranges table is shown below.

Thermocouple type	Minimum [K]	Maximum [K]
K	73.15	1645.15
C	273.15	2473.15
E	73.15	1273.15
N	3.15	1572.15

Table 1.1: Thermocouple ranges

The HEAT3 can operate with DT670/DT470 silicon diodes which are capable of measuring temperature in cryogenic systems. Diodes ranges are listed below:

Diode type	Minimum [K]	Maximum [K]
DT470	1.4	475
DT670	1.4	500

Table 1.2: Diodes ranges

WARNING

Exceeding the measuring range of the diodes.
Exceeding the maximum operating temperature of the diode may damage the diode. Avoid temperature stabilization near the upper measuring range.

There is also possibility to use PT100 resistance thermometer which can measure from 73.15 to 1123.15 K.

The HEAT3 can delivery 480W watts of power (40V for 12Amps) to the heater for Resistive heating and 300W watts of power for Electron Bombardment Heating (1000V for 300mA).

1.3 SAFETY

The owner of the device must ensure that all the users have been informed about the safety requirements contained in this manual. In the event of sale or transfer of the device to another owner this manual should be attached.

1.3.1 PERSONNEL QUALIFICATIONS

All work described in this document may only be carried out by persons who have suitable technical training and the necessary experience or who have been instructed by the final user of the device.

1.3.2 ILLUSTRATION OF RESIDUAL DANGERS

This user manual illustrates safety notes concerning dangers as follows:

1. Information on potential serious accident or personal injury.

2. Information on possible damage to the device.

3. Information on correct handling or use. Disregarding safety notes can lead to malfunctions or device damage.

4. **Note. Indicates particularly important, but not safety-relevant information.**

1.3.3 GENERAL SAFETY INSTRUCTIONS

The HEAT3 has been designed to maximally protect the user and his environment against burns or electric shocks, mechanical hazards, high temperature and fire spreading out of the device. The environmental conditions different from those specified below may pose a threat to the user and his environment:

- Use inside buildings.

- Elevation above sea level of up to 2000 metres.
- Temperature range of safe operation: 5 °C to 40 °C.
- Maximum relative humidity: 80% (to 31°C), decreased linearly down to max. 50% at 40°C.
- Fluctuations of supply voltage cannot exceed ±10% of the rated value.
- Protection class 1.

During all the operations carried out with the use of the device described in this manual, observe the applicable safety regulations. Observe all the safety notes given in this document and forward the information to all other users of the device. Pay particular attention to the following safety notes:

DANGER

Supply voltage.
Contact with live parts is extremely hazardous when any objects are introduced or any liquids penetrate into the device.
Make sure that no objects enter through the vent holes of the device. Keep the device dry.

DANGER

Fire of device.
If smoke or flames coming from the device are sighted, disconnect power supply immediately (by unplugging the power cord, or if it is not possible by disconnecting a relevant circuit in the switchboard powering the device). Remove flammable materials at a safe distance. Start extinguishing the fire. If the power supply could not be disconnected use only E-type extinguishers or dry-powder extinguishers designed to extinguish equipment under voltage.

WARNING

Improper installation, operation or use.
Improper installation, operation or use may damage the HEAT3 . Strictly adhere to the stipulated installation and operation data.

Self-configuration of the device.
Self-configuration of the HEAT3 by the user through the service application results in waiver of the PREVAC's liability for proper functioning of the device.

Failure to observe the general safety instructions may result in potentially dangerous situations.

Figure 1.3: Make sure that no objects enter through the vent holes of the device. Keep the device dry.

1.3.4 GROUNDING

The HEAT3 is the class 1 device. To minimize a risk of electric shock connect the device to the mains with a 3-conductor mains cable. Conductor cross-section should be min. 1 mm2 (17AWG). Plug the mains cable into wall sockets with protective ground only.

1.3.5 INTERNAL CIRCUITS OF DEVICE

The operating personnel cannot remove the device covers. The device does not contain any internal control systems and replaceable elements, which could be operated by unauthorized persons. Replace any attached components only after disconnecting the mains cable. To avoid electric shock always disconnect the mains cable, any external voltage sources and discharge the output circuits.

1.3.6 SPARE PARTS AND MODIFICATIONS

Replacement of spare parts, modifications and repairs may be carried out only by the PREVAC's authorized personnel. Therefore, the device must be delivered to the PREVAC's service.

1.3.7 VENTILATION

The device has vent holes located on the side panels of the enclosure. Do not cover the vent holes during the operation of the device.

1.3.8 OPERATION IN EXPLOSIVE ATMOSPHERES

DANGER

Operation in explosive atmospheres.
The device cannot be used in the presence of flammable gases or vapours. The device cannot be used in potentially explosive atmospheres.

1.3.9 CLEANING

Keep the device dry. For cleaning device's enclosure, use only moistened cloth. Do not use any aggressive or abrasive cleaning agents.

1.4 TECHNICAL DATA

1.4.1 MECHANICAL DATA

The section describes the external dimensions of the device. Figure 1.4 present the HEAT3 , which may be rack-mounted or used as a desktop device.

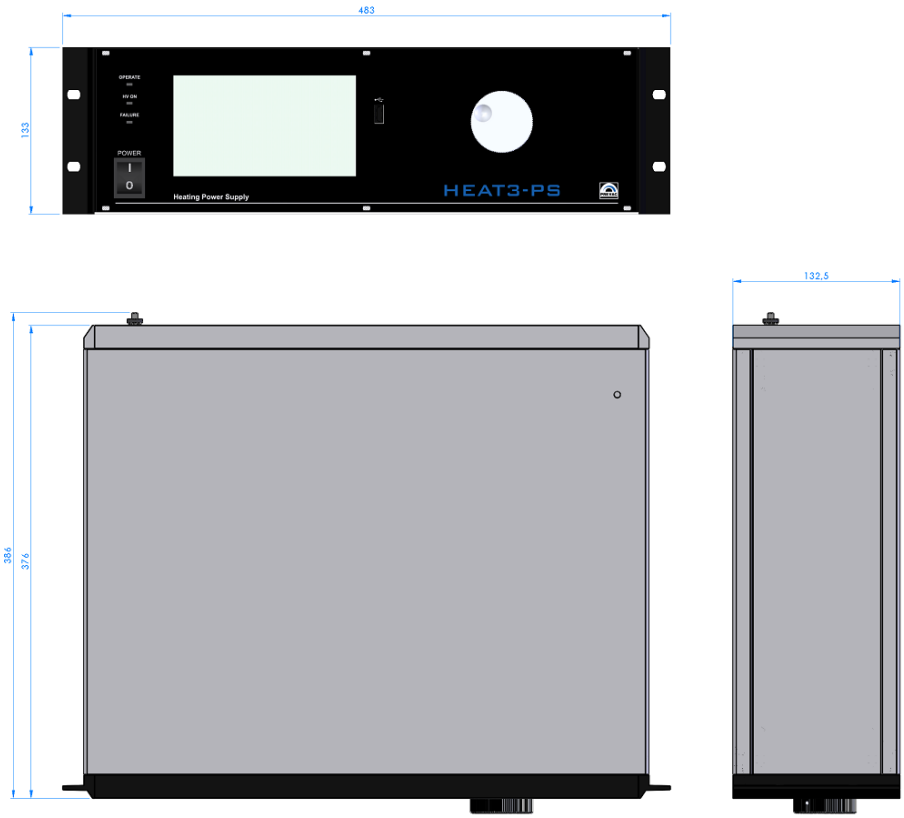


Figure 1.4: Dimensions

1.4.2 SPECIFICATION

PARAMETER	DESCRIPTION
Temperature control	Process temperature control with build-in PID controller
Process parameters.	PID controller finds optimized process PID parameters with auto-tuning function.
Temperature set point ramp rate	Adjustable from 0.1°/h to 1000°/s.
Cathode current ramp rate	Adjustable from 0.1 to 10 A/min
Emission voltage ramp rate	Adjustable from 10 to 1000 V/min
Temperature measurement	Two independent thermocouple inputs supports thermocouples: type K, C, E, N Two independent inputs for silicon diodes DT670/DT470 (option).
Temperature range	1,4K - 2473K, dependent on sample holder and temperature sensor type
Vacuum measurement	Compatible transmitters: CTR90/91, TTR90, TTR211/216, PTR225/237, PTR90, ITR90, ITR100, MKS870b, MKS937, PG105 (with PGA13 amplifier only)
Cathode power supply output voltage ripple	Less than 0.06 %
High voltage power supply output voltage ripple	Less than 0.05 %
Cathode voltage ramp rate	0.01 V/h - 200 V/s
Emission voltage ramp rate	1 V/h - 1000 V/s
Cathode power supply	0 - 40 V, 0 - 12 A wersion with two DC modules: 0 - 80 V, 0 - 12 A or 0 - 40 V, 0 - 24 A or DC1: 0 - 40 V, 0 - 12 A DC2: 0 - 40 V, 0 - 12 A
High voltage power supply (EB mode)	0 - 1000 V, 0 - 300 mA DC
Digital Input	4 inputs active with high state (24V), galvanically isolated (max 50 V to GND)
Digital Output	6 relay outputs with contacts capability: 4 relay NO; 2A/120VAC or 2A/24VDC 2 relay NO,NC; 8A/250VAC or 8A/24VDC

continued on next page

continued from previous page

PARAMETER	DESCRIPTION
Analog Inputs	1 Vacuum gauge input 2 Universal inputs 0 - 10V, non isolated to GND
Analog Outputs	2 outputs 0 - 10V, non isolated to GND

Table 1.3: Device specification

1.4.3 OPERATION

The device can be controlled in two ways:

- Manually on the display with touch panel.
- Remotely via RS232, RS485 or Ethernet, see chapter 6.

1.4.4 VACUUM GAUGE CHANNEL

Independent vacuum gauge may be connected to the HEAT3 .

PARAMETER	VALUE
PRESSURE CHANNEL:	
Sensor connector	RJ45
Compatible sensors	CTR90/91, TTR90, TTR211/216, PTR225/237, PTR90, ITR90, ITR100, BARATRON, ANALOG-IN, MKS870b, MKS937, MKS937A, PKR251/360/361, PCR280, TPR280/281, PG105, ATMION, IKR360/361
Voltage	Relative to voltage reading: ±0,3%
Absolute	±2 mV
Measuring rate	10 s^{-1}
Display rate	4 s^{-1}
Temperature drift	Temperature drift < 0.1 % per °C
Unit of measurement	mbar, Pa, Torr
Resolution of the A/D converter	24 bit

Table 1.4: Pressure channels specifications

1.4.5 STANDARDS

- The HEAT3 conforms to the following standards and harmonised standards:
  - PN-EN 61326-1:2013-06 (EN 61326-1:2013) - Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements.
  - PN-EN 61000-6-4:2008/A1:2012 (EN 61000-6-4:2007/A1:2011) - Electromagnetic compatibility (EMC) – Part 6-4: General standards – Emission standard for industrial environments.
  - PN-EN 61010-1:2011 (EN 61010-1:2010) - Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements.
  - PN-EN 50581:2012 EN 50581:2012 - Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.
- Conforms to the essential requirements of the following directives
  - EMC 2014/30/EU - Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility.
  - LVD 2014/35/EU - Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits.
  - RoHS 2011/65/UE - Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment Text with EEA relevance.
  - WEEE 2012/19/UE - Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) Text with EEA relevance.

2 INSTALLATION

This chapter describes the procedures for unpacking, mechanical installation and electrical installation. Take care when lifting the unit that the weight and position do not exceed comfortable limits.

2.1 UNPACKING

1. Visually inspect the transport packaging for signs of external damage.
2. Unpack the HEAT3 .

   Note: Retain the packaging materials for later use. The HEAT3 must be stored and transported in the original packaging material only.
3. Examine the HEAT3 for completeness.
4. Visually inspect the HEAT3 for signs of damage.

DANGER

Damaged product.
Using the destroyed or damaged device or connection cables can result in electric shock. Never attempt to put a damaged product into operation. Secure the damaged product from unintended operation. Send a damage report to the courier company or the insurer.

2.2 MECHANICAL INSTALLATION

The HEAT3 is designed for installation into a rack according to DIN 41 494 (19", 3 HU) and occupying the whole width of the cassette. Before taking any actions read the safety notes below.

WARNING

Ambient temperature.
Exceeding the maximum permitted ambient temperature may damage the device. Make sure that the maximum permitted ambient temperature is not exceeded and that the air can flow freely through the louvers. Do not expose the device to direct sunlight.

DANGER

Protection class of the rack.
If the product is installed in a rack, it is likely to lower the protection class of the rack (protection from foreign bodies and water) e.g. according to the EN 60204-1 regulations for switching cabinets. Take appropriate measures to restore the required protection class of the rack.

2.3 COOLING

The HEAT3 is equipped with a cooling system. The power unit is equipped with a suction fan. Air is supplied from the panels located by the power unit enclosure. Hot air outlet is located on the rear panel. At least 15mm should be ensured to let air get inside from the side panels. The HEAT3 should not be operated at temperatures exceeding 40°C.

2.4 ELECTRICAL INSTALLATION

2.4.0.1 POWER REQUIREMENTS

This section describes the general power requirements and how to connect power to the device.

PARAMETER	VALUE
Voltage	100 – 130 VAC 200 – 260 VAC
Frequency	50 – 60 Hz
Power consumption	1500 W
Current consumption	7 A (at 230V) 15 A (at 110V)
Fuses	2x8A (at 230V) 2x16A (at 110V)

Table 2.1: Power requirements

2.4.1 MAINS CONNECTION

The mains connection is designed for a mains cable which contains a European appliance connector IEC 320 C20 on the device side.

A mains cable is supplied with the device. To improve grounding , connect vacuum system to the ground screw of HEAT3 power supply using additional ground cable as short as possible with cross-section $4mm^2$. Device output circuits are protected by 8A or 16A fuse in relations to the supply voltage.

CAUTION

Fuses
Before first use make sure that rated currents of the installed fuses are appropriate in relations to the supply voltage.

DANGER

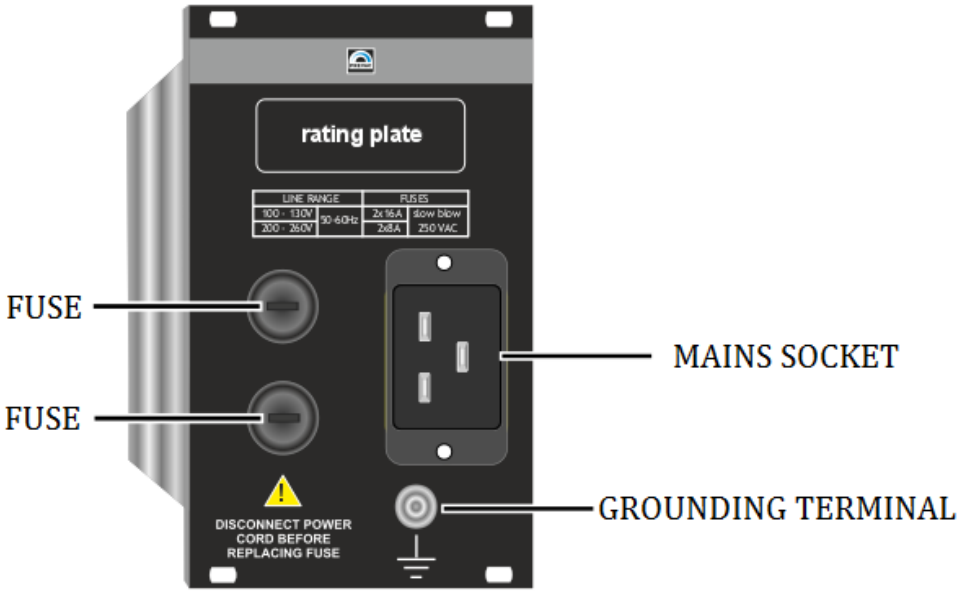


Figure 2.1: Rectifier module

Mains power.
Improperly grounded devices can be extremely dangerous in the event of a fault. Use three-wire mains or extension cables with protective ground only provided with HEAT3 . Plug the mains cable into wall sockets with protective ground only.

- Connect the European appliance connector of the mains cord with the mains connection of the device
- Connect the plug of the mains cable with the wall socket

NOTE: If the device is installed in a switching cabinet, the mains power can be supplied via a switchable central power distributor.

Figure 2.2: Power connector

DANGER

Risk Of Electric Shock - Fuse Replacement
To avoid electrical shock or personal injury, disconnect the power cord before opening the cover on the power entry module.

WARNING

When device is working on 110V voltage uses two 16A fuses, while working on 230V voltage - two 8A fuses. Changing supply voltage, remember to change fuses on suitable. Otherwise, the device will not work correctly.

2.4.2 POWER CORD

The HEAT3 comes with a detachable, three-wire power cord for connection to a power source with protective ground. The HEAT3 chassis is connected to the power ground to protect against electrical shock. Always connect to an AC outlet which has a properly connected protective ground. If necessary, or when in doubt, consult a certified electrician.

2.4.3 POWER SWITCH

The power switch is located on the front of the HEAT3 . The switch is a toggle type, marked with **I** and **O**. The **I** (on) position applies the power to the instrument. The **O** (off) position cuts off the power to the instrument. However, turning the power switch off does not fully remove the AC power from inside the instrument.
Always disconnect the power cord from the power entry module to fully remove AC power from inside the instrument.

DANGER

Risk Of Electric Shock
Do NOT use the power switch as a disconnecting device; disconnect the power cord from the power entry module to fully remove hazardous voltage from inside the HEAT3 .

2.4.4 GROUNDING TERMINAL

A functional grounding clamp is located at the back panel of the device, right next to the power socket. It should be connected to the central power distributor by means of a wire or grounding braid. This shall ensure electromagnetic compatibility and the device's resistance to disturbances in its working environment.

DANGER

Screw for internal protective conductor.
The internal protective conductor is connected with the enclosure through a screw.
Do not turn or loosen this screw.

2.4.5 DEVICE REAR PANEL

This section contains a description of available sockets and connectors on the rear panel.

The design of the HEAT3 power unit is based on replaceable modules. All the modules except for rectifying ones can be removed by the user. The device is equipped with seven different types of modules:

- Rectifier Module
- DC Module
- HV Module
- Measurement Module
- Analog I/O Card
- Digital I/O Card
- Communication Card

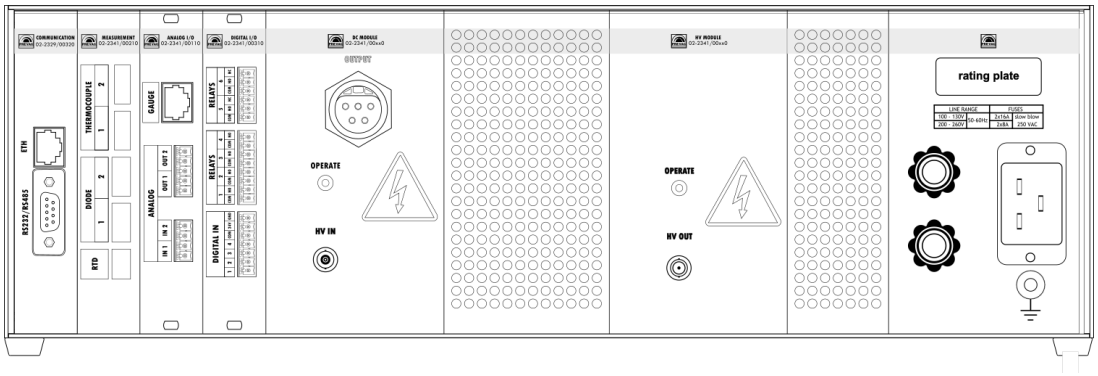


Figure 2.3: Rear view of HEAT3

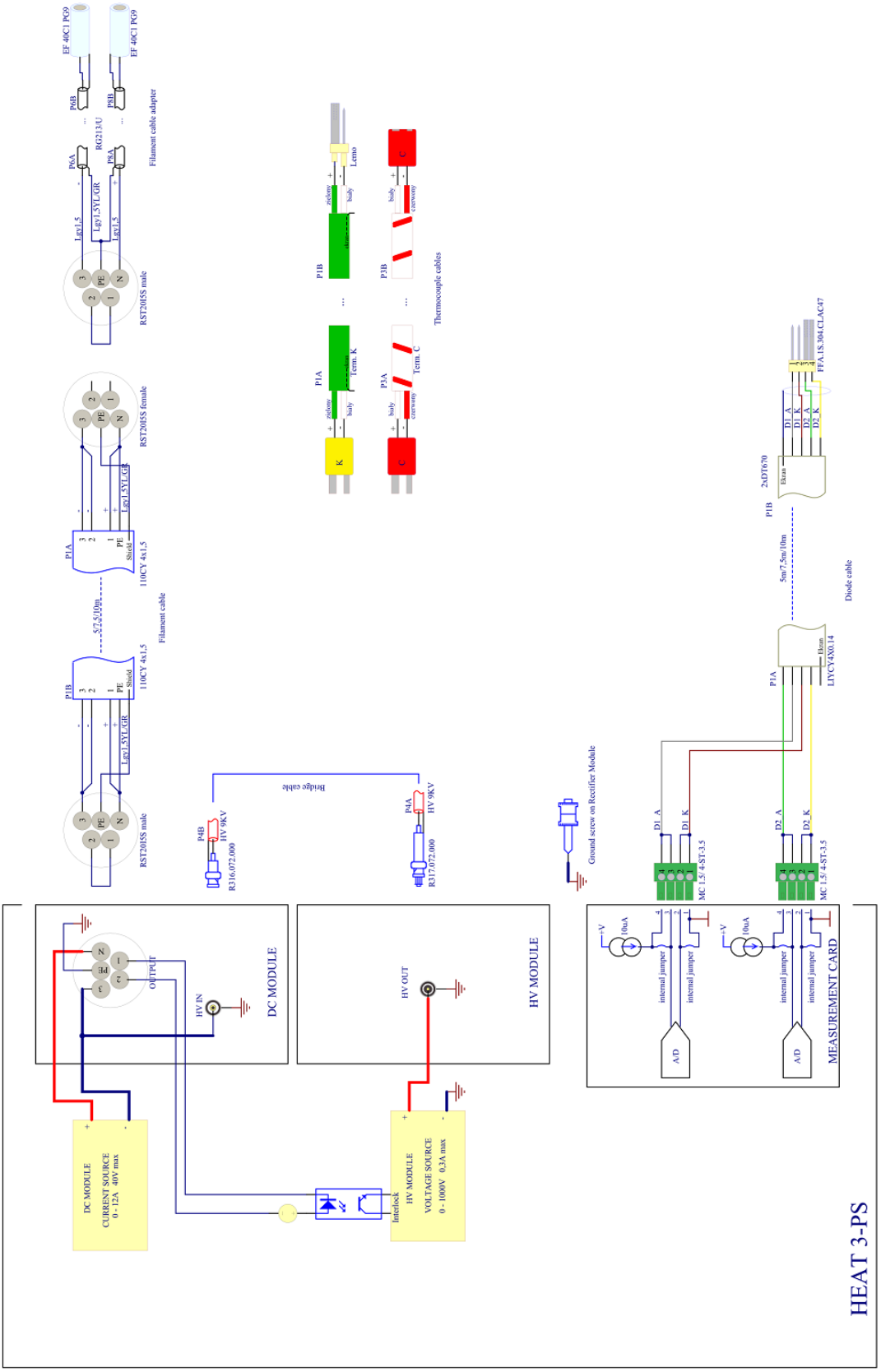


Figure 2.4: Wiring diagram description

2.4.6 RESISTIVE HEATING

Resistive heating, as mentioned, is used to heat the sample to a temperature of several hundred degrees. This method of heating the sample requires the DC Module, which is described below. This section provides information about the connections for the resistive heating.

2.4.6.1 DC MODULE

The HV IN socket in the DC Module is designed for Electron Bombardment Heating and therefore does not apply to resistive heating. This module has an LED indicator which informs if the DC Module is operating or not. During normal operation, the LED glows orange.

DANGER

DC Module
Under no circumstances should the DC Module be moved while it is operating (when Operate LED glows orange).).

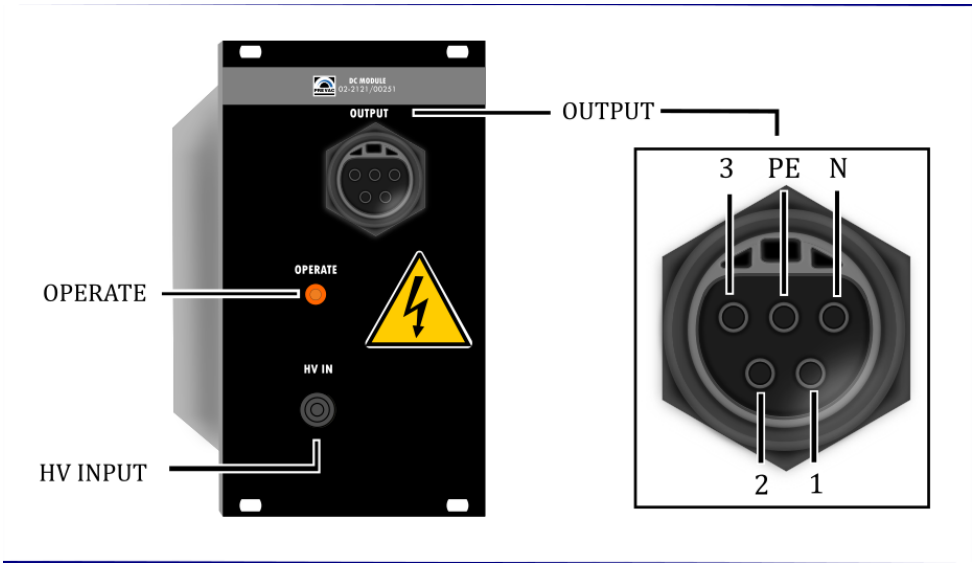


Figure 2.5: DC Module overview

PIN NAME	DESCRIPTION
1	Interlock
2	Interlock
3	Negative Output
PE	PE - Ground
N	Positive Output

Table 2.2: Module DC - pin description

Pins 1 and 2 in Module DC Output (fig.2.5) are used as safety INTERLOCK pins. At Electron bombardment heating mode they have to be short-circuited, because only then the HV module can turn on. At resistance heating mode pins 1 and 2 does not have to be short-circuited.

2.4.6.2 WIRING FOR RESISTING HEATING

In order to meet the required connections for resistance, the DC Module output should be connected to the sample. The following images show the cathode (filament) cable.

Figure 2.6: Filament cable

Figure 2.7: Filament cable adapter

2.4.7 ELECTRON BOMBARDMENT HEATING

High temperature heating by electron bombardment of a sample uses both DC and HV modules.

2.4.7.1 HV MODULE

This module has an LED indicator which informs if the HV Module is operating or not. During normal operation the LED glows orange.

DANGER

HV Module
Under no circumstances should the HV Module be handled or moved while it is operating (when Operate LED glows orange).

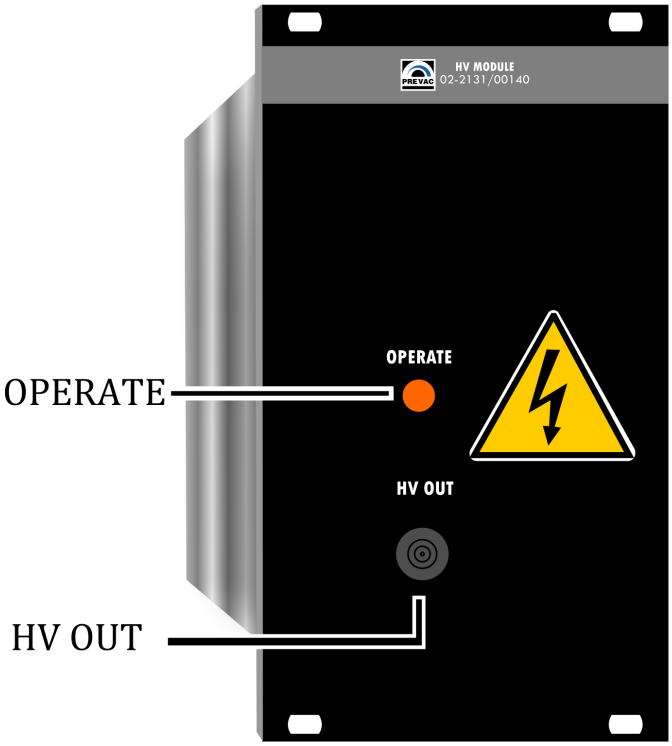


Figure 2.8: HV Module overview

2.4.7.2 WIRING FOR ELECTRON BOMBARDMENT HEATING

Electron bombardment heating requires a specific connection between the HV and DC modules. The connection is made by a bridge cable (red cable) supplied with the HEAT3. Link the HV OUT of HV Module with HV IN of DC Module as shown in the following figure.To supply the cathode the same cable as the resistive heating is used.

Figure 2.9: Connection necessary for proper operation in Electron Bombardment mode

2.4.8 RESISTIVE HEATING WITH TWO DC MODULES

If the output power of a single DC module is insufficient, a special version of the power unit to operate two DC modules working in series or in parallel can be ordered. The rear panel is then equipped with additional modules to enable parallel operation. DC modules can also work independently. The manner of connecting the outputs of modules (serial, parallel, independent) is detected by measuring resistance at pin 1 and 2 of the DC2 module output port

CAUTION

Two DC modules
The power unit equipped with two DC modules (regardless of configuration) cannot be used to heat by electron bombardment (no HV module). However, the other DC module can be replaced with a HV module to enable electron bombardment heating.

2.4.8.1 Serial operation

Serial connection of two DC modules enables doubling the output voltage in relations to the voltage of a single DC module. The maximum output current is the same as the current of a single module. Modified venting panels are not used in this configuration. Figure 2.10 shows the manner of connecting a serial connection cable.

CAUTION

Serial connection
The DC1 cable plug should be connected to the DC1 module (the module on the left looking at the rear panel) and the DC2 cable plug should be connected to the DC2 module (the module neighbouring the rectifying one). Only then the power unit will be properly set in the serial operation.

Figure 2.10: Serial connection

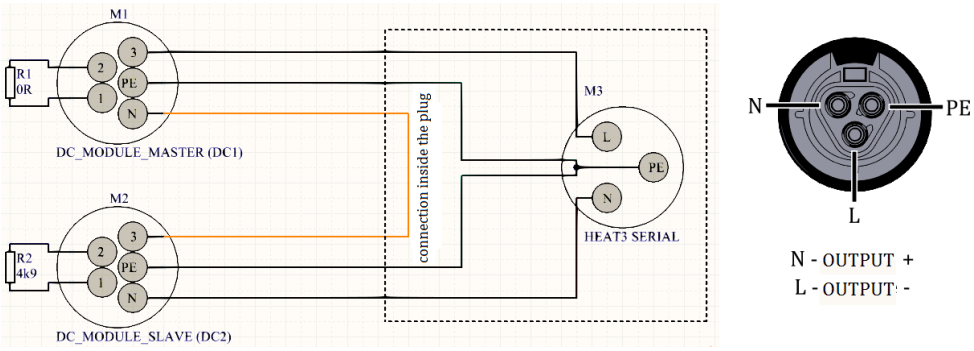


Figure 2.11: Diagram of serial connection cable

2.4.8.2 Parallel operation

Parallel connection of the outputs of DC modules enables doubling the output current in relation to the current of a single DC module. The maximum output voltage is the same as the voltage of a single module. Modified venting panels have diodes connected in series with the positive outputs of the modules to enable parallel operation. Figure 2.12 shows the manner of connecting a parallel connection cable.

CAUTION

Parallel connection

The DC1 cable plug of a venting panel should be connected to the DC1 module (the module on the left looking at the rear panel) and the DC2 cable plug of a venting panel should be connected to the DC2 module (the module neighbouring the rectifying one). Only then the power unit will be properly set in the parallel operation.

Figure 2.12: Parallel connection

2.4.8.3 Independent operation

If neither a serial connection cable nor a parallel connection cable of a venting panels are connected to the DC2 module output port, the power unit will be set in the independent mode. In this mode all the positions in the DC module setting menu are doubled (limits, ramps, interlocks, analogue outputs assignments, etc.). Two independent PID controller are also implemented to control the DC modules. The heating panel in this operation mode is presented in section 3.3.2.

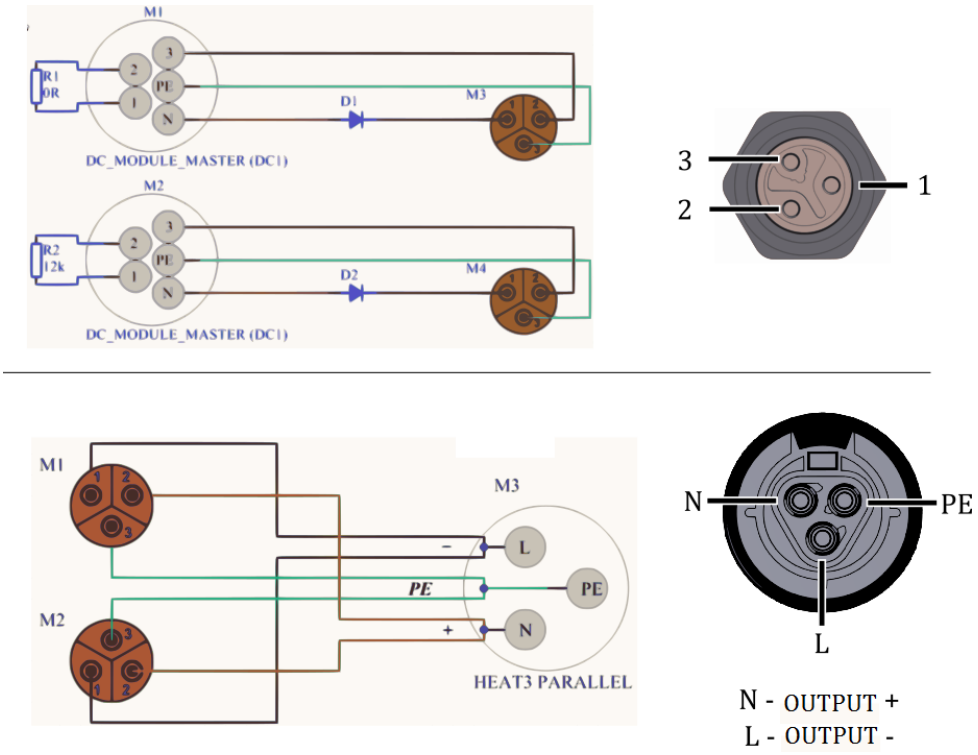


Figure 2.13: Diagram of venting panel and parallel connection cable

2.4.9 TEMPERATURE MEASUREMENT

Temperature measurement module contains:

- two thermocouples sockets
- two diode sockets
- one resistance thermometer socket

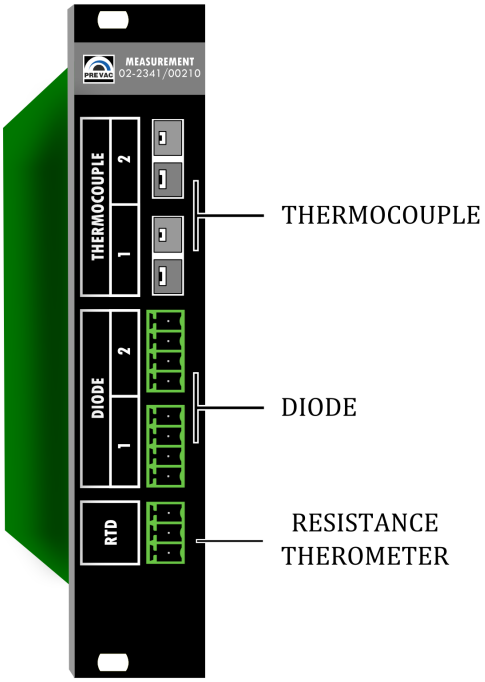


Figure 2.14: Measurement Module overview

2.4.9.1 RTD (RESISTANCE TEMPERATURE DETECTOR)

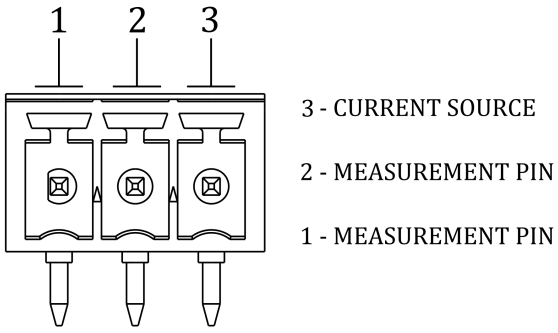


Figure 2.15: RTD (resistance temperature detector) socket

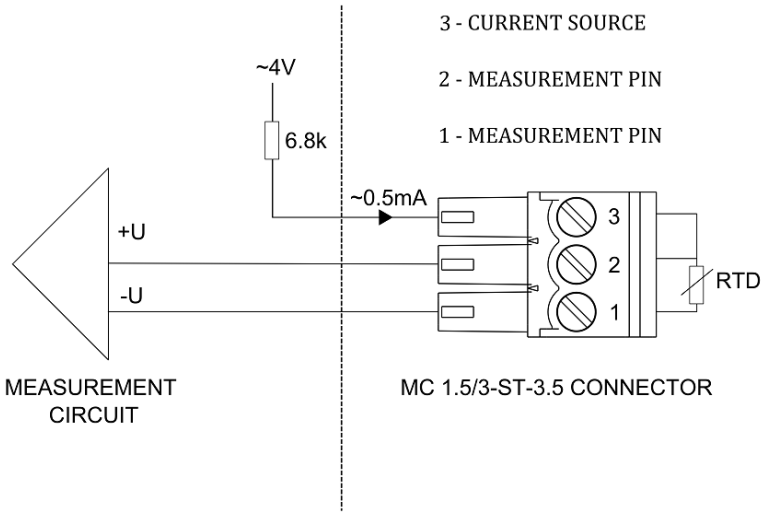


Figure 2.16: RTC Connection schematic

2.4.9.2 DIODE

Diode socket is used to connect DT670 and DT470 silicon diodes.

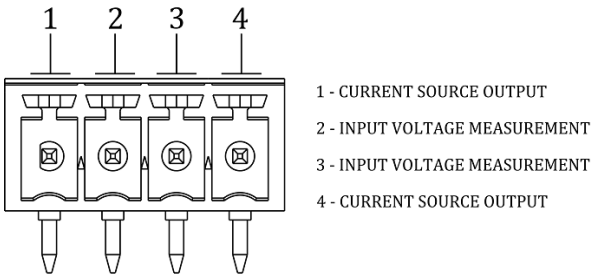


Figure 2.17: Diode socket

2.4.9.3 THERMOCOUPLE

The power supply has two independent thermocouple inputs. Both of them can be used to connect three types of thermocouples: C, K, E and N.

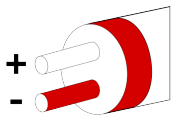
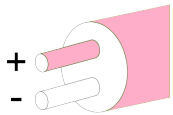
Thermocouple type	Colours	Standard
C		ANSI MC 96.1 Color Coding
E		IEC 584-3 Color Coding
K		IEC 584-3 Color Coding
N		IEC 584-3 Color Coding

Table 2.3: Supported thermocouple types

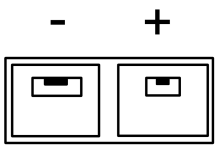


Figure 2.18: Thermocouple socket

2.4.10 DIGITAL IO CARD

The Digital Input/Output card provides four digital inputs and six relay outputs.

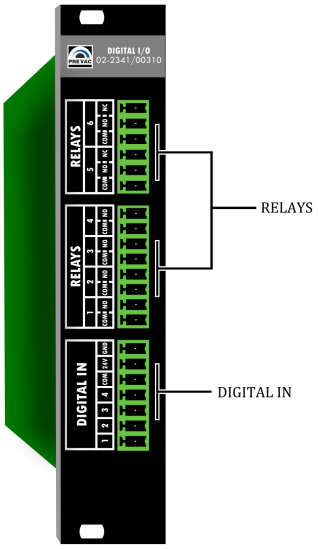


Figure 2.19: DIGITAL IO CARD view

2.4.10.1 DIGITAL IN CONNECTOR

The all digital inputs is active high logic level 24V, to activate single input should be connected as shown in Figure 2.20 below.
Digital IN 1 is reserved for e.g. a vacuum interlock signal from a suitable pressure gauge. The input is active low and should be connected as shown in Figure 2.20 below.
Digital IN 2 is reserved for a remote control signal from a host.

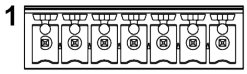


Figure 2.20: Digital In male connector

Interlock protection signal is provided to prevent accidental operation of the device when not under vacuum. If the protection signal is missing (open circuit), the HEAT3 returns to STANDBY mode and displays 'No interlock' message accompanied by a flashing control failure LED.

PIN NUMBER	FUNCTION	DESCRIPTION
1	Master Interlock	The global enable signal to switch the device to *OPERATE* state
2	Digital In 2	Configurable input from the device menu
3	Digital In 3	Configurable input from the device menu
4	Digital In 4	Configurable input from the device menu
5	Digital COM	Reference pin for digital inputs
6	24V	24V power output, the maximum total current can not be greater than 0.5A
7	GND	Ground

Table 2.4: Pin out Digital In description

WARNING

Permission signal

Switching device to *OPERATE* state requires the presence of a signal *MASTER INTERLOCK*. No *MASTER INTERLOCK* signal is indicate by warning message on screen.

Internal diagram of a single digital input shown in Figure 2.21.

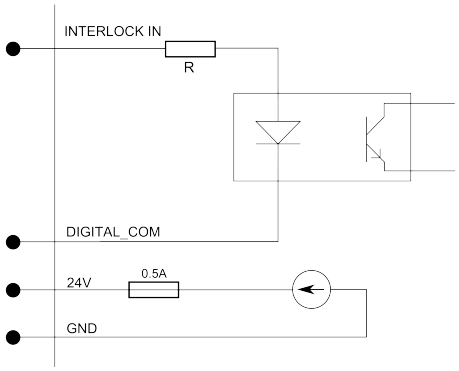


Figure 2.21: Digital in - internal diagram

Examples of control schematics digital inputs.

- Input activated permanently(Fig. 2.22). This connection can be used an initial testing *Digital IN* but is not recommended during normal device operation .
- Activation of the inputs using an external power source (DC supply, PLC, etc.). Allows activate any input by apply 24V relative to *Digital COM* pin .
- Activation input using external relays. Allow control device working state depending on external factors(pressure value, temperature etc.). Shown in figure keys may indicate: vacuum meter relay, bimetallic placed on a vacuum system etc.

WARNING

Digital input maximum voltage
Logic inputs accept signals from a range of 0 to 24 V. Exceeding these values may damage the input and measures should be in place to ensure these limits are not exceeded.

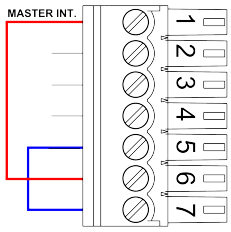


Figure 2.22: Permanently *Interlock*(not recommended)

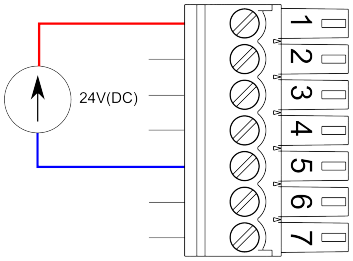


Figure 2.23: Inputs activated by external power supply

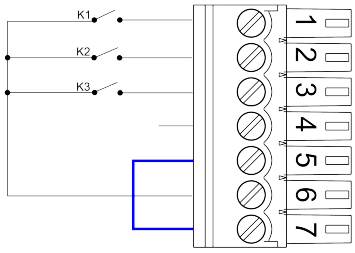


Figure 2.24: *Digital IN* activated by external relays.

2.4.10.2 RELAY OUTPUTS

DIGITAL IO CARD includes six relays outputs:

- four outputs with terminals COM and NO - connector RELAY 1-4,
- two relay outputs with terminals COM, NO and NC - connector RELAY 5 i 6.

The relay outputs pins are physically isolated from the device. The maximum current is limited by the model used relays and is 2 A.

Detailed relay outputs configuration, see 3.4.12.1.

Figure 2.25: Connector ”RELAYS 1-4”

PIN NUMBER	FUNCTION	DESCRIPTION
1	Relay 1 output	contact COM (common)
2	Relay 1 output	contact NO (normal open), User-defined functions
3	Relay 2 output	contact COM (common)
4	Relay 2 output	contact NO (normal open), User-defined functions
5	Relay 3 output	contact COM (common)
6	Relay 3 output	contact NO (normal open), User-defined functions
7	Relay 4 output	contact COM (common)
8	Relay 4 output	contact NO (normal open),User-defined functions

Table 2.5: Pin out description of connector ”RELAYS 1-4”

WARNING

The maximum current relays.
Output relays are rated for 24 VDC or 120 VAC and 2 A. Proper fusing and adequate wiring isolation and separation should be provided to assure these limits are not exceeded

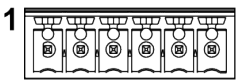


Figure 2.26: Connector ”RELAYS 2”

PIN NUMBER	FUNCTION	DESCRIPTION
1	Relay 5 output	contact COM (common)
2	Relay 5 output	contact NO (normal open), fUser-defined functions
3	Relay 5 output	contact NC (normal close) contact, User-defined functions
4	Relay 6 output	contact COM (common)
5	Relay 6 output	contact NO (normal open), User-defined functions
6	Relay 6 output	contact NC (normal close) contact, User-defined functions

Table 2.6: Pin out description of connector ”RELAYS 5-6”

2.4.11 ANALOG IO CARD (OPTION)

Analog Input/Output card contains analogue inputs, outputs and connection for a suitable vacuum gauge .

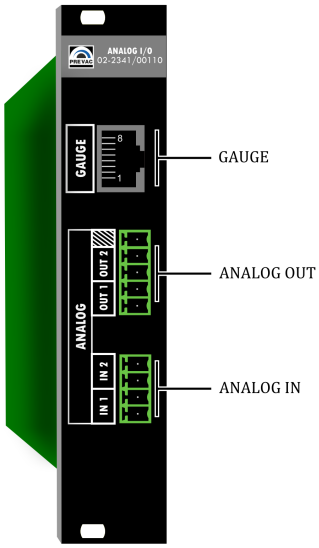


Figure 2.27: Analog I/O overview

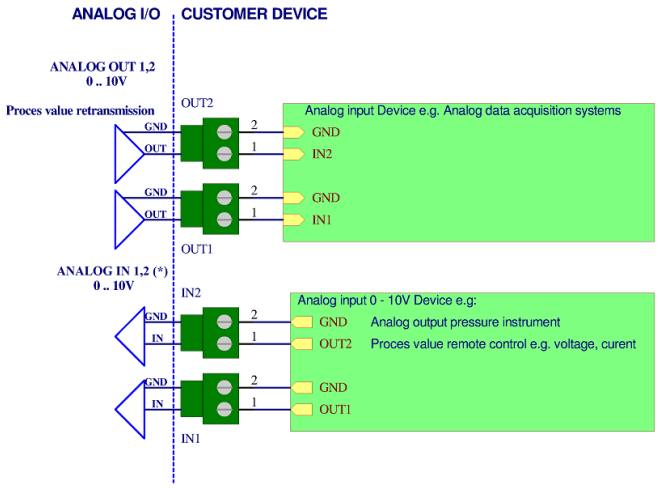


Figure 2.28: Analog Connection

In order to connect a vacuum gauge to the HEAT3 , an appropriate transmitter must be used as described below.

Pin assignment of this connector is shown in Table 2.7:

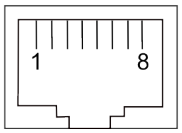


Figure 2.29: RJ45 Gauge connector

PIN NUMBER	FUNCTION	DESCRIPTION
1	24 V DC	Power supply
2	0 V DC	Ground
3	0 - 10 V DC	Analog measurement signal
4	Identification	Gauge type identification signal
5	GND	Signal GND
6	Input signal	CHANNEL STATUS
7	No connect	Not connected
8	24 V	HV ON (emission) steering signal

Table 2.7: Pin assignment of the channel sensors connector

WARNING

Improper transmitter.
Transmitters which are not designed for use with the HEAT3 may damage the device. Operate the HEAT3 with proper transmitters only. See compatible sensors list in Measuring Channel section in Operation chapter.

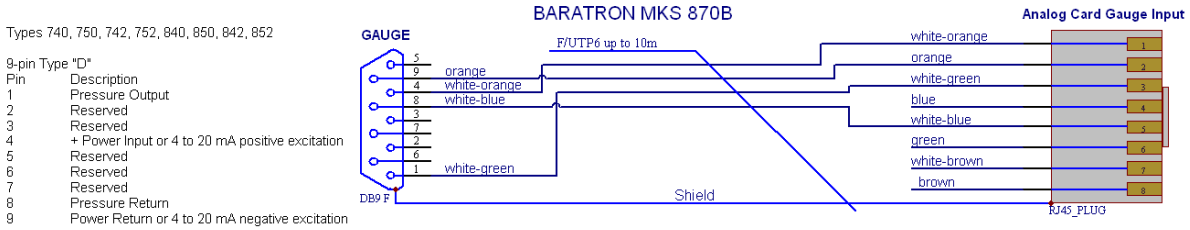


Figure 2.30: Baratron MKS gauge connection

Figure 2.31: Pirani gauge connection

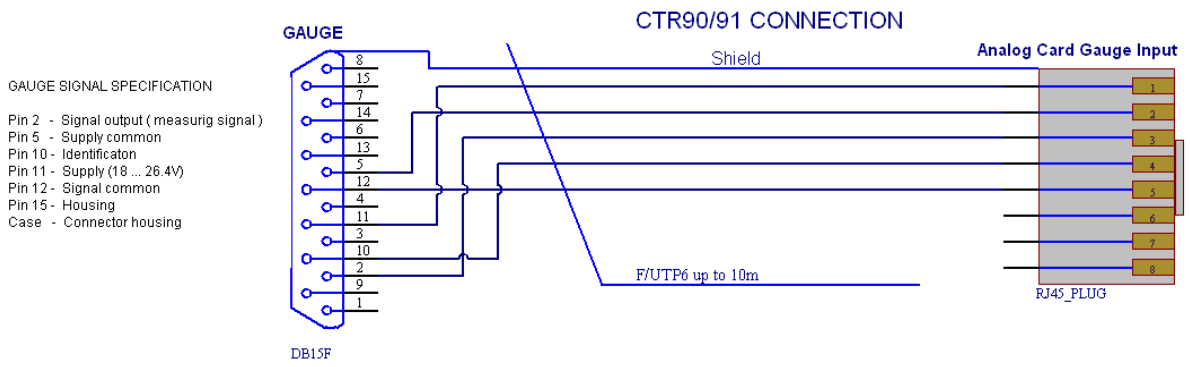


Figure 2.32: CTR90/91 gauge connection

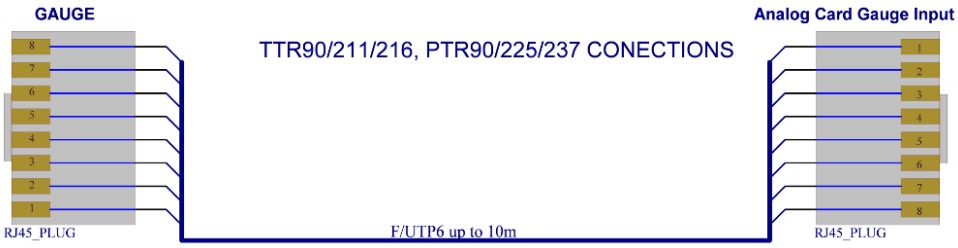


Figure 2.33: TTR/PTR gauge connection

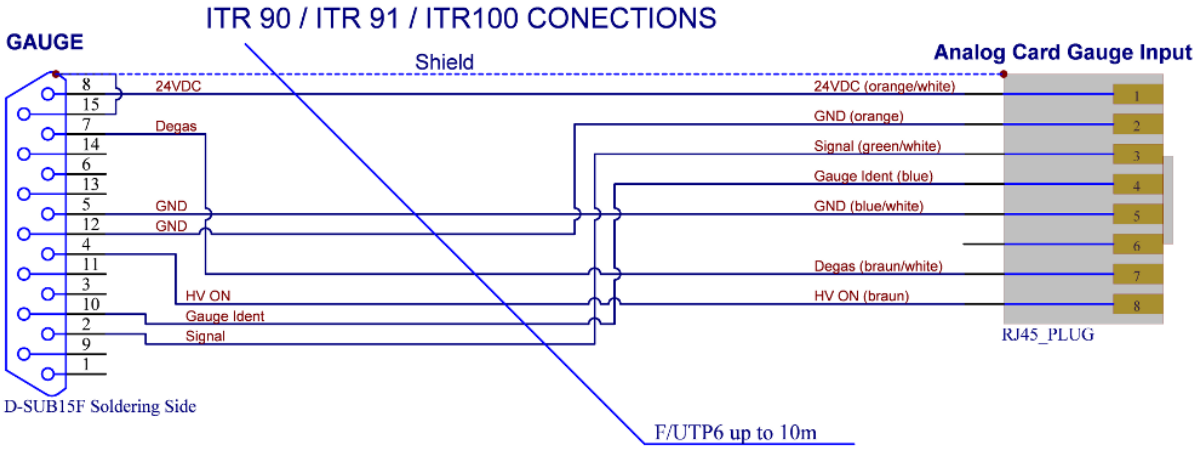


Figure 2.34: ITR gauge connection

Analog inputs can be used to control parameters such as:

- I_C
- I_{CLimit}
- U_C
- U_{CLimit}
- I_{ELimit}
- U_E

Analog output 0-10V allowing the retransmission of values such as:

- Cathode and emission current and voltage
- Process Value
- Thermocouples temperature
- Diodes temperatures
- Pressure

2.4.12 REMOTE CONTROL

The device comes supplied with the following communication interfaces:

- Serial interface RS232/RS485 (selected from menu),
- Ethernet interface (IEEE 802 standard),

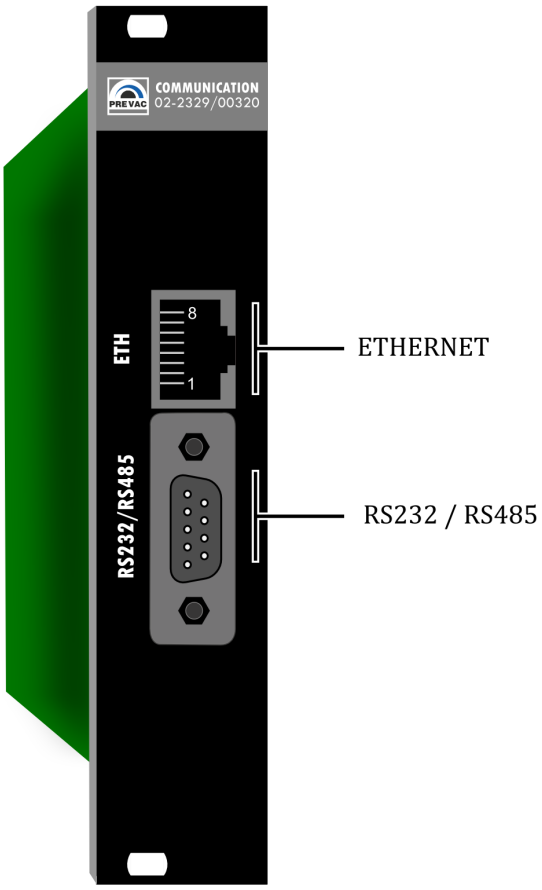


Figure 2.35: Remote control module

The remote interface allows read-back of the device parameters. In order to control and set the device parameters, the device must be switched to the remote control mode.
For a detailed description of the remote interface configuration, please see section 2.4.12

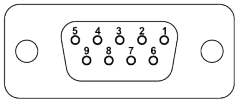


Figure 2.36: Serial interface connector(female 9 pin)

PIN NUMBER	FUNCTION	DESCRIPTION
2	RX	RS232 - Data signal RX
3	TX	RS232 - Data Signal TX
5	GND	Ground
8	D+	RS485 - Data signal positive
9	D-	RS485 - Data signal negative
1,4,6,7	none	not used

Table 2.8: Serial interface connector - pin description

3 OPERATING

Interaction with the HEAT3 takes place mainly via the touch panel and encoder. The front panel also contains LED status indicators describing the current state of the power supply.

3.1 SWITCHING ON THE DEVICE

In order to turn on the device make sure that all of the connections on the rear panel are made correctly and that the AC connection meets the criteria provided in the AC source requirements section. If all the requirements are met, set ***Power Switch*** into ***ON*** position on the front panel.

3.2 FRONT PANEL

There are several principal parts of the HEAT3 user interface:

- LED diode indicators
- Touch panel display
- USB port
- Digital encoder knob for setting parameters
- Power switch
- Backlight logo

Front panel of the HEAT3 device is shown in Figure

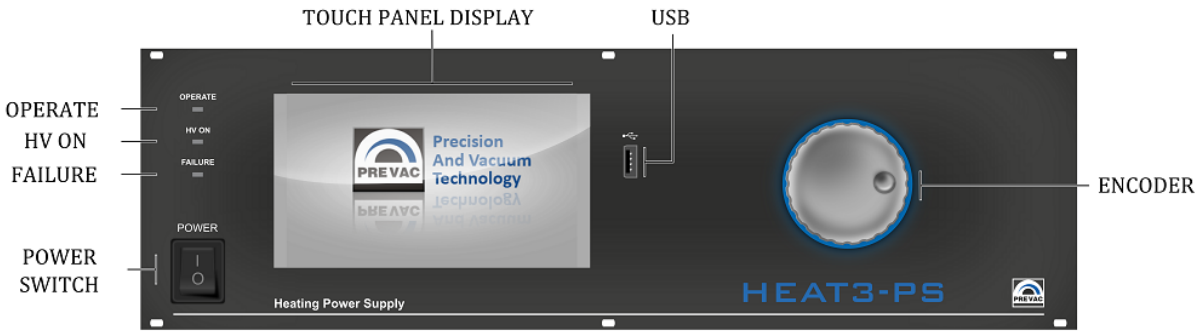


Figure 3.1: Front panel

3.2.1 LED INDICATORS

LED indicators inform about the operating state of the power supply:

- OPERATE – Green diode indicates operate status. Blinking indicates that some of the parameters are still stabilize.
- HV ON – Yellow diode indicates high voltage (> 48V) applied to any output pin,
- FAILURE – Blinking red diode indicates failure of the power supply. Additionally a corresponding failure message is displayed on the touch screen display.

3.2.2 DISPLAY WITH TOUCH PANEL

The device is equipped with a TFT 7inch colour display with a 16:10 format. The display has an integrated touch panel enabling communication with the user.

CAUTION

The touch panel can record only a single press at a time. It is forbidden to touch the panel at several points simultaneously.

CAUTION

Do not use any indicators or sharp objects. Using inappropriate objects for pressing may damage the foil resulting in entering incorrect data.

3.2.3 USB PORT CONNECTOR

Allows removable media to be used for e.g. update the software . It also enables copying videos and logs from/to the user's activity records.

3.3 USER INTERFACE

The HEAT3 is equipped with a colour display touch screen. All data and functions are accessible via the menus from this touch screen interface. Every operation must be performed by a tap on screen.
Main view contains 3 elements:

1. Main window - contains the most important parameters controlled by the device,
2. Menu - contains the device menu from where the user may enter the setup menu, upgrade firmware, show contents of the usb stick, playing videos,
3. Setup shortcut - contains list of favourites setup positions (see section ***Setup shortcuts***).

3.3.1 SWITCHING BETWEEN SCREENS

To toggle between screens, press the left or right hand side of the display. The navigation buttons are not initially shown on the screen but will be activated and displayed after pressing either side for longer than 1s. Movement between windows is looped- after window number 3, window number 1 is displayed again and vice versa.

3.3.2 PANELS OVERVIEW

The device contains three separate and distinct panels

- Heating panel

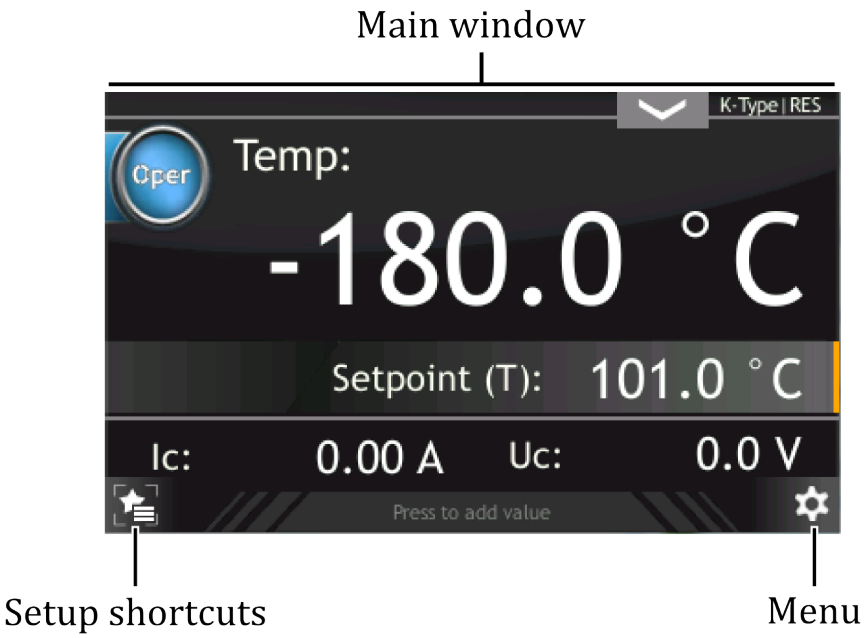


Figure 3.2: Screen main view

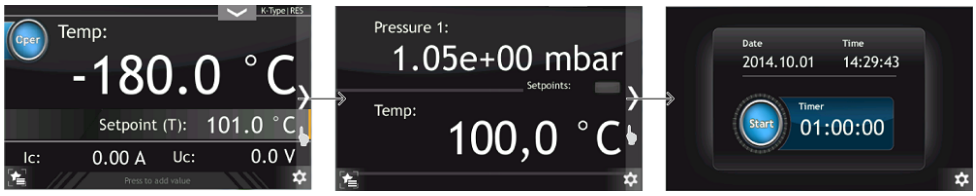


Figure 3.3: Moving between screens

- Vacuum panel
- Timer panel

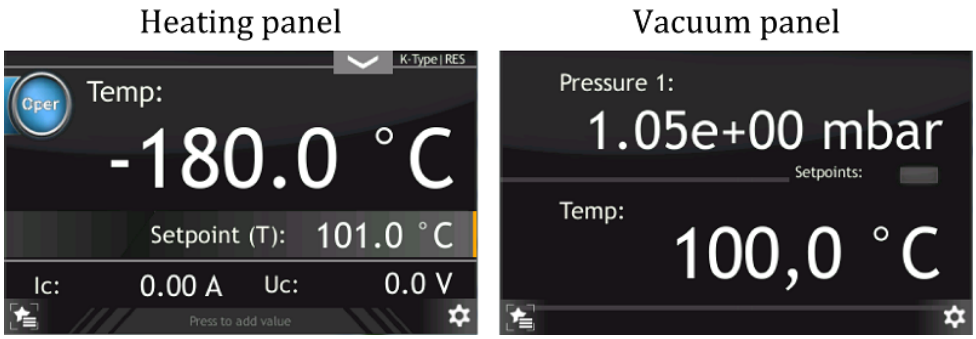


Figure 3.4: Moving between screens

The figures below describe panel configuration and interactive area for Heating and Vacuum panels which can be changed by tapping. The Timer panel will be described at the end of chapter.

The Heating panel contains information which is dependent on the current device configuration and which may be displayed in several configurations.

- Mode: RES, Regulation method: PID

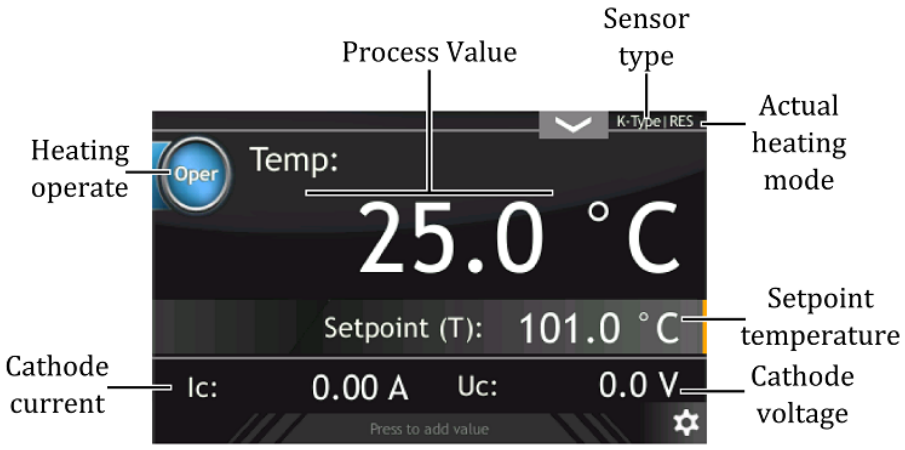


Figure 3.5: Heating panel description, Mode: RES, Regulation method: PID

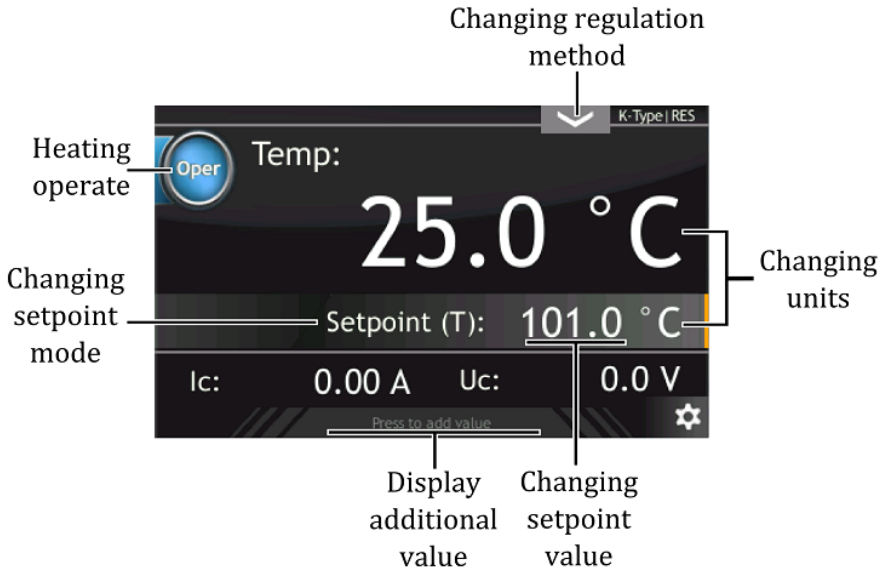


Figure 3.6: Heating panel active areas, Mode: RES, Regulation method: PID

- Mode: RES, Regulation method: Manual

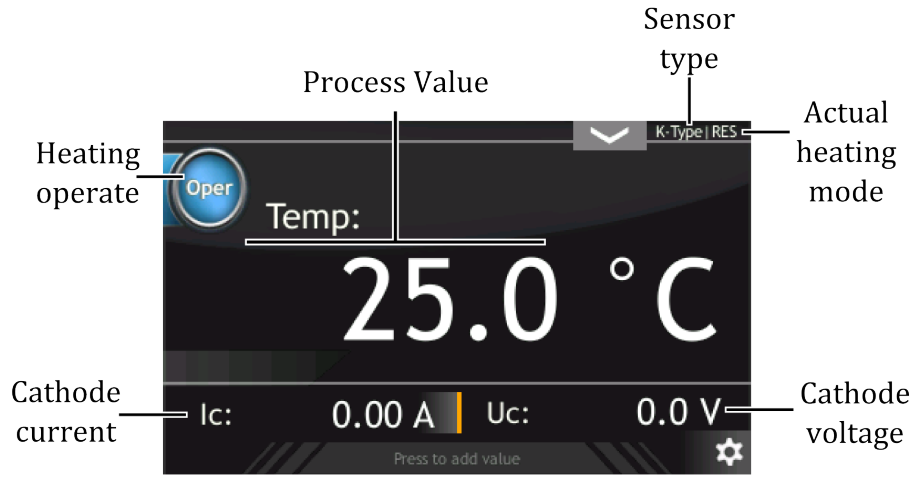


Figure 3.7: Heating panel description, Mode: RES, Regulation method: Manual

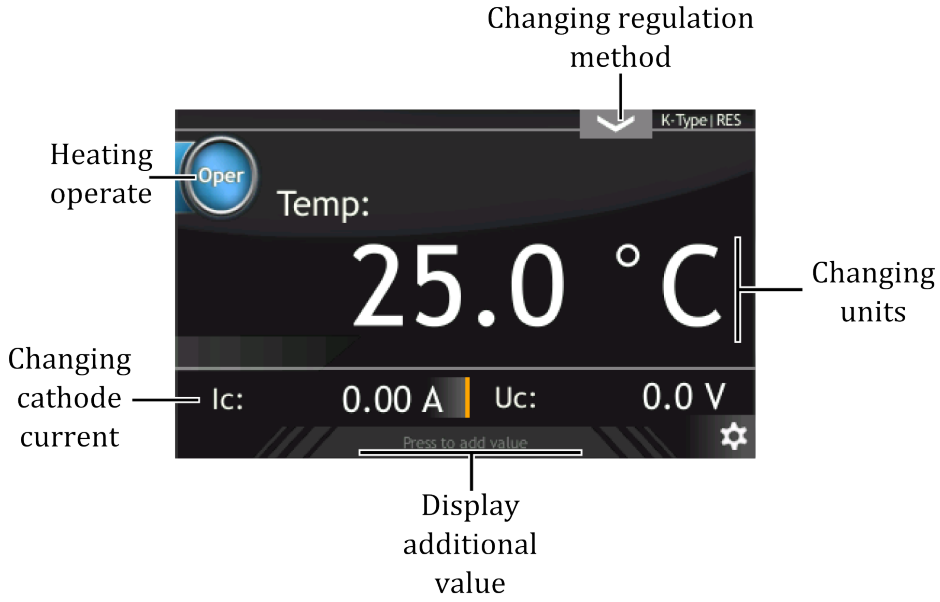


Figure 3.8: Heating panel active areas, Mode: RES, Regulation method: Manual

- Mode: 2xRES, Regulation method: DC1 module - Manual, DC2 module - PID

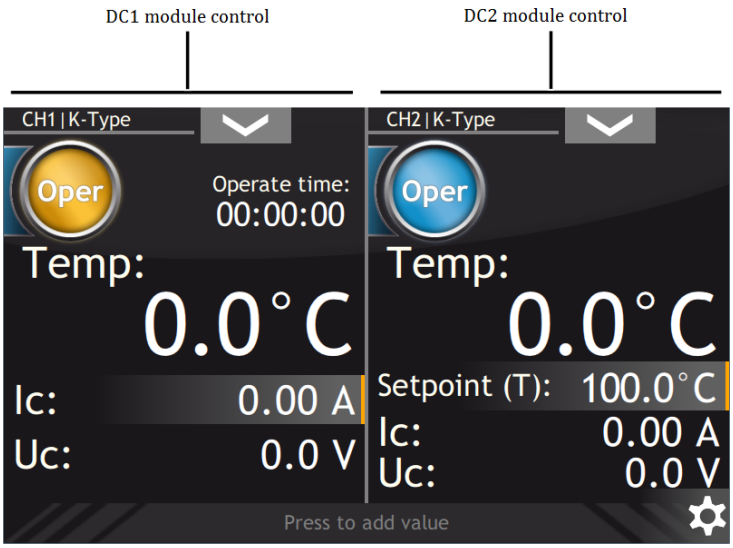


Figure 3.9: Heating panel description - device with two DC modules working independently

- Mode: EB, Regulation method: PID

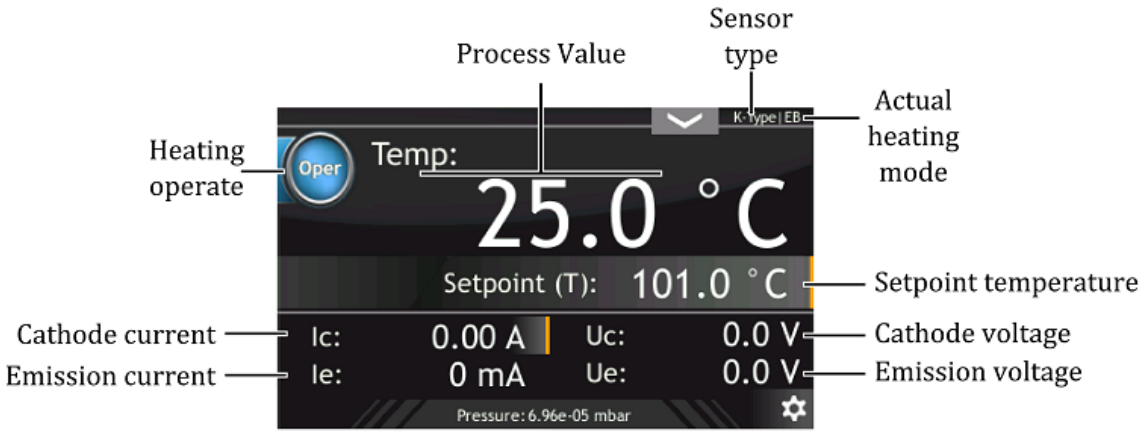


Figure 3.10: Heating panel description, Mode: EB, Regulation method: PID

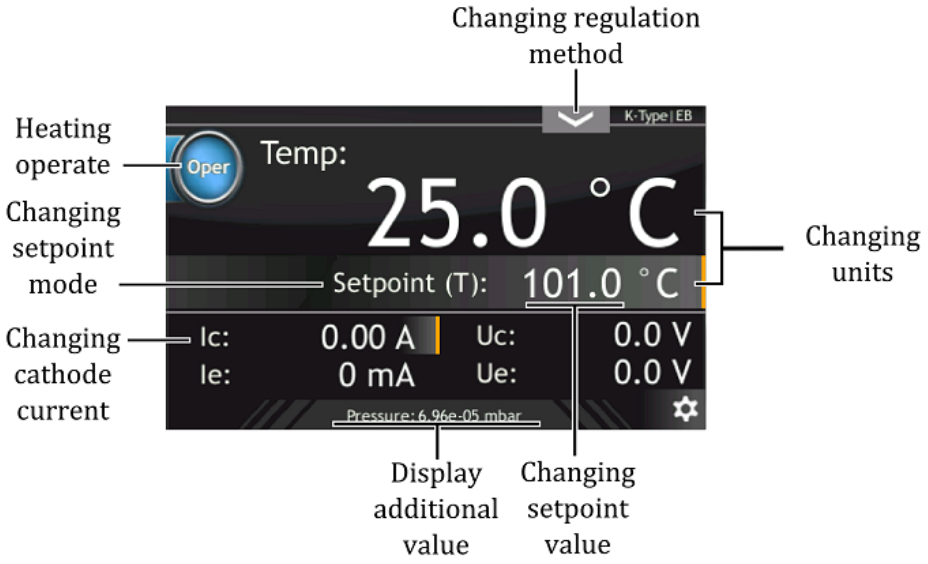


Figure 3.11: Heating panel active areas, Mode: EB, Regulation method: PID

- Mode: EB, Regulation method: Manual

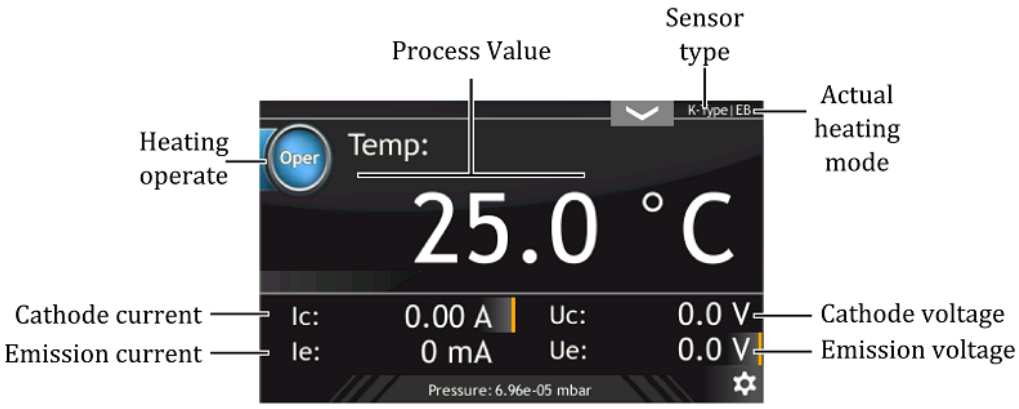


Figure 3.12: Heating panel description, Mode: EB, Regulation method: Manual

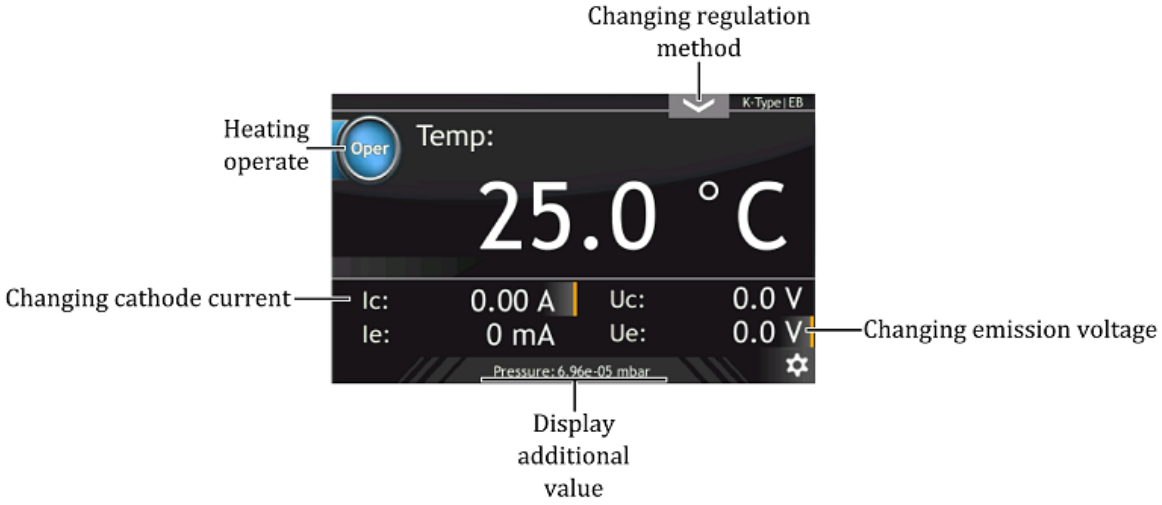


Figure 3.13: Heating panel active areas, Mode: EB, Regulation method: Manual

- Vacuum panel

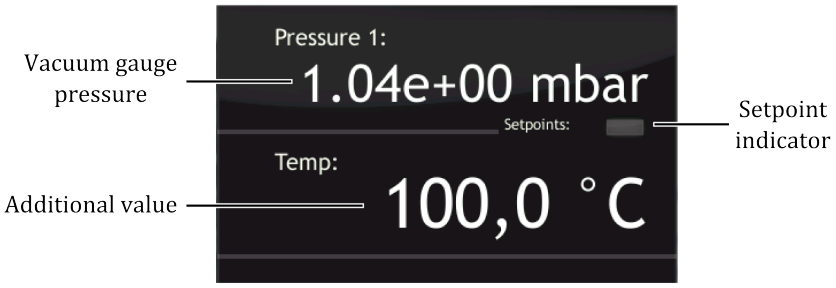


Figure 3.14: Vacuum panel description

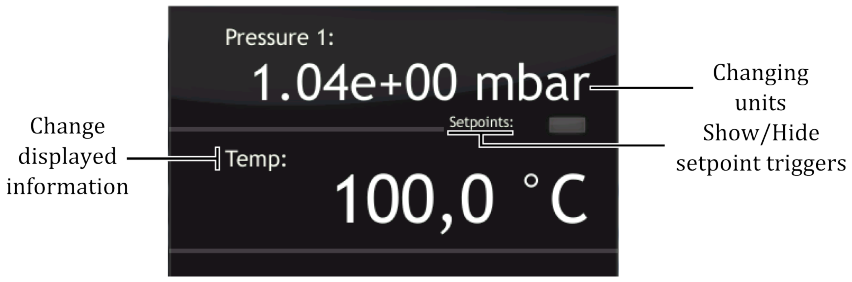


Figure 3.15: Vacuum panel active areas

3.3.3 DEVICE INTERACTION

To change the displayed measurement units:

1. Tap on units to change (e.g. Temp)
2. Select target units
3. Value in new units is displayed

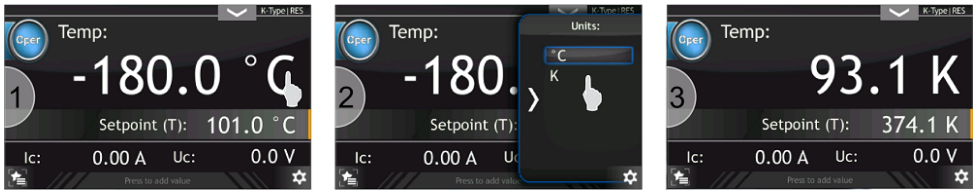


Figure 3.16: Changing units

To add or change the display information on the Heating panel

1. Tap the bottom of the display
2. Select information to be displayed
3. New value is displayed

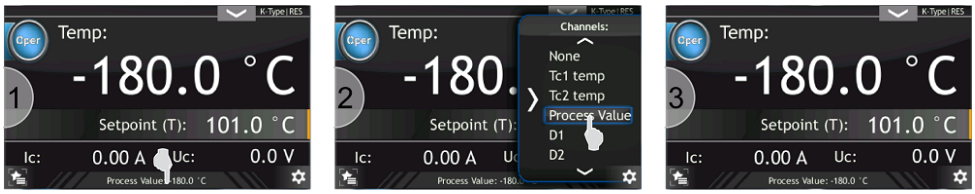


Figure 3.17: Changing additional information – Heating panel

To add or change the display information on the Vacuum panel

1. Tap on additional value label
2. Select value to be displayed
3. New value is displayed

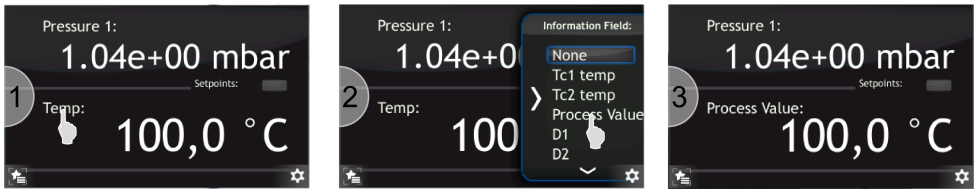


Figure 3.18: Changing additional information – Vacuum panel

3.3.4 OPERATING KNOB

Every input value can be modified using the knob located on the front panel. The Knob can be used to change values in both the main windows and setup menu.

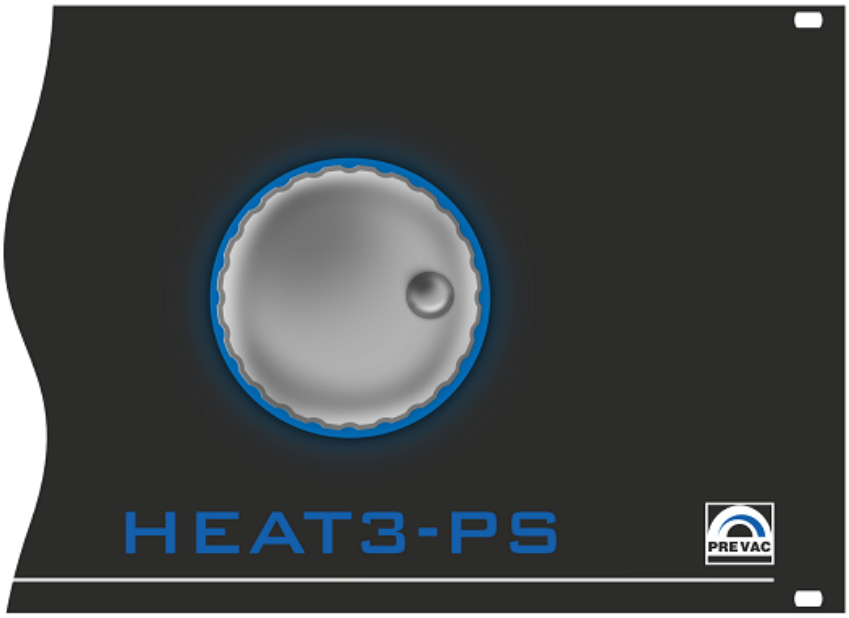


Figure 3.19: Knob placement

Every value in the main window with an orange line can be modified (e.g. Setpoint value). Changing the setpoint value by this method is described by the figure below; Changing setpoint value using knob.

1. Tap setpoint value. After tapping, the setpoint value will blink
2. Turn knob to change value
3. Tap again on setpoint value to disable value editing

Figure 3.20: Changing setpoint value using knob

Each value can also be modified by using the numeric keyboard. In order to display the numeric keyboard:

1. Tap value to edit (e.g. Setpoint),
2. Tap numeric keyboard button (see figure below),
3. For more information about numeric keyboard see *Numeric keyboard* section,

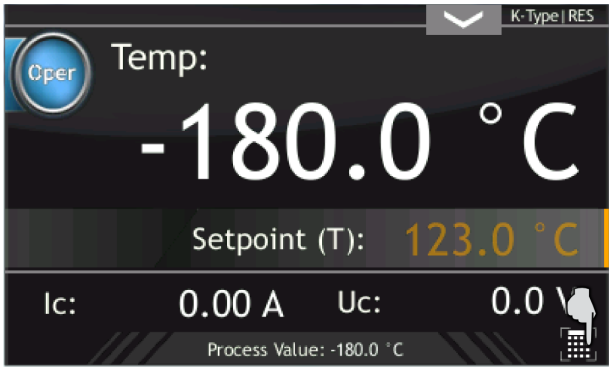


Figure 3.21: Editing value by numeric keyboard

3.3.5 NUMERIC KEYPAD

Numerical values in the device can be edited via the numeric keypad. It consists of basic numbers from 0 to 9 and function keys to enter new data and update the existing ones. The numeric keypad is shown in fig. 3.22.

Data can be entered directly from the numeric keypad by entering and confirming the value entered using the following three methods:

- by entering data as decimal values.
- by entering data as a mantisaa and exponent.

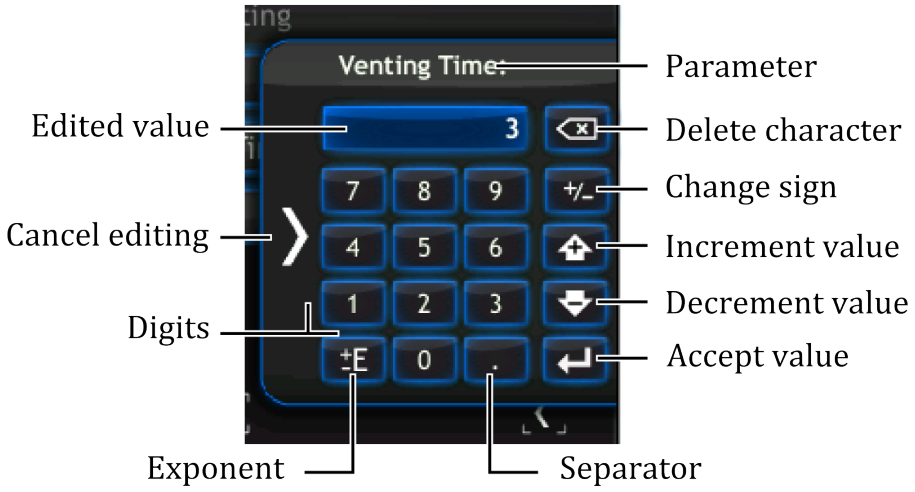


Figure 3.22: Numeric keypad

- by increasing/decreasing the current value by a given step.

To increase/decrease the current value:

1. Select the value for edition (e.g. Venting Time).
2. Press ***1*** and ***2***, to increase the value by 12.
3. Press the ***Increment value*** key (every press of this key increase the value by 12).
4. The value has been increased.
5. To decrease the value press the ***Decrement value*** key (every press of this key decreases the value by 12).
6. Value is decrement.
7. Confirm the value with the ***Confirm value*** key.

Figure 3.23: Increasing/Decreasing value via numeric keypad

To enter a number in the exponential form:

1. Enter the value of the mantisee with an appropriate character via the numeric keypad (e.g. 12.5).
2. Press the ***Exponent*** key. The index character can be changes by clicking it twice.
3. Enter the exponent value.
4. After entering the value, it is still possible to modify the sign of mantissa and the sign of exponent by using the ***Exponent*** key or the ***Change sign*** key (see 3.22 Figure).
5. Confirm the value with the ***Accept value*** key.

Figure 3.24: Number in exponential form

3.3.6 ALPHANUMERIC KEYPAD

The on-screen keyboard is used for entering alphanumeric data and also facilitates text entry. Figure 3.25 shows the alphanumeric keyboard with description of the main keys.

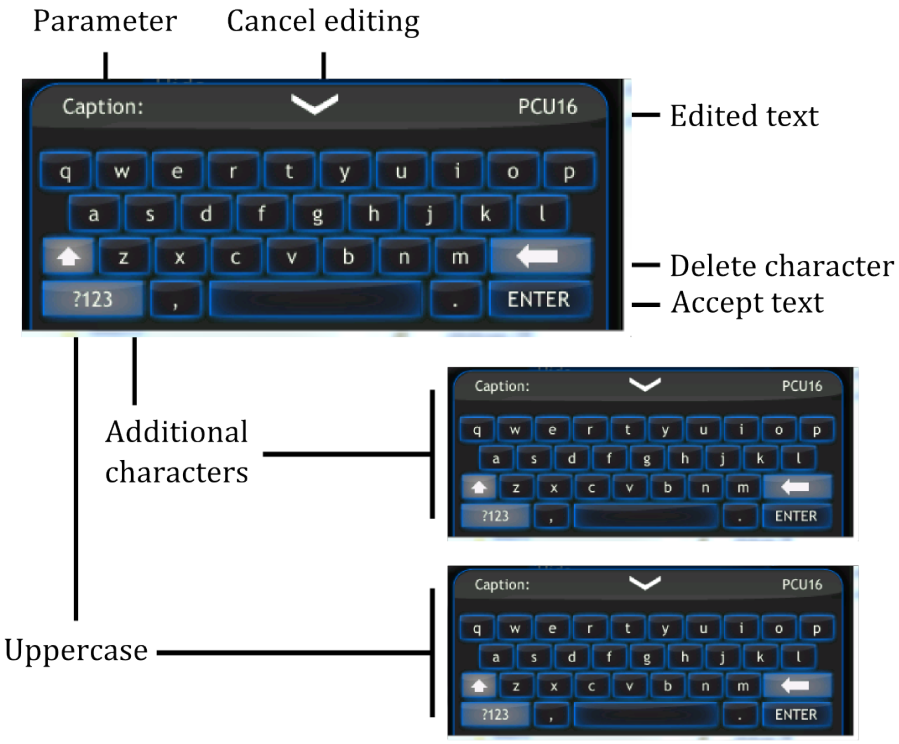


Figure 3.25: Alphanumeric keypad

3.3.7 SETUP

Advanced configuration of the device parameters is possible via the setup menu. Tap the menu icon to expand the menu and then tap device setup icon (see Figures 3.26 - 3.27).

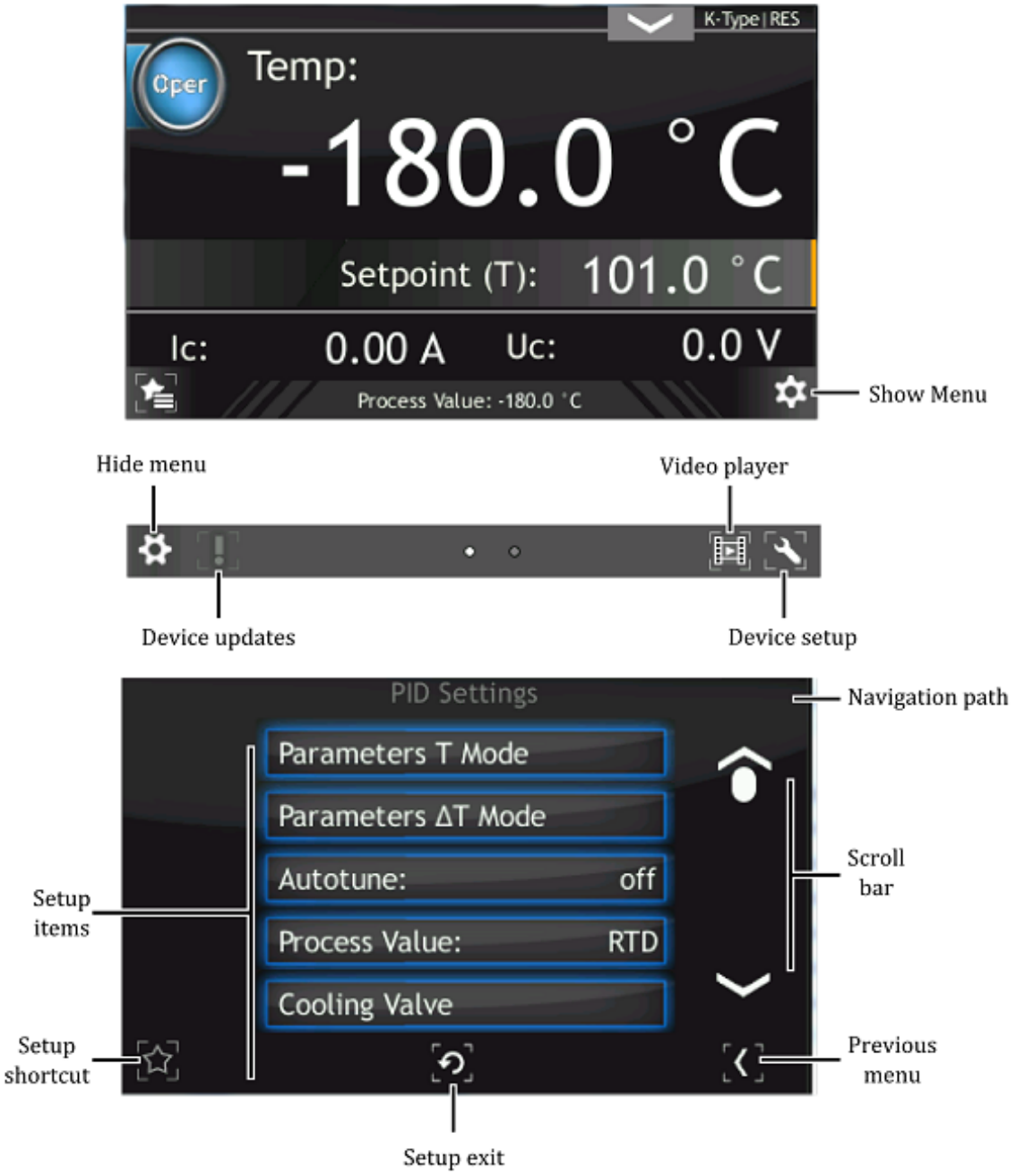


Figure 3.26: Device setup

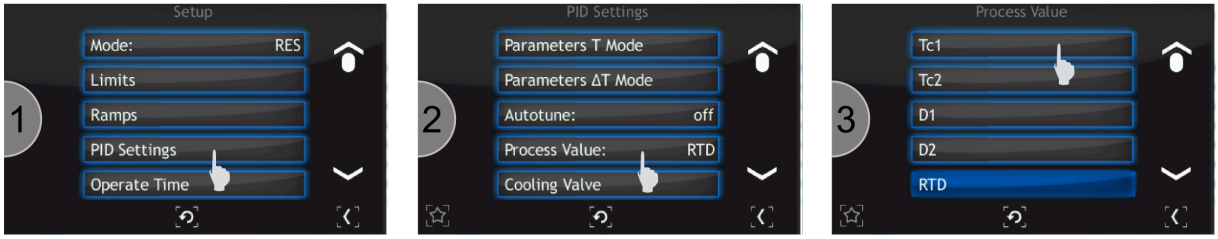


Figure 3.27: Navigating the setup (example)

3.3.8 SETUP SHORTCUTS

Frequently used commands/settings can be conveniently accessed by creating shortcuts.
To create a shortcut:

1. Navigate to the setup position where a shortcut should be created.
2. Press on the ***Setup shortcut***, icon to add the position to shortcuts. To remove position from shortcut list tap again on the ***Setup shortcut*** icon.

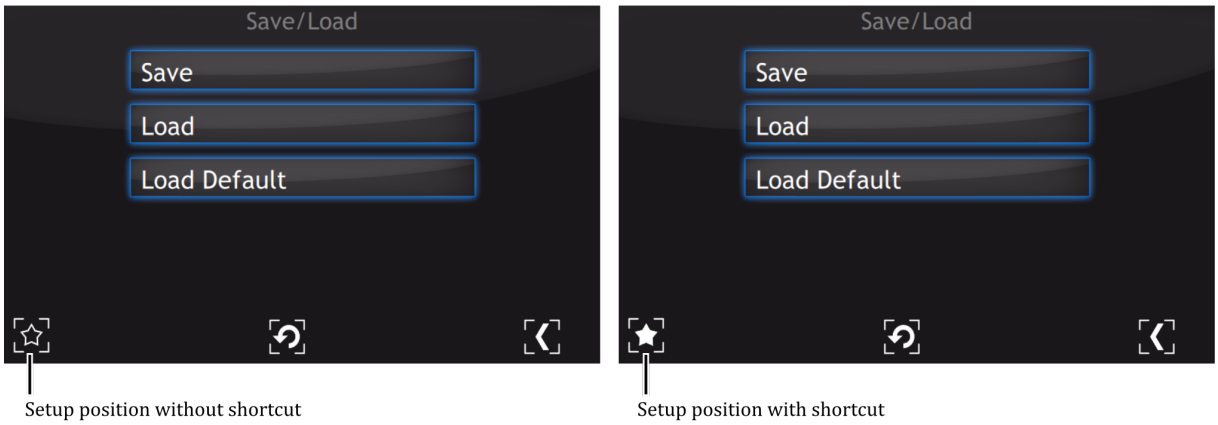


Figure 3.28: Set up shortcut in the setup menu

To use a shortcut:

1. Press on the ***Setup shortcut*** icon on the main window.
2. Select setup shortcut to enter (e.g. Save/Load).
3. Current setup menu item should be displayed.

Figure 3.29: Example use of shortcut

3.3.9 MESSAGES

The HEAT3 will automatically display both warning and error messages as appropriate.

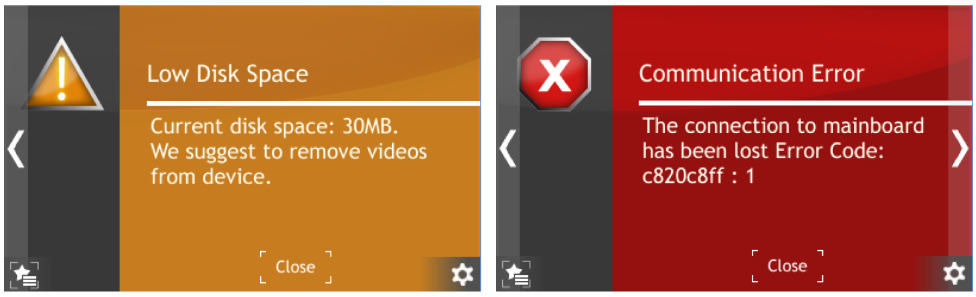


Figure 3.30: Example warning and error messages.

3.3.9.1 WARNING MESSAGES

Warning messages are displayed on the right of the screen. When present, they can be clicked to display the full warning information (see Figure 3.31). The warning message field consists of its name and description. A warning is information about an event that occurred in the system, but it is not critical for the operation of the device. When the problem causing the error no longer exists, the message is automatically removed whether or not it has been confirmed.

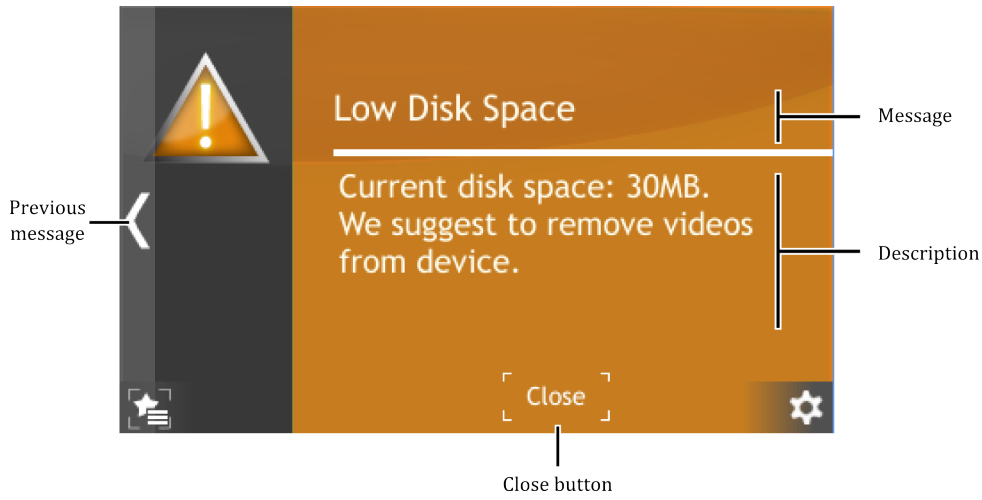


Figure 3.31: Warning message

3.3.9.2 ERROR MESSAGES

Error messages inform about critical events. The message is displayed in full screen (see Figure 3.32). The error message field consists of its name and description. If the cause of error no longer exists, the error message will disappear after the user clicks OK. When the user clicks OK but the error still exists, then information about the event will continue to be displayed on the right hand side of the screen. If the cause of error still exists, please contact the manufacturer.

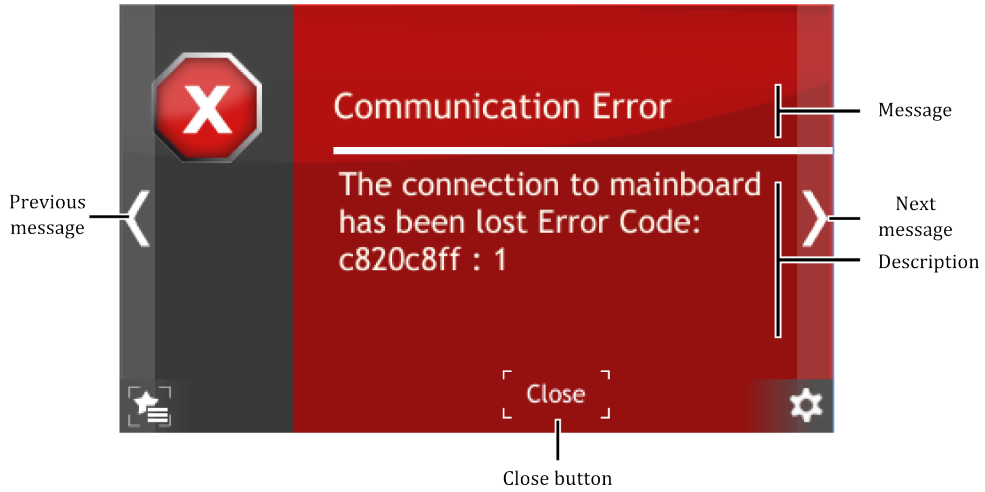


Figure 3.32: Error message

3.3.9.3 MULTIPLE MESSAGES

If several errors or warnings occur simultaneously they are indicated with a counter on the right hand corner of a screen. The first digit (red) of the message counter indicates the number of errors, the second digit (yellow) indicates the number of warnings occurred in the device. Clicking on this counter will bring up the message list. The list is displayed in date/time order from most recent to oldest. Error messages appear in the list before Warning messages.

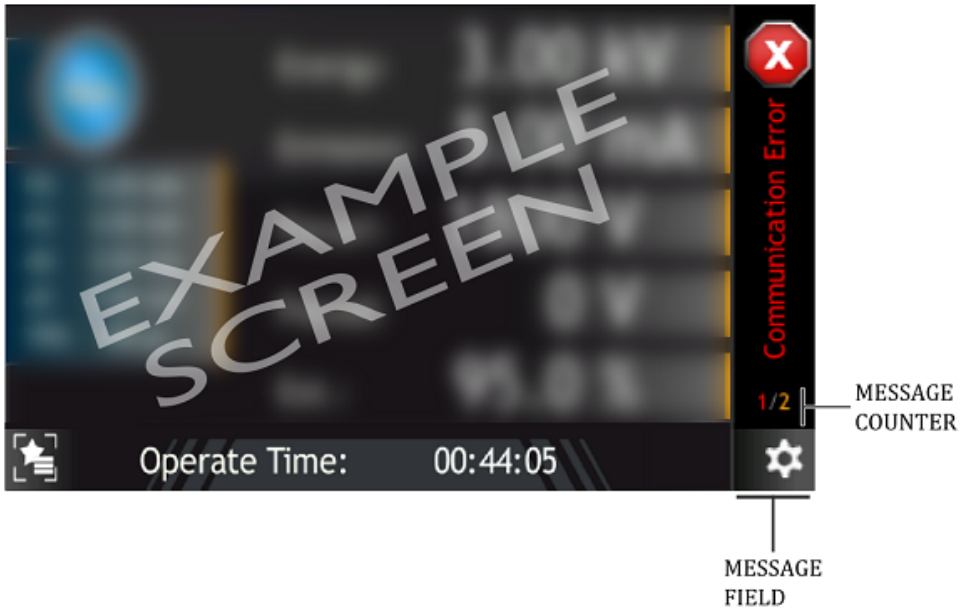


Figure 3.33: Multiple messages

3.3.10 VIDEO PLAYER

The HEAT3 can play video files. Files can be played only from the device. The full instructions on how to copy a video file onto the device is in the subsection ***Copy video file to the device***. A short guide on how to play the video is included in subsection ***Playing Video***.

3.3.10.1 PLAYING VIDEO

In order to play a video go to the main screen and press the ***Menu icon*** on the bottom right corner of the screen to display the menu bar. Then press the ***Video player*** icon on the bottom right (see Figure 3.34).

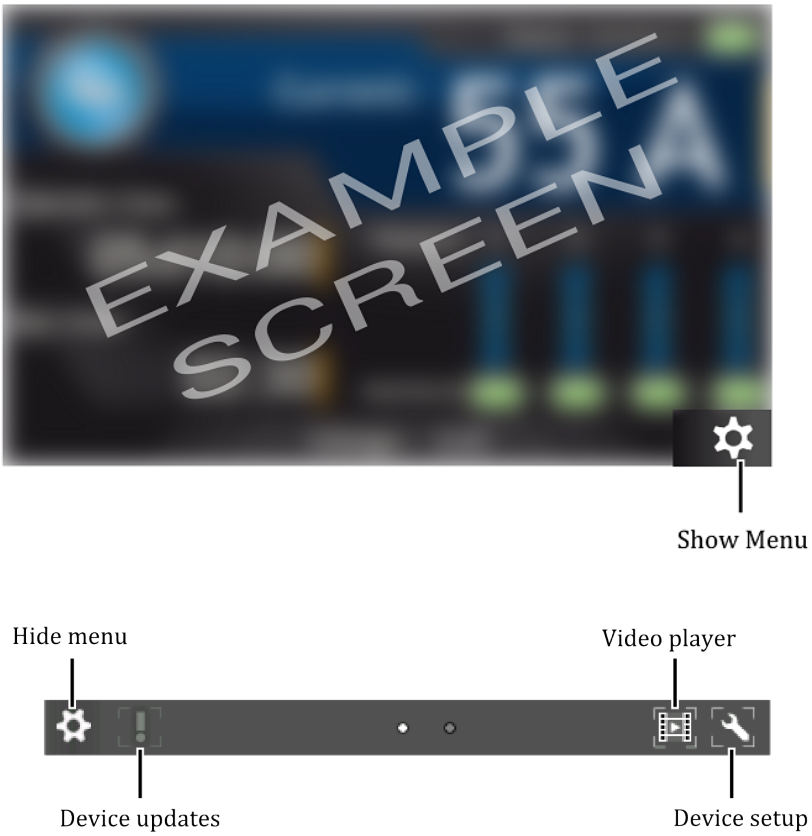


Figure 3.34: Menu bar - video player

1. Tap on the desired file to open video menu.

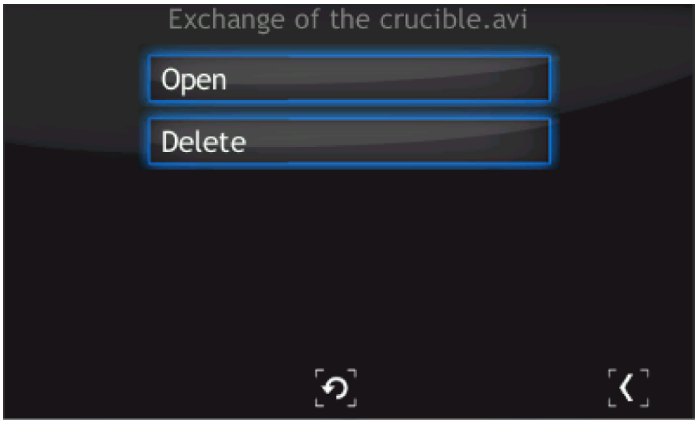


Figure 3.35: Video player - menu

2. From this menu, a video file can be played or deleted. In order to delete the file, press ***Delete*** and confirm the action by pressing ***Yes***.

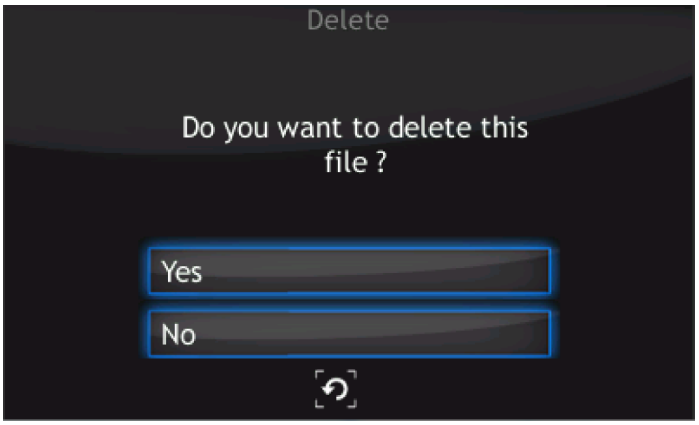


Figure 3.36: Deleting a video file

3. To open a video, press ***Open***. The video player is displayed.
4. Tap on the screen to see the video player menu.

All the video player menu items are described in the figure below:

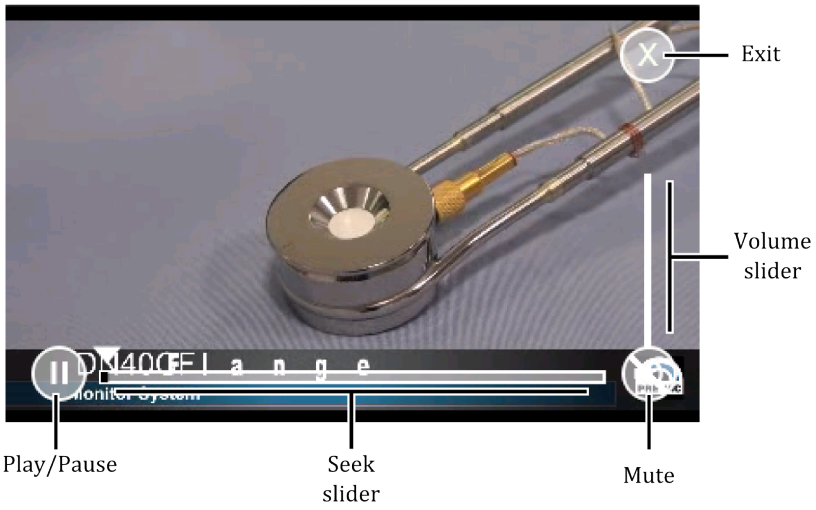


Figure 3.37: Video player

3.3.10.2 COPY VIDEO FILE TO THE DEVICE

In order to copy a video file to the device, connect a USB flash drive which contains the files. A new icon and information about detecting a new USB device will appear on the screen: ***New USB device detected***. After pressing the icon, the menu will be displayed.
Press on the ***List of videos on USB*** button to see all the videos stored on the USB drive with *.avi extension (see Figure 3.39).

1. Choose a file from the list.
2. To copy file, press ***Copy file to the device***.
3. Depending on the file size, the copy operation can take from a few seconds to several minutes. At the end of the copy operation, press the ***Return*** button.

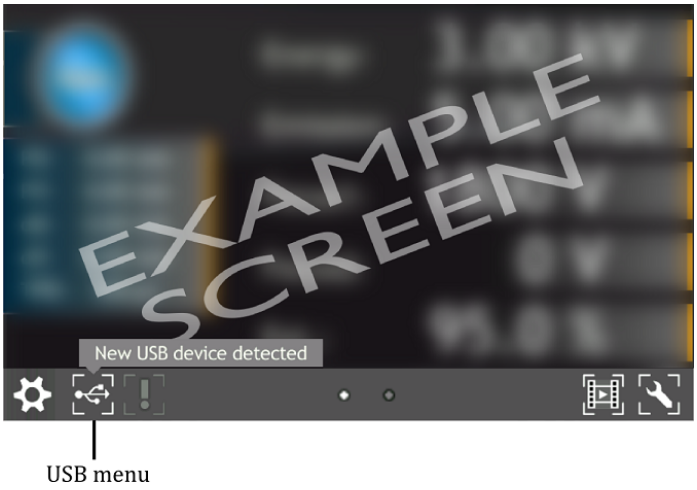


Figure 3.38: Notification about detecting USB

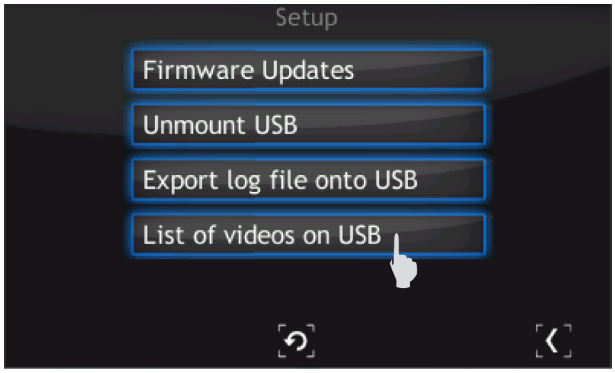


Figure 3.39: USB menu - list of videos on USB

Figure 3.40: Copy *.avi to device

3.3.11 TIMER WINDOW

An additional window contains a timer and information on the current time and date. Elapsing time is connected with the progress bar located around the Start/Stop button. The value of the timer can be set in a range from 00h:00m:01s to 23h:59m:59s. After pressing the ***Start*** button time is counted down from the set value to zero. The counting ends with an acoustic signal. When the counting ends the timer is stopped and the value of the time which has been counted is displayed.

3.3.11.1 TIMER SETTING

To set the timer carry out the following operations:

1. Press the ***timer field***.

Figure 3.41: Entering system date

2. Enter a start value of the timer using the number keys ***from 0 to 9*** and symbol ***":"*** as a separator. Confirm the value by pressing the ***Enter*** button.
3. The new value has been set and displayed in the ***timer field***. Press ***Start*** to activate the timer.
4. The timer will start counting time.

Time can also be entered in seconds. Then, the value entered is automatically converted to the ***hh:mm:ss*** format

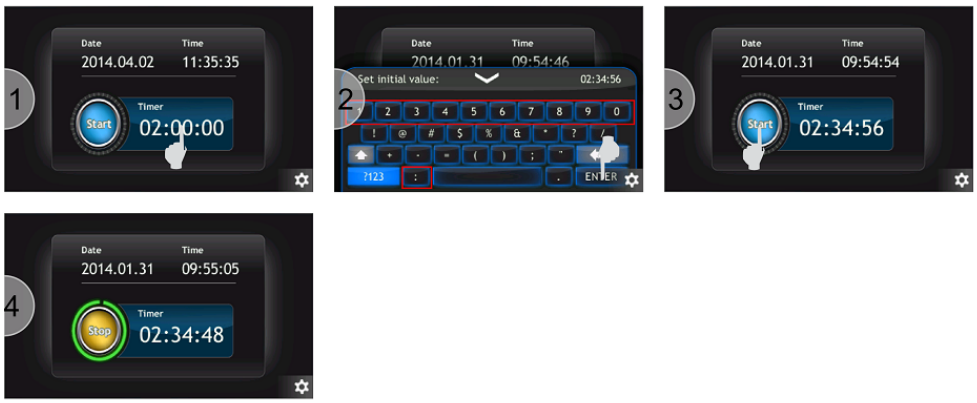


Figure 3.42: Timer setting

3.3.12 CHART WINDOW

The additional window contains a chart module. The module is used to visualise graphically the behaviour of a chosen physical quantity in time. In the further part of the manual a single physical quantity in time will be called data series.
The time axis is scaled in minutes for the time of recording of charts up to one hour. Above one hour the time axis is scaled in hours.

The charts module in some devices is available optionally at an additional charge. The user may order the device with an activated charts module or activate it later - refer to chapter 3.3.12.7

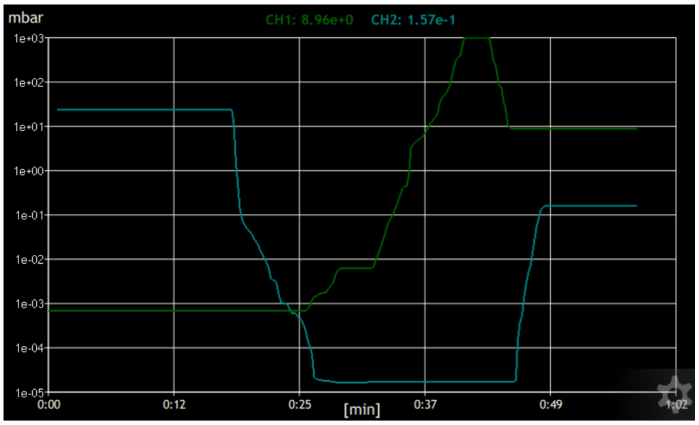


Figure 3.43: Chart module

3.3.12.1 ADDING OF DATA SERIES

To add or remove data series follow the procedure presented in fig. 3.44:

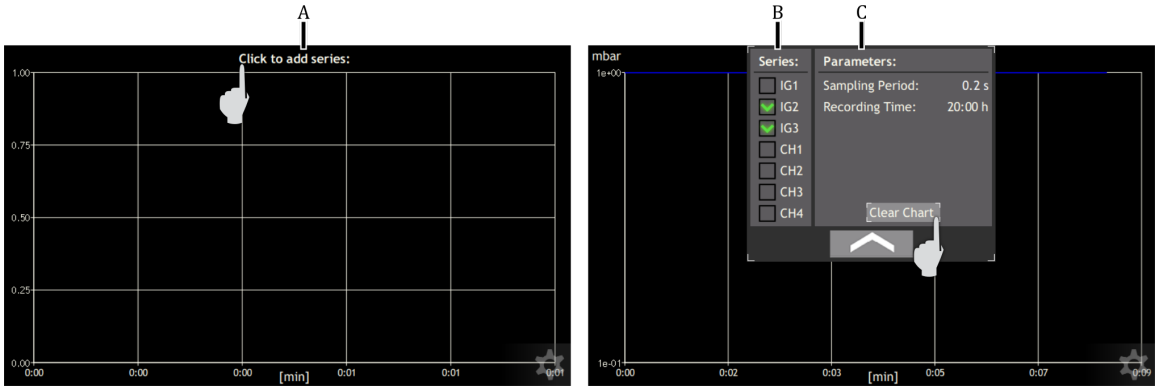


Figure 3.44: Adding data series and editing chart parameters

- **A** - Click on top field, with currently drawn data series
- **B** - Define the data series to be drawn

3.3.12.2 EDITING OF CHART PARAMETERS

To change the chart drawing parameters follow the procedure presented in fig. 3.44:

- **A** - Click on top field, with currently drawn data series
- **B** - Click on a selected parameter to be edited

Parameters that can be edited:

- **Sampling period** - the parameters determines time intervals at which another data is added to the chart. Increasing this parameter extends the maximum time of recording but simultaneously decreases precision.
- **Recording time** - the parameter determines time window during which data are recorded.

3.3.12.3 CLEARING OF CHART

To clear all to date recorded data and start recording from scratch press the ***Clear chart*** shown in fig. 3.44.
Remember that pressing the button ***Clear chart*** deletes all the data recorded so far.

3.3.12.4 VIEW OF PART OF CHART

The chart module enables viewing a selected part of the chart on full screen. For this purpose, as shown in fig. 3.45 (marker **A**), press the screen at a given place and mark the selected part to view by dragging.

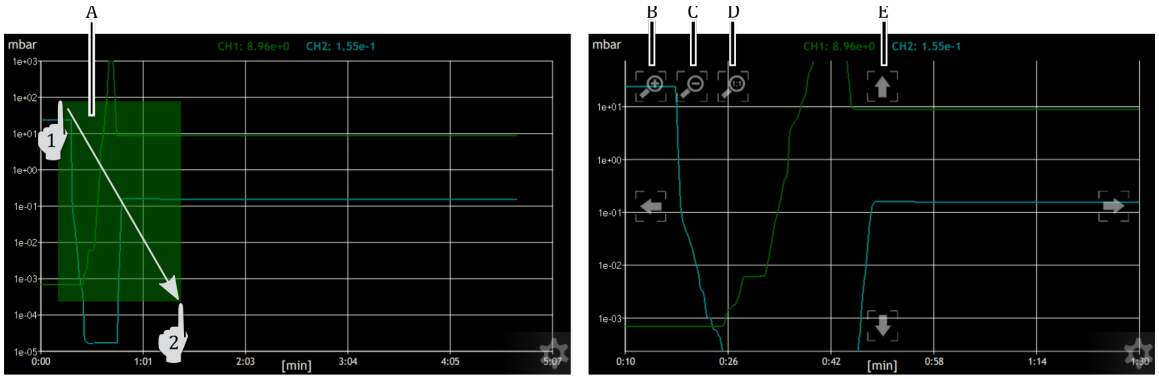


Figure 3.45: View of selected fragment of chart

After enlarging the selected fragment of the chart additional buttons will appear to perform other manipulations:

- **B** - Enlarging the current chart area
- **C** - Reducing the current chart area
- **D** - Returning to normal recording mode
- **E** - Four arrows to scroll the chart in any direction.

3.3.12.5 CHANGE OF CHART UNITS

To change the unit, in which the chart is being drawn, click on this unit and select the item on the list.

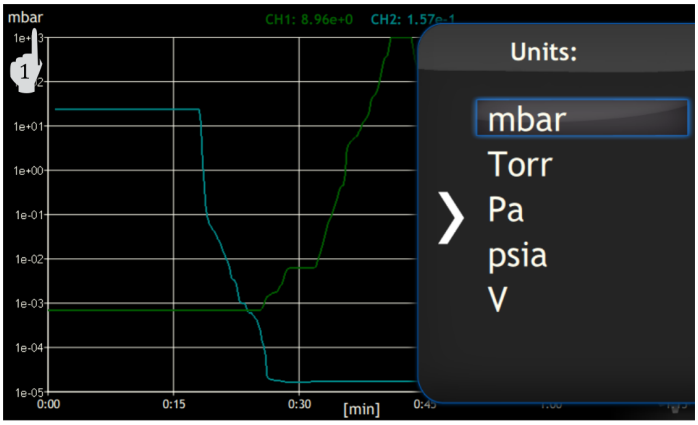


Figure 3.46: Change of chart units

3.3.12.6 SAVING CHART DATA ON USB

All the chart data can be saved on a pen drive. To save data connect a USB mass storage device . A new icon and information about detecting a new USB device will appear on the screen: ***New USB device detected***. After pressing the icon, the USB menu will be displayed.

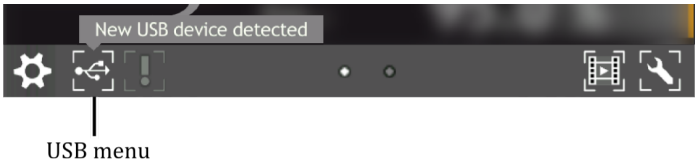


Figure 3.47: Notification about detecting USB

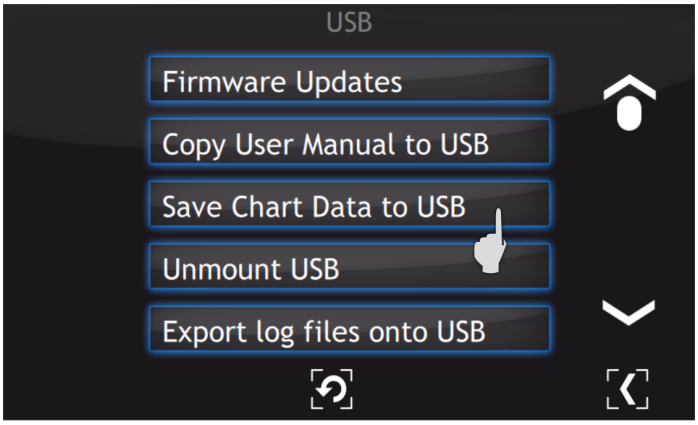


Figure 3.48: USB menu - chart data saving

In the USB menu select the position ***Save Chart Data to USB*** and wait for the message informing about completion of the saving. Before removing the memory stick, unmount it by clicking ***Unmont USB***.

The data of each session are stored in files named ChartData_ *series_name*.csv. The file contains information about the time and value of each point. The time is compatible with the system date. Example content of the data file:

Time;data[mbar]
2017-01-01 11:59:46.816;1.50e+3
2017-01-01 11:59:47.028;8.36e+2

3.3.12.7 ACTIVATION OF CHART MODULE

To activate the module:

1. Read the product and serial numbers from the ***Information*** menu
2. Read the product key from the ***Device Settings*** → ***Chart Activation***
3. Contact the sales department (+48 32 459 2130 lub sale@prevac.pl) and provide both numbers and the product key.
4. After completing the procedure a licence key will be provided, which should be entered after clicking on the ***License key*** 3.49

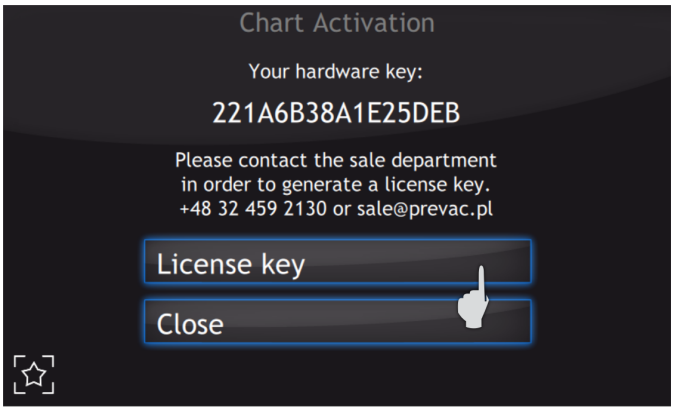


Figure 3.49: Chart activation menu

After correct completion of the activation of the chart module, the message shown below in fig. 3.50 should appear.

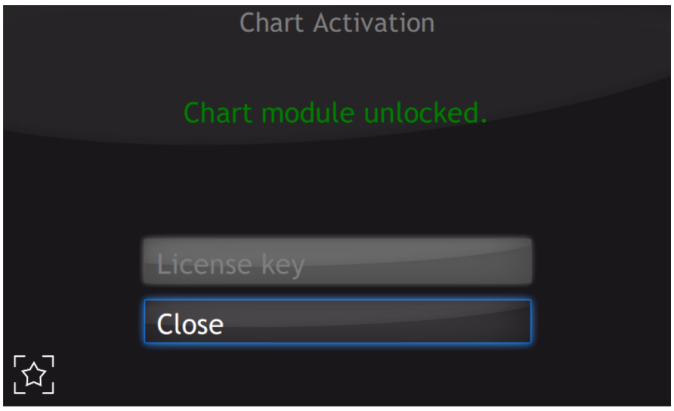


Figure 3.50: Correct activation of chart module

3.4 SETUP MENU

Allows access to the device configuration options such as PID settings, communication, etc., to store the changes, save them in accordance with instructions from the section 3.4.15.

3.4.1 SETUP TREE

- Mode
  - RES
  - EB
- Limits
  - RES Mode Limits
    - Ic limit
    - Uc limit
  - EB Mode Limits
    - Ic limit
    - Uc limit
    - Ie limit
    - Ue limit
- Ramps
  - RES Mode Ramps
    - Uc OPER
    - Uc OPER Unit
    - Uc OPER->STBY
    - Uc OPER->STBY Unit
    - Ic OPER
    - Ic OPER Unit
    - Ic OPER->STBY
    - Ic OPER->STBY Unit
  - EB Mode Ramps
    - Uc OPER
    - Uc OPER Unit
    - Uc OPER->STBY
    - Uc OPER->STBY Unit
    - Ic OPER
    - Ic OPER Unit
    - Ic OPER->STBY
    - Ic OPER->STBY Unit
    - Ue OPER
    - Ue OPER Unit
    - Ue OPER->STBY
    - Ue OPER->STBY Unit
- PID Settings
  - Parameters T Mode
    - P
    - I
    - D
    - Ramp
    - Ramp Unit
      - K/s
      - K/min

- K/h
- Parameters ΔT Mode
  - P
  - I
  - D
  - Trigger Temp
  - End Temp
- Output Signal
  - Ue
  - Uc
- Autotune
- Process Value
  - Tc1
  - Tc2
  - D1
  - D2
  - RTD
  - Ain1
  - Ain2
- Cooling Valve
  - Mode
    - Still OFF
    - Still ON
    - Auto
  - Trigger Temp
  - Linked Outputs
- Output Ramp Limit
  - Ramp
  - Ramp Unit

• Safe Settings
- Safe Setpoint
  - Enable
  - Disable
- Safe Setpoint Value
- Ramp
- Ramp Unit
- Normal Setpoint Auto Return
  - OFF
  - ON

• Operate Time
- Direction
  - COUNT UP
  - COUNT DOWN
- Time
- Seconds
- Minutes
- Hours

• Inputs Settings
- Temperature Sensors
  - Thermocouple 1, 2
    - K

- C
- E
- N
- Diode 1, 2
  - DT670
  - DT470
- RTD
  - PT100
- Analog Inputs
  - Controlled Value
    - Ic limit, Uc, Ie limit, Ue
      - None
      - Ain 1
      - Ain 2
  - Range Inputs
    - Ain 1 Min
    - Ain 1 Max
    - Ain 2 Min
    - Ain 2 Max
  - Function Voltage->Temp
    - Ain1 0V Temp
    - Ain1 10V Temp
    - Ain2 0V Temp
    - Ain2 10V Temp
- Digital Inputs
  - Assignment of Inputs
    - Interlock
      - Input 1
    - Remote Control
      - Input 2
    - Operate ON
      - Input 1 .. 4
      - None
    - Operate OFF
      - Input 1 .. 4
      - None
    - Pressure Emiss ON
      - Input 1 .. 4
      - None
    - Pressure Emiss OFF
      - Input 1 .. 4
      - None
  - Sense Control
    - Input 1
      - High Level
    - Input 2
      - High Level
    - Input 3
      - Low Level
      - High Level
      - Falling Edge

- Rising Edge
- Input 4
- Low Level
- High Level
- Falling Edge
- Rising Edge

• Outputs Settings
- Relay Outputs
- Out 1, 2, 3, 4, 5, 6
- Setpoint
- Pressure Setpoint
- Operate
- Shutter
- Cooling Valve
- High Voltage
- Still OFF
- Still ON
- None
- Analog Outputs
- Out 1, 2
- Source
- Process Value
- PID Out
- Ic actual
- Uc actual
- Ie actual
- Ue actual
- Tc1 Temp
- Tc2 Temp
- D1 Temp
- D2 Temp
- RTD Temp
- Pressure
- None
- Mode
- User Range
- 1 to 1
- EXPO
- Ranges
- Min Process Value
- Max Process Value
- Min Ic actual
- Max Ic actual
- Min Uc actual
- Max Uc actual
- Min Ie actual
- Max Ie actual
- Min Ue actual
- Max Ue actual
- Min Tc1 Temp
- Max Tc1 Temp

- Min Tc2 Temp
- Max Tc2 Temp
- Min D1 Temp
- Max D1 Temp
- Min D2 Temp
- Max D2 Temp
- Min RTD Temp
- Max RTD Temp
- Min Pressure
- Max Pressure
- Scale
  - Linear
  - Logarithmic
- Min Voltage
- Max Voltage

• Pressure Channel
- Setpoints
  - Setpoint Low
  - Setpoint High
- Unit
  - mbar
  - Torr
  - Pa
  - psia
- Gauge
  - CTR90
    - range
  - TTR91
  - TTR211
  - PTR225
  - PKR251/360/361
  - PCR280/TPR28x
  - PTR90
  - ITR90
  - ITR100
  - Baratron
    - range
  - ANALOG IN
  - MKS 937A
  - PG105
  - MG13/14
  - ATMION
  - IKR360/361
- Gas Type
  - Air
  - He
  - Ne
  - Ar
  - Kr
  - Xe
  - H2

- CO
- Define
- Filter
- Low
- Medium
- High
- Degas
- Time
- Degas

• Vacuum Interlock
• Advanced Options
- External EB Power Supply
- Parameters of the external PS
- Nominal Voltage (Ue)
- Nominal Current (Ie)
- Aout1 (Max. Ue Set)
- Aout2 (Max. Ie Set)
- Ain1 (Max. Ue Read)
- Ain2 (Max. Ie Read)

• Work Time
- Work Time
- Reset

• Device Settings
- Communication
- Protocol
- Modbus
- Prevac V2.1
- Interface
- Ethernet
- RS232
- RS485
- RS232/485/USB
- Bluetooth
- Ethernet/IP
- Parameters
- Baud Rate
- IP
- Mask
- Gateway
- DHCP
- Enable
- Disable
- TCP server
- TCP server port
- Host Address
- Remote Enable
- Address
- Logical Group
- Display
- Brightness
- Touch screen autolock

- Customer Name
- Show
- Hide
- Caption
- System Date
- Date
- Time
- Language
- Chart Activation

• Save/Load
- Autosave
- Save
- Load
- Load Default

• Information
• Logs
• Reboot

3.4.2 SELECTING THE TYPE OF LOAD

The current chosen method of heating can be observed in the upper right corner of the main window. Selection of the heating method is performed in the setup menu. Below is an example of switching from resistive heating mode to electron bombardment heating mode:

1. Go to: ***Setup Menu*** -> ***Mode***
2. Tap **EB**
3. Heating mode will change into **EB**
4. Leave setup
5. Heating mode change is visible on the main screen in the upper right corner

3.4.3 SELECTING THE TYPE OF TEMPERATURE MEASUREMENT

The temperature measurement module is capable of measuring temperature using various types of thermocouples, diodes and resistance thermometers. This section describes the steps that should be followed in order to change the type of temperature sensor and corresponding PID process value.

3.4.3.1 SELECTING THERMOCOUPLE

The HEAT3 is able to measure temperature via two thermocouple inputs simultaneously. The user can choose between three thermocouple types. The thermocouple type can be selected/changed for each channel as follows:

1. Go to: ***Setup Menu*** -> ***Input Settings*** -> ***Temperature Sensors***
2. Tap desired thermocouple channel
3. Tap desired type of thermocouple
4. Thermocouple type on the selected channel will change
5. Selected thermocouple type will appear in the **Temperature Sensors** menu

3.4.3.2 SELECTING DIODE

Two channels are available for temperature measurement using diode sensors. The type of diode for each channel can be selected/changed as follows:

1. Go to: ***Setup Menu*** -> ***Input Settings*** -> ***Temperature Sensors***
2. Tap desired diode channel
3. Tap desired type of diode
4. Diode type on the selected channel will change
5. Selected diode type will appear in the **Temperature Sensors** menu

3.4.3.3 SELECTING RTD

Two channels are available for temperature measurement using resistance thermometers. The type of resistance thermometer for each channel can be selected/changed as follows:

1. Go to: ***Setup Menu*** -> ***Input Settings*** -> ***Temperature Sensors***
2. Tap **RTD**

3.4.3.4 CONTROLLED CHANNEL SELECTION

Each of the sensors connected to Temperature Measurement Module can be used as PID Regulator process value. The process value is simply an input signal for the PID Regulator. To assign a sensor as a process variable, the following steps should be taken:

1. Go to: ***Setup Menu*** -> ***PID Settings*** -> ***Process Value***
2. Choose desired Process Value from available sensors
3. Selected sensor will be assigned as **Process Value**
4. Selected sensor type will appear in the **PID Settings** menu, tap **Setup Exit** button
5. In the right upper corner of screen, information concerning the selected sensors for process value is displayed

3.4.4 RESISTIVE HEATING

The following subsection describes how to select and configure the resistive type of heating, and describes the set limits and ramp values for each parameter.

Depending on the installed type of DC module (voltage type or current type), Heat3 device allows the User to control the value of the cathode current I_c (DC current module) or cathode voltage U_c (DC Voltage Module).

3.4.4.1 SELECTING RESISTANCE HEATING MODE

1. Go to: ***Setup Menu*** -> ***Mode***
2. Tap **RES**
3. RES heating mode will be assigned
4. RES heating mode will appear in the **Setup menu**
5. RES heating mode will appear in the **Main window** in the upper right corner of the screen

3.4.4.2 PID REGULATION

There are two methods of regulating in RES mode; manual and AUTO. In AUTO Regulation mode, the cathode voltage is controlled by the PID Controller. The AUTO Regulation method is selected as follows:

1. Tap **Regulation Method** button to display the **Regulation menu**
2. Tap **AUTO** button
3. Resistive heating will now be regulated by the PID Controller

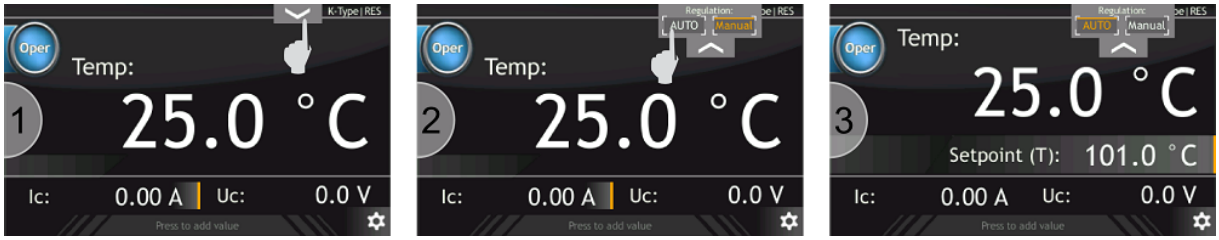


Figure 3.51: Setting PID Regulation for resistive heating

3.4.4.3 MANUAL REGULATION

In Manual Regulation mode, the cathode current is under user control. The manual regulation method is chosen as follows:

1. Tap **Regulation Method** button to display the Regulation menu
2. Tap **Manual** button
3. Resistive heating will now be regulated by the user

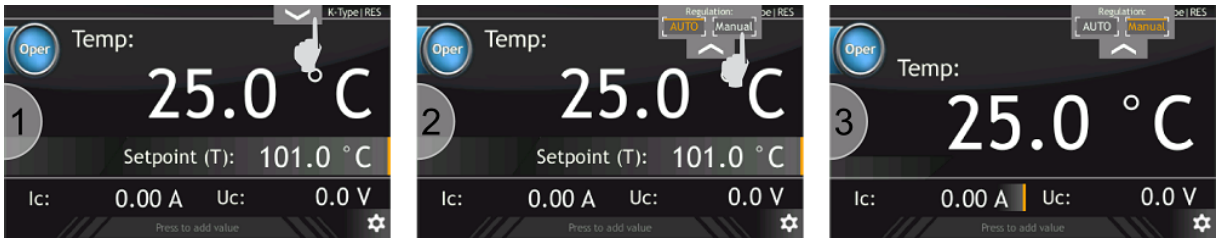


Figure 3.52: Setting manual regulation for resistive heating

3.4.4.4 SETTING RAMPS

Ramp levels can be set in a number of ways:

1. I_C Operate – ramp for cathode current during operation. This parameter accepts the following units:
   - A/s
   - A/min

- A/h

2. I_C Operate->Standby – ramp for cathode current while changing operating state to standby. This parameter accepts the following units:
   - A/s
   - A/min
   - A/h
3. U_C Operate – ramp for cathode Voltage during operation. This parameter accepts the following units:
   - V/s
   - V/min
   - V/h
4. U_C Operate->Standby – ramp for cathode Voltage while changing operating state to standby. This parameter accepts the following units:
   - V/s
   - V/min
   - V/h

In order to determine the slope of the ramp for the selected parameters for resistive heating:

1. Go to: ***Setup Menu*** -> ***Ramps*** -> ***RES Mode Ramps***
2. Select desired ramp to change and tap it
3. Tap **Numeric keyboard button**
4. Enter value
5. Tap **Enter** button in order to confirm new ramp value
6. Select desired ramp unit to change and tap it
7. Select one of the available units and tap it
8. New ramp unit will be applied
9. Newly selected ramp unit will appear on the **RES Mode Ramps** menu

3.4.4.5 SETTING LIMITS

Additional control of resistive heating can be accomplished by changing the limits of the cathode current and voltage supplies. These limits are valid for both manual and PID Controller regulation in Resistive Heating mode. Limits also affect the scaling values read via analog inputs, for example:

- U_C Limit is set to 10V
- Analog input is set as UC
- Analog input range is between 0V and 10V
- 0V on analog input will be equivalent to 0V of cathode voltage

- 10V on analog input will be equivalent to 10V of cathode voltage
- voltage scaling is described by the following formula:

$$U_C = \frac{A_{IN}}{A_{INMax}} U_{CLimit}$$

U_C - cathode voltage
A_{IN} – analog input voltage
A_{INMax} – maximum voltage level for analog input which is 10V
U_{CLimit} – limit for cathode voltage
The following example shows how to set limit for the cathode voltage of 20.60 V, this value will then never be exceeded for manual and PID regulation.

1. Go to: ***Setup Menu*** -> ***Limits*** -> ***RES Mode Limits***
2. Tap U_C **Limit**
3. Tap **Numeric Keyboard**
4. Enter desired limit
5. New value is set

3.4.5 ELECTRON BOMBARDMENT HEATING

The following subsection describes how to select and configure the Electron Bombardment type of heating, and describes the set limits and ramp values for each parameter.
Depending on the installed type of DC module (voltage type or current type), Heat3 device allows the User to control the value of the cathode current I_c (DC current module) or cathode voltage U_c (DC Voltage Module).

3.4.5.1 SELECTING ELECTRON BOMBARDMENT MODE

1. Go to: ***Setup Menu*** -> ***Mode***
2. Tap **EB**
3. EB heating mode will be assigned
4. EB heating mode will appear in the **Setup menu**
5. EB heating mode will appear in the **Main window** in the upper right corner of the screen

3.4.5.2 PID REGULATION

There are two methods of regulating in EB mode; manual and AUTO. In AUTO Regulation mode, the cathode emission voltage is controlled by the PID Controller whilst cathode current is under user control. The AUTO Regulation method is selected as follows:

1. Tap **Regulation Method** button to draw forth Regulation menu
2. Tap **AUTO** button
3. Electron bombardment heating is now regulated by the PID Controller

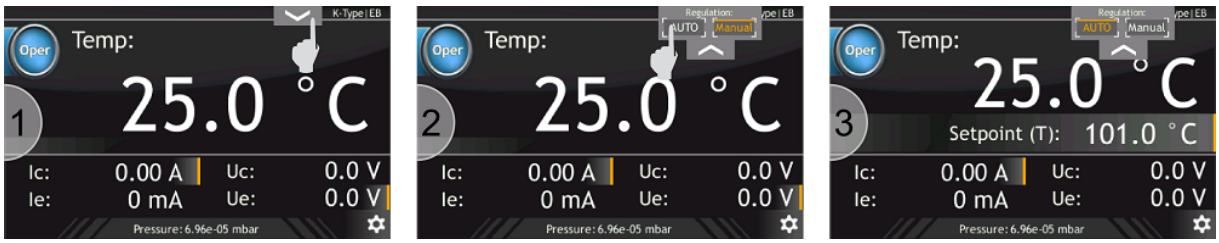


Figure 3.53: Setting AUTO Regulation for electron bombardment

3.4.5.3 MANUAL REGULATION

In Manual Regulation mode, the cathode current and emission voltages are under user control. The manual regulation method is chosen as follows:

1. Tap Regulation Method button to draw forth Regulation menu
2. Tap Manual button
3. Electron bombardment heating will now be regulated by the user

Figure 3.54: Setting manual regulation for electron bombardment

3.4.5.4 SETTING RAMPS

Ramp levels can be set for:

1. I_C Operate – ramp for cathode current during operation. This parameter accepts the following units:
   - A/s
   - A/min
   - A/h
2. I_C Operate->Standby – ramp for cathode current while changing operating state to standby. This parameter accepts the following types of units:
   - A/s
   - A/min
   - A/h
3. U_E Operate – ramp for emission voltage while operating. This parameter accepts the following types of units:
   - V/s

- V/min
- V/h

4. U_E Operate->Standby – ramp for emission voltage while changing operating state to standby. This parameter accepts the following units:
   - V/s
   - V/min
   - V/h
5. U_C Operate – ramp for cathode Voltage during operation. This parameter accepts the following units:
   - V/s
   - V/min
   - V/h
6. U_C Operate->Standby – ramp for cathode Voltage while changing operating state to standby. This parameter accepts the following units:
   - V/s
   - V/min
   - V/h

In order to determine the slope of the ramp for the selected parameters for Electron Bombardment heating:

1. Go to: ***Setup Menu*** -> ***Ramps*** -> ***EB Mode Ramps***
2. Select desired ramp to change and tap it
3. Tap **Numeric keyboard** button
4. Enter value
5. Tap **Enter** button in order to confirm new ramp value
6. Select desired ramp unit to change and tap it
7. Select one of the available units and tap it
8. New ramp unit will be selected
9. Newly selected ramp unit will appear on the **EB Mode Ramps** menu

3.4.5.5 SETTING LIMITS

Additional control of Electron Bombardment heating can be accomplished by changing the limits of:

- Cathode current and voltage
- Emission current and voltage

These limits are valid for both manual and PID Controller regulation in Electron Bombardment Heating mode. Limits also affect the scaling values read via analog inputs, for example:

- Cathode voltage limit U_C Limit is set to 10V
- Analog input is set as U_C
- Analog input range is between 0V and 10V
- 0V on analog input will be equivalent to 0V of cathode voltage
- 10V on analog input will be equivalent to 10V of cathode voltage
- voltage scaling can be described by the following formula:

$$U_C = \frac{A_{IN}}{A_{INMax}} U_{CLimit}$$

U_C - cathode voltage A_{IN} – analog input voltage A_{INMax} – maximum voltage level for analog input which is 10V U_{CLimit} – limit for cathode voltage
The following example shows how to set limit for the emission voltage of 500V, this value will then never be exceeded for manual and PID regulation.

1. Go to: ***Setup Menu*** -> ***Limits*** -> ***EB Mode limits***
2. Tap U_E Limit
3. Tap **Numeric Keyboard**
4. **Numeric Keyboard** will pop up
5. Enter 500V and tap **Enter** button in order to confirm new value
6. New value of U_E **Limit** will appear

3.4.6 PID CONTROLLER

Closed loop PID control, often called feedback control, is the control mode most often associated with temperature controllers. In this mode, the controller attempts to keep the load at exactly the user entered setpoint, which can be either temperature or voltage. To do this, it uses feedback from the control sensor to calculate and actively adjust the control (heater) output. The control algorithm used is termed PID.

3.4.6.1 THEORY OF OPERATIONS

The PID control equation has three variable terms: proportional (P), integral (I), and derivative (D)
The PID equation is:

$$PIDOutput = K \cdot e + I \int (e)dt + D\frac{dPV}{dt}$$

where the error (e) is defined as:
e = Setpoint – Process Value (PV)
PIDOutput varies over the range [0-100%]. This value is converted to: cathode voltage (U_C), emission voltage(U_E) or analog signal, depending on the working mode and the power supply configuration.
In MODE RES the PIDOutput controls cathode voltage (U_C). The Uc value is calculate by the following equation:

$$U_c = PIDOutput\frac{UClimit}{100}$$

In MODE EB the PIDOutput controls emission voltage (U_e). The Ue value is calculate by the following equation:

$$U_c = PIDOutput\frac{UElimit}{100}$$

If the PIDOutput is converted to an analog signal, then the output voltage is calculated by following equation:

$$AnalogOut(x) = PIDOutput[\%]\frac{100\%Voltage - 0\%Voltage}{100\%} + 0\%Voltage$$

The PIDOutput value is available in the additional information bar on the heating panel.
To configure the additional information bar to display the PID Output value:

1. From heating panel, tap additional information bar
2. Select PID Output from the subsequent available display information
3. Switch power supply to Operate mode
4. The actual PID Output value is displayed.

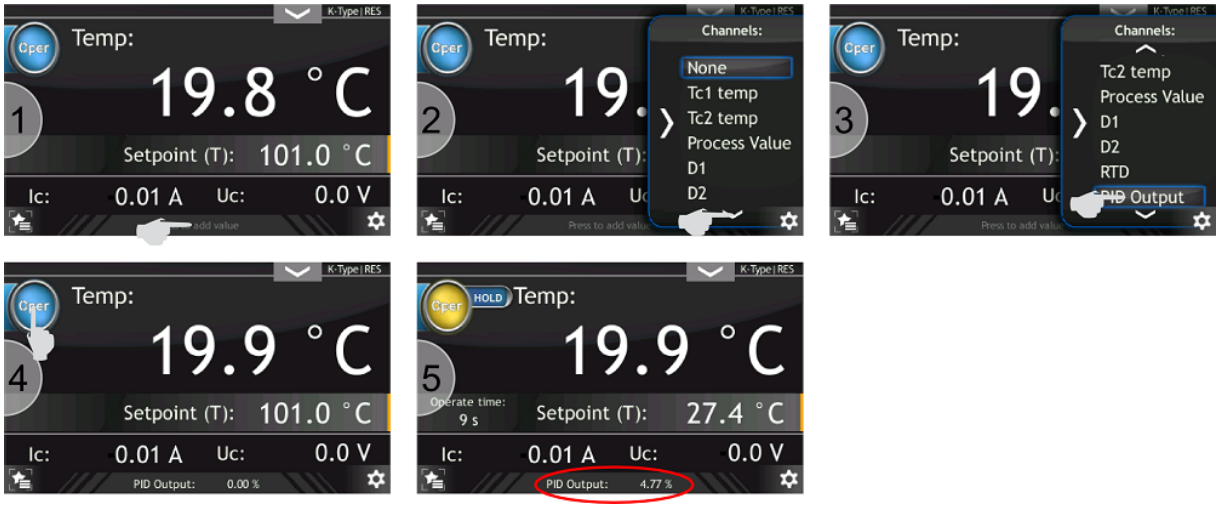


Figure 3.55: PIDOut configuration

3.4.6.2 Proportional band (PB)

The bandwidth over which the output power is proportioned between 0 – 100%. The relationship between proportional band and gain is described as:

$$K = \frac{100}{PB}$$

This means that a large proportional band corresponds to a small gain. A relatively small proportional band therefore corresponds to a large gain (K).
The gain(K), must have a value greater than zero. The value of the gain is multiplied by the error (e) which is defined as the difference between the setpoint and feedback temperatures, to define the proportional contribution to the output: Output (P) = Ke. If the proportional term is acting alone, with no integral, then there must always be an error value or the output will go to zero. Detailed information about the load, sensor, and controller is used to compute a gain setting (K). Most often, the gain setting is simply determined by trial and error. The gain setting is part of the overall control loop gain, as well as the heater range and object environment (e.g. cooling power). The gain setting will need to be changed if either of these conditions change.

3.4.6.3 Integral (I)

In the control loop, the integral term, also called reset, monitors the error over time in order to generate the integral contribution to the output:

$$Output(I) = I \int (e) dt$$

By adding the integral to the proportional contribution, the error that is necessary in a proportional-only system can be eliminated. When the error is at zero, controlling at the setpoint, the output is held constant by the integral contribution. The integral setting (I) is more predictable than the proportional setting. It is related to the dominant time constant of the load. Measuring this time constant allows a reasonable calculation of the integral setting.

3.4.6.4 Derivative (D)

The derivative term, also called rate, acts on the change in error with time:

$$Output(D) = D \frac{dPV}{dt}$$

By reacting to a fast changing error signal, the derivative can work to boost the output when the setpoint changes quickly, reducing the time it takes for temperature to reach the setpoint.

It can also see the error decreasing rapidly when the temperature nears the setpoint and reduce the output for less overshoot.

The derivative term can be useful in fast changing systems, but it is often turned off during steady state control because it reacts too strongly to small disturbances or noise. The derivative setting (D) is related to the dominant time constant of the load.

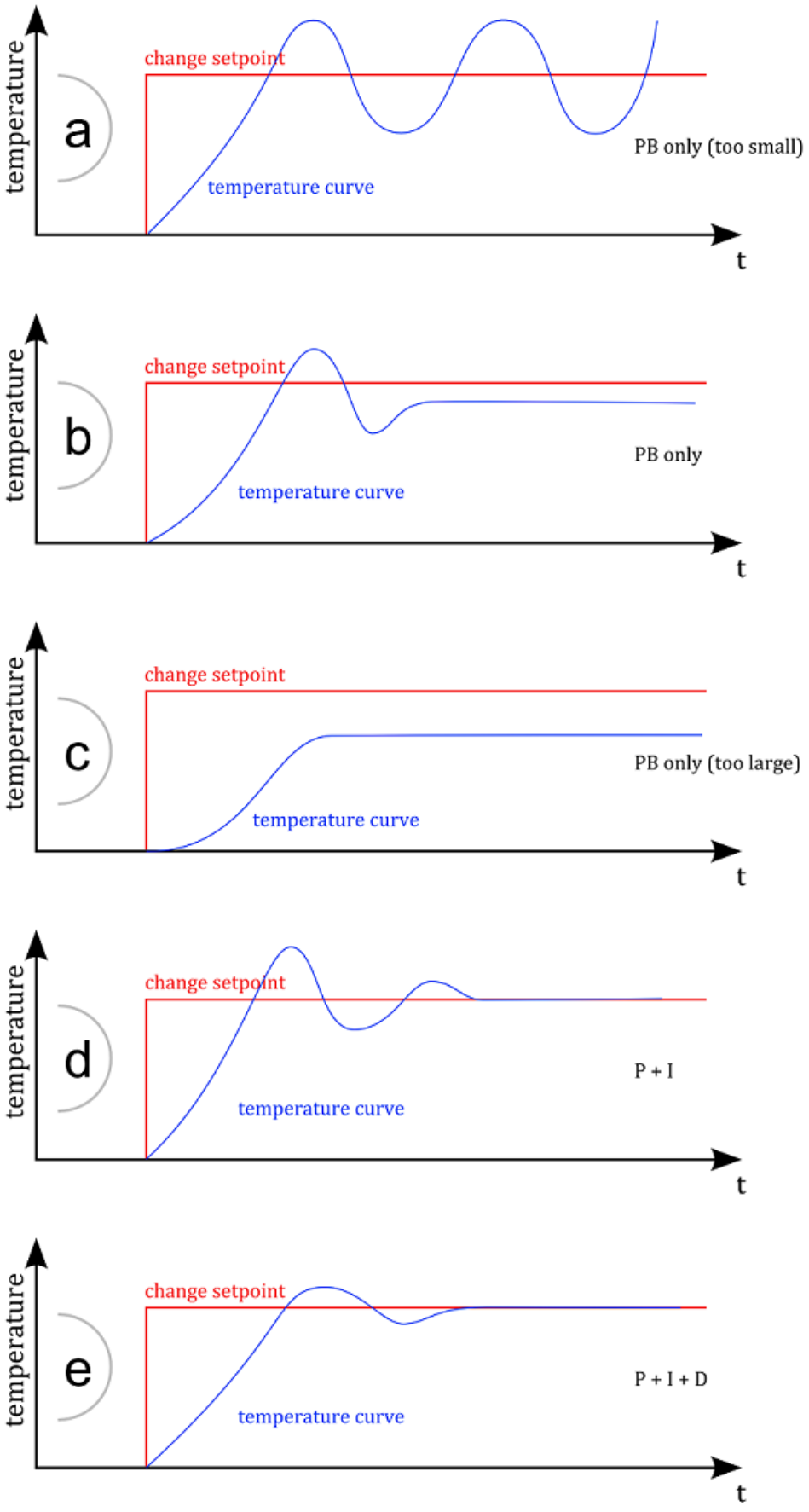


Figure 3.56: Examples of PID control.

3.4.6.5 TEMPERATURE CONTROL

The HEAT3-PS has a control setting that is not a normal part of a PID control loop. Manual Output can be used for open loop control, meaning feedback is ignored and the heater output stays at the user's manual setting. This is a useful way to apply constant heating power to a load when needed. The Manual Output term can also be added to the PID output. Some users prefer to set a power near that necessary to control.
The Built-in PID controller device has a flexible configuration (see PID block Diagram). The user can define one of the 7 input signals (TC1, TC2, D1, D2, RTD, Analog Input 1, Analog Input 2) and redirection output to one of the 4 outputs (HV module, DC module, Analog Out 1, Analog Out 2).

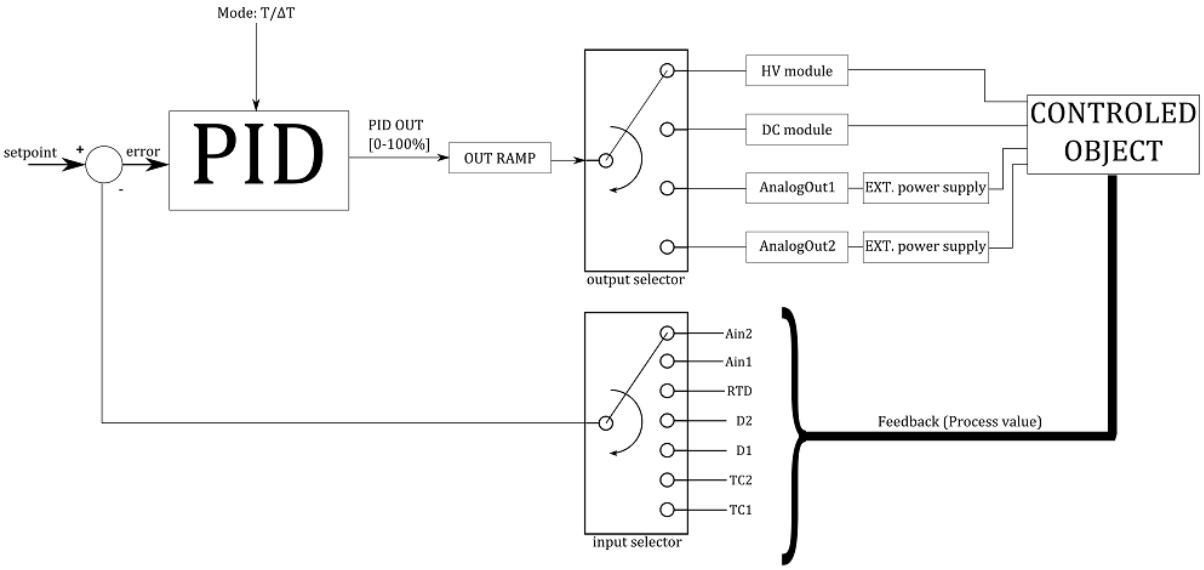


Figure 3.57: PID Block diagram.

The HEAT3 has the ability to work under two modes of process variable control:

- T mode - Classical PID temperature regulator
- ΔT mode - stabilizing derivative of object temperature $SP = \frac{dT}{dt}$

3.4.6.6 T MODE PARAMETERS

- **P** - Proportional Band adjustable from 0.1 to 1000.0.
- **I** - Integral Time adjustable from 1 to 1000 s, or turned off,
- **D** - Derivative Time adjustable from 1 to 1000 s, or turned off,
- **Ramp** - speed of set point ramp rate, or rise speed. Parameter can be changed within the range of 0.1 to 1000.0
- **Ramp Unit** – The temperature increment in a given time. Temperature increment can be set in second[s], minutes[min] or hour[h].

3.4.6.7 ΔT MODE PARAMETERS

- **P** - Proportional Band adjustable from 0.1 to 1000.0.
- **I** - Integral Time adjustable from 1 to 1000 s, or turned off,
- **D** - Derivative Time adjustable from 1 to 1000 s, or turned off,
- **Trigger Temp** – defines switching temperature at which switch from ΔT mode to T mode occurs.
- **End Temp** – defines final temperature (setpoint), after crossing the threshold temperature (Trigger Temperature) and switching to T mode.

Output signal
For EB MODE allows specify witch a physical quantity: the voltage current or the emission voltage will be controlled by a PID controller.

$\mathbf{U}_E$ - emission voltage is controlled by a PID regulator, cathode voltage is adjusted manually.

$\mathbf{U}_C$ - cathode voltage is controlled by a PID regulator, the emission voltage is controlled manually.
OUTPUT SIGNAL can be changed when the PID controller is in HOLD state.

For the operating in EB MODE when the cathode voltage is controlled by PID, should be chosen appropriate emission voltage Ue. The best results in dT MODE is obtained for the lowest Ue voltage, which allows achieve the target temperature.

For example, for the stabilization of the ramp temperature at 1K/s from the 300 °C to 1000°C, known that the temperature of 1000°C can be achieved with a voltage U_E = 530 V. Should therefore set the voltage U_E = 550 V. Setting the voltage much higher than required for a particular process, can cause oscillations in dT MODE.

Figure 3.58: Select output signal.

Autotune
The HEAT3-PS can automate the tuning process of typical vacuum system with the Autotune feature. To initiate autotune process tap the ***Autotune*** bar. When the Autotune process is run, the "Autotuning" message appears during changes to the actual temperature.
Autotune functions must run in PID mode and OPERATE state, after reaching a sample temperature that does not vary by more than ± 10% of the set point. Autotune is available only in PID T mode. After completion of the autotune process , the PID parameters are modified accordingly, and the power supply returns to normal operation in operate state. To abort the process before the end of the autotune process, the user should select ***Autotune off*** option from the ***PID Settings*** submenu.
Process Value – Input signal for the PID controller. It is an actual value in the control loop. The selected value is displayed on the heating panel.
Available input signals:

- Thermocouples (TC1, TC2),
- Diode (D1, D2),
- Resistance thermometer detectors (RTD),
  For detailed information refer to: Temperature module
- External analog signals (AIN1, AIN2),
  For detailed information refer to: Analog input configuration

3.4.6.8 COOLING VALVE

The Cooling valve option can control the cooling medium inflow if the vacuum system is properly configured for this. This option allows control of an external cooling valve, depending on the set-point temperature. For correct operation, this function requires correct configuration of the relay output for the attached valve.
MODE – working mode of cooling valve

- Still OFF – the assigned relay output is always OFF independent of setpoint temperature
- Still ON – the assigned relay output is always ON independent of setpoint temperature
- Auto – control of the assigned relay output depends on the setpoint temperature and preset threshold temperature.
- Trigger temp. – threshold temperature for on/off cooling valve.
- Linked Outputs - if any output relay is assigned to drive the cooling valve then the number value will be displayed. If no relays output is assigned to drive a cooling valve the message “none” is displayed.

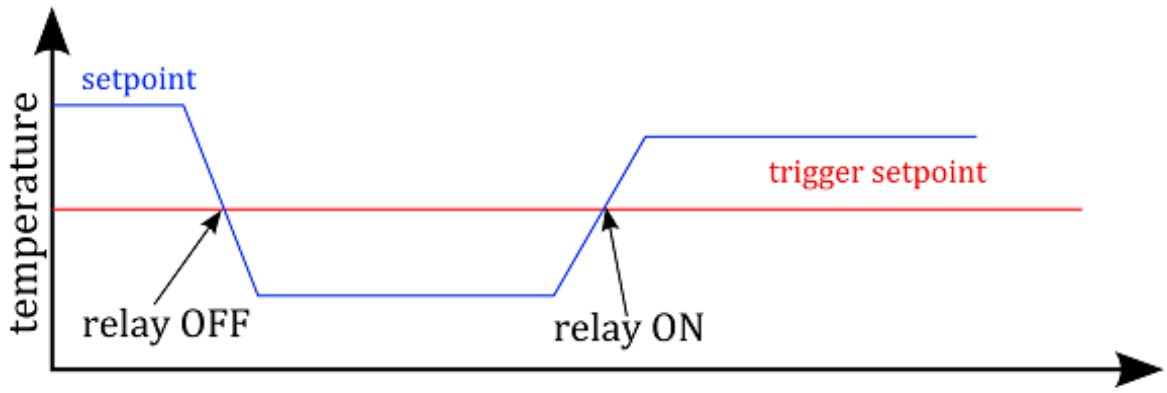


Figure 3.59: Relay driving relating set point value.

Output Ramp Limit Parameters supplied to the object to prevent too much power in a short time, and so prevent damage to the controlled object.
This option is available when the PID Output is assigned to Analog Out1 or Analog Out2.
For detailed information refer to: *Analog output configuration.*
Ramp - defines the rate of change of the output voltage. Is expressed in PIDOut[%]/[time unit].
Ramp Unit – defines time unit for Output Ramp Limit – seconds[s], minutes[min], hours[h].
Example: The output cannot change more than 10 % per minute.

Adjust: RAMP = 10
Set: RAMP UNIT = %/min

Example: The process temperature cannot change more than 5% per second.
Adjust: RAMP = 5
Set: RAMP UNIT = %/s

3.4.6.9 RAMP CONTROL

The HEAT3 generates a smooth setpoint ramp. The purpose of the Ramp rate function is to control the rate at which the process temperature can change. This feature would be used when rapid temperature changes could otherwise damage the product being controlled. The user can set a ramp rate in degrees per second[s]/minutes[min]/hours[h] with a range of 0 to 1000 and a resolution of 0.1. Once the ramp feature is turned on, its action is initiated by a setpoint change and switching from standby to operate. When a new setpoint is entered, the power supply changes the setpoint temperature from the old value to the new value at the ramp rate. When the Operate button is tapped, the actual process value is assigned to setpoint and changes to destination setpoint. A positive ramp rate is always entered and it is used by the instrument for ramping up and down.

Example: The process temperature cannot change more than 5 degrees per minute.
Adjust: RAMP = 5
Set: RAMP UNIT = K/min

Example: The process temperature cannot change more than 60 degrees per hour.
Adjust: RAMP = 60
Set: RAMP UNIT = K/h

NOTE: The ramp rate is not functional if RAMP is set to zero.

If RAMP function is enabled the actual setpoint value is displayed on the heating panel. After switching to OPERATE mode, the actual measurement temperature is assigned to the actual setpoint value. The setpoint actual value then changes according to the RAMP settings until the setpoint is reached.

Depending on the case, the actual setpoint value is increased or decreased.

If the capture temperature is greater than setpoint then the actual setpoint is decreased.

If the capture temperature is less than setpoint then the actual setpoint is increased.

The RAMP function can be paused at any time by tapping the *Hold* button. The actual setpoint change is stopped and the controller will stabilize at the last setpoint. When the *Hold* button is tapped again, the setpoint changes and RAMP function are resumed.

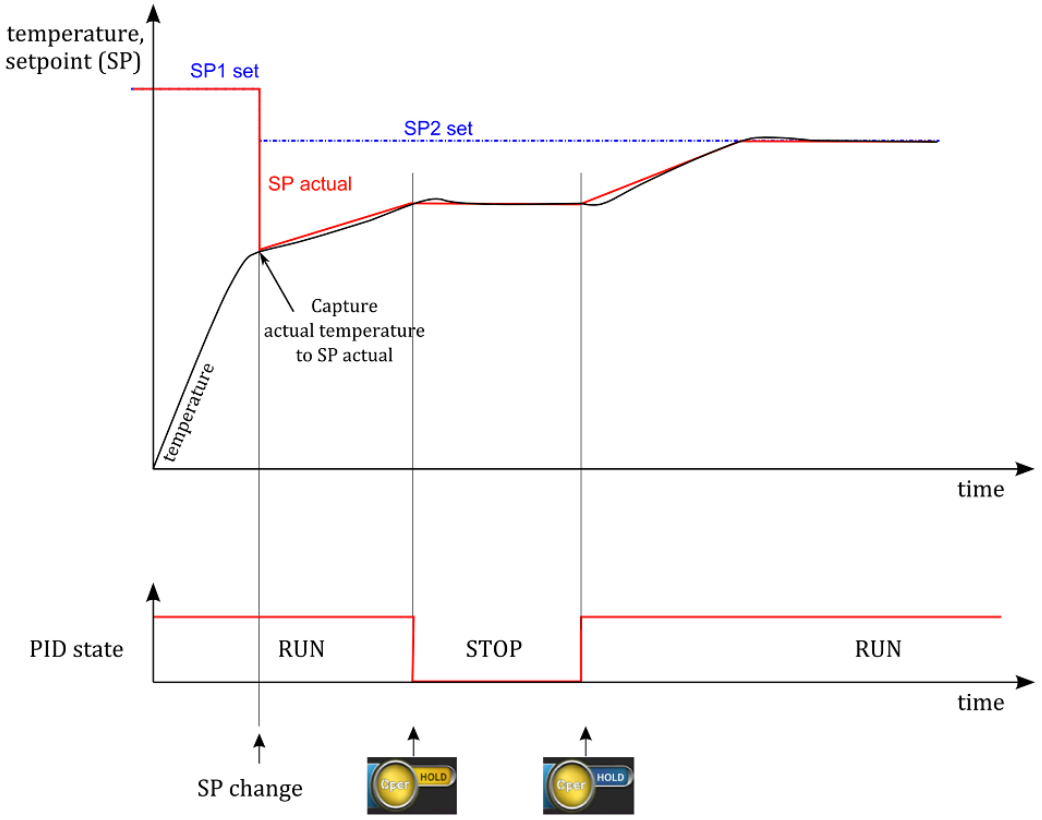


Figure 3.60: Timing in T mode with RAMP.

3.4.6.10 dT MODE PID CONTROL

dT mode allows for very precise control of temperature ramp . The user can set a ramp rate in degrees per second over the range -5 to 5 and with a resolution of 0.1.

To enable dT mode PID control, tap the ***Setpoint (T)*** on the main screen and select Working mode ***Setpoint(ΔT)*** from the list. Enabling dT mode switches the PID controller to the HOLD state with stabilization of temperature at the last set point. Ramp stabilization begins when the HOLD button is tapped and then the regulator proceeds to the RUN state. Tapping the HOLD button whilst operating in ΔT mode results in the PID controller switching to the HOLD state with stabilization of temperature at the last measurement temperature. Tapping HOLD again resumes working in ΔT mode.

Operation in ΔT mode continues until the *Trigger Temperature* is reached, at which point the regulator switches to T mode and stabilizes at the *End Temperature*.

There is complete flexibility in determining the value of Trigger Temperature and End Temperature. Trigger Temperature may by greater than End Temperature and vice versa.

The PID parameters for ΔT mode are fundamentally different from the parameters for the T mode. Therefore, the parameters for the ΔT mode and T mode are separated.

For ΔT mode, a typical parameter value set is:

- Proportional band (P) – Range 1 to 20,
- Integral time (I) – Range 1 to 10,
- Derivative time (D) – Range 1 to 20.

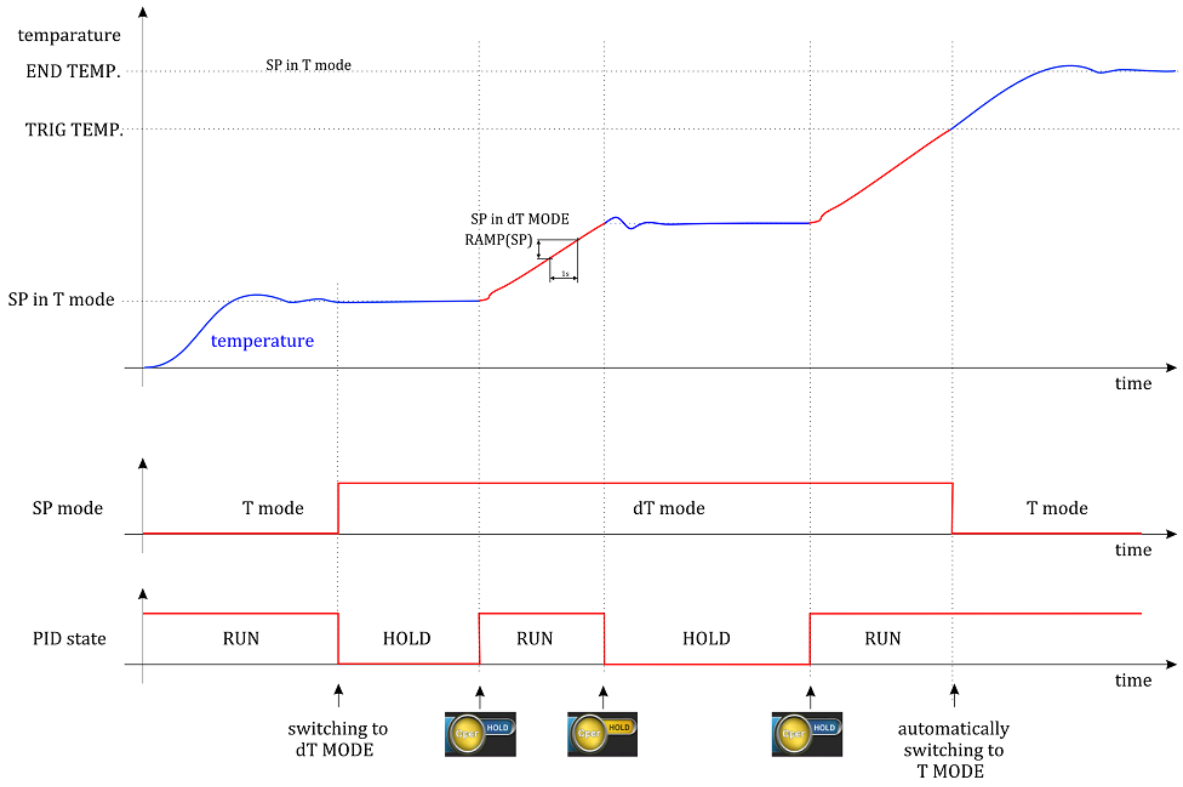


Figure 3.61: T mode/ dT mode switching characteristic.

3.4.6.11 TUNING

The HEAT3 offers various ways to set the necessary P, I and D parameters for closed loop control.

This section describes a few basics to help users get started. This technique will not be applicable in every case, but it has worked for many others in the field. It is also a good idea to begin at the middle of the temperature range of the heating system.

During tuning, we are essentially trying to match the characteristics of the controller to those of the process being controlled in order to obtain good control.

3.4.6.12 Manual PID Tuning:

Manual tuning is the most basic tuning method. The user manually enters values for P, I and D as well as the temperature range using their knowledge of the heating cooling system and some trial and error. Manual tuning can be used in any situation within the control capabilities of the instrument. Specify the controller parameters manually using the method describe below:

1. Set power supply to operate mode,
2. Switch the power supply to PID mode(closed loop PID control mode),
3. Turn integral and derivative off,
4. Enter a setpoint below the heating system's highest temperature,
5. Enter a proportional band of approximately 100,
6. The PIDOut value in additional information bar (onto heating panel) should display a value greater than zero and less than 100% when temperature stabilizes.

The load temperature should stabilize at a temperature below the setpoint. If the load temperature swings rapidly, the proportional value may be set too low and should be increased. Very slow changes in load temperature that could be described as drifting are an indication of a proportional setting that is too high.

7. Gradually decrease the proportional setting to halve it each time. At each new setting, allow time for the temperature of the load to stabilize,
8. As the proportional setting is decreased, there should be a setting in which the load temperature begins a sustained and predictable oscillation rising and falling in a consistent period of time (see fig. Examples of PID control (a))
9. The goal is to find the proportional value in which the oscillation begins. Do not turn the setting so high that temperature changes become rapid and unpredictable.
10. Record the proportional setting and the amount of time it takes for the load change from one temperature peak to the next. This time is called the oscillation period of the load. It helps describe the dominant time constant of the load, which is used in setting the integral.
11. Set the values of P, I and D according to Table 1 below.

Controller	P	I	D
P	$2 \cdot PB_{osc}$	OFF	OFF
P+I	$2.2 \cdot PB_{osc}$	0.8T	OFF
P+I+D	$1.7 \cdot PB_{osc}$	0.5T	0.12T

Table 3.1: PID parameters calculate

3.4.6.13 Automatic PID Tuning

The HEAT3 automates the tuning process with an AutoTune algorithm. This algorithm measures the system characteristics and calculates P, I and D. AutoTune will not work in every situation. In order to correct the parameters chosen in the autotune process use the guidance provided in the table below.

Controller	P	I	D
Slow Response	reduce	reduce	reduce
Large oscillations	increase	increase	increase

Table 3.2: Adjust PID parameters

3.4.7 SAFE SETTINGS

Safe Setpoint - protection, the purpose of which is to lower the temperature set as SETPOINT, e.g. in the event of loss of water flow through the effusion cell or another device that is controlled by the HEAT3-PS power supply unit.
In this mode, if the *Safe SP Interlock* signal is lost (factory set Input 2), the power supply unit switches to the SAFE mode - the *Safe Setpoint Value* is set on the power supply unit, in accordance with the defined ramp (*Ramp*) and the *Ramp unit*.

If the *Safe Setpoint Value* set temperature is higher than the current temperature of the controlled object, the object will not warm up to the*Safe Setpoint Value* with OPERATE switched on.
An additional option is to automatically return to the value of NORMAL SETPOINT defined and adjusted before the loss of the *Safe SP Interlock* signal – this option is called *Normal Setpoint Auto Return* and it does not apply to the loss of the MATTER INTERLOCK signal.
If this function is activated when the *Safe SP Interlock* signal returns, the original NORMAL SETPOINT value is automatically set according to the set *Ramp* in the PID Settings. If the function is deactivated, normal operation mode will not be automatically switched on, and the power supply unit will remain at the temperature set in the SAFE mode.

The *Safe Setpoint functionality* requires one of the digital inputs to be assigned to the *Safe SP Interlock* function (Inputs Settings -> Digital Inputs -> Assignment of Inputs-> Safe SP Interlock -> Input 1..4)
All settings of the Safe Setpoint mode do not pertain to the loss of the main security signal - *MASTER INTERLOCK*
The loss of this signal results in a complete disconnection of power from HEAT3-PS power supply unit output modules. Therefore, if you want to use the functionality of the *Safe Setpoint*, you need to ensure proper wiring of digital inputs. Regardless of the SAFE mode activation, the MASTER INTERLOCK signal should be connected.

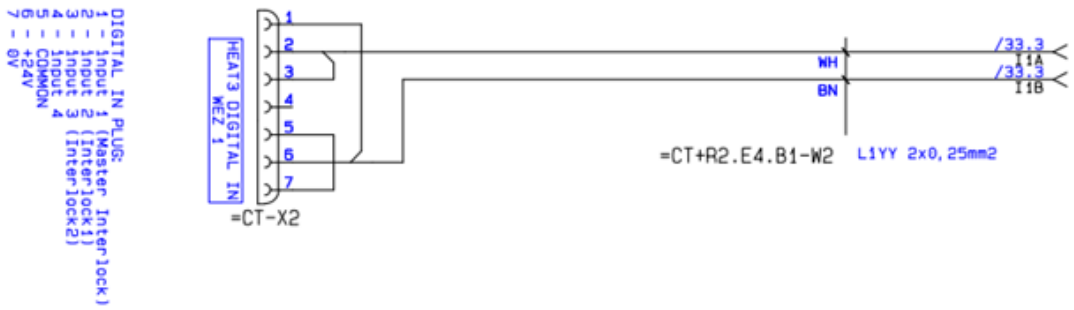


Figure 3.62: Connection diagram for MASTER INTERLOCK (Input 1) and Safe SP Interlock ch1 (Input 2), Safe SP Interlock ch 2 (Input 3)

3.4.7.1 Description of menu items

- **Safe Setpoint** – a position responsible for activating the SAFE functionality
  Enable - activation
  Disable - deactivation
- **Safe Setpoint Value** – temperature value to which the power supply unit is to stabilize the temperature in the event of the *Safe SP Interlock* signal failure
- **Ramp** - value of temperature increase rate in the SAFE mode
- **Ramp Unit** - unit of temperature increase rate in the SAFE mode
  °C/s
  °C/min
  °C/h
- **Normal Setpoint Auto Return** - menu responsible for activating the automatic return to setpoint from before the loss of the *Safe SP Interlock* signal
  OFF - deactivation
  ON – activation

3.4.8 VACUUM MEASUREMENT

The HEAT3 accommodates one pressure gauge head connection. The socket for connecting an appropriate gauge head is located on the rear panel on the Analog I/O Card. In order to ensure proper operation of the connected gauge, the device must first be configured appropriately. The vacuum measurement panel displays the values of the vacuum device attached to the vacuum head.

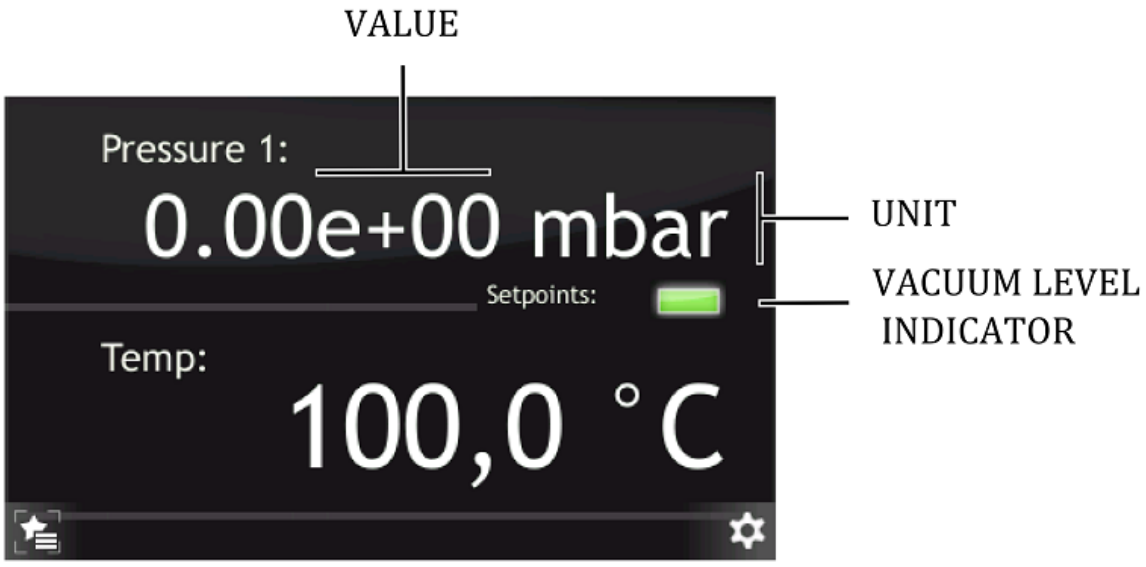


Figure 3.63: Vacuum measurement panel.

The Vacuum measurement panel contains of information about:

- **Unit** – changes pressure units
- **Value** – displays current value of pressure
- **Vacuum Level Indicator** - pressure setpoint

To check the current setpoint value for measurement channel, tap the *Vacuum Level Indicator* icon. The subsequent display contains information about the preset vacuum level. The displayed value is compared with the vacuum levels (Setpoint Low and High) and then the value is indicated by the vacuum gauge.
Set Levels are determining by the width of the hysteresis loop:

- The vacuum is below a preset level (LED off)
- The vacuum is above a preset level (LED on)

During operation, and if supported by the particular model, the device may relay additional information about the vacuum state. The displayed messages and their descriptions are detailed in the table 3.3.

INFORMATION	DESCRIPTION
Sensor Break!	Sensor is not connected or is damaged
Not calibrated	The head is not calibrated. This message appears when the head is connected to a PG105 gauge without prior calibration
High pressure	The vacuum level is outside the upper measuring range
Low pressure	The vacuum level is outside the lower measuring range
Degasing [time left]	The process of Degas is pending, information available from Degas heads
Wait for emission	The emission is enable and device wait for feedback from the vacuum gauge.

Table 3.3: Vacuum gauge messages

3.4.8.1 SELECTING GAUGE TYPE

Gauge type specifies the type of transmitter. Supported gauge types with pressure parameters are included in the ***Introduction*** chapter in the ***Measuring Channel*** section. CTR90/91 and MKS870B models require the additional parameter FS (Full Scale) according to the model of head which is attached. This parameter defines the measuring range associated with the specific gauge type. For CTR90/91 heads, the FS value is expressed in units of Torr. For MKS970B heads, the FS value is expressed in units of Torr and PSI.
In order to select the desired gauge type:

1. Go to: ***Setup Menu*** -> ***Pressure Chanel*** -> ***Gauge***
2. Tap desired gauge type.
3. Selected gauge type will appear in the ***Pressure Channel***.

3.4.8.2 SELECTING UNITS

Changing the displayed measurement units:
- from the vacuum panel, by tapping ***Unit*** field (see ***Device interaction***)
- through ***Setup Menu***.

Example of how to change the displayed unit:

1. Go to: ***Setup Menu*** -> ***Pressure Chanel*** -> ***Unit***
2. Select desired unit.
3. Desired unit will be assigned
4. Desired unit will appear in the ***Pressure channel*** menu.

3.4.8.3 SELECTING GAS TYPE

Sensors are normally calibrated for measurement in nitrogen or in air. If pressure measurements are being performed with other gases, it will be necessary to correct the reading accordingly. The Gas Type parameter is used to adjust the correction factor for the respective gas type. The actual pressure is obtained by multiplying the measured pressure with the correction factor:

$$P = \frac{I_c}{S_g \cdot I_e},$$

where:
$P-$ pressure,
I_c- ion current,
S_g- sensitivity factor for gas g, $S_g = S_{N_2} \cdot R_g$
I_e- emission current,
$S_{N_2}-$ gauge sensitivity for N_2,
R_g- gas correction factor.

The gas type correction becomes a function of the pressure if the pressure exceeds 0.5 mbar. This fact is taken into consideration for all gas types that can be selected:

GAS	R_g
He	0.18
Ne	0.30
D_2	0.35
H_2	0.46
N_2	1.00
Air	1.00
O_2	1.01
CO	1.05

continued on next page

continued from previous page	
GAS	**R_g**
H_2O	1.12
NO	1.15
NH_3	1.23
Ar	1.29
CO_2	1.42
CH_4 (methane)	1.4
Kr	1.94
SF_6	2.2
C_2H_6 (ethane)	2.6
Xe	2.87
Hg	3.64
C_3H_8 (Propane)	4.2
DEFINE	0.1 - 10

Table 3.4: Gas correction table

In order to select the correct gas type, use the Gas type in the setup menu. An example of the correct procedure is shown below:

1. Go to: ***Setup Menu*** -> ***Pressure Chanel*** -> ***Gas Type***
2. Tap desired gas.
3. Desired gas will be assigned.
4. Desired gas will appear in the ***Pressure Channel*** / ***Pressure Channel menu***.

3.4.8.4 DEGAS SETTINGS

For the ionization gauge heads the degas procedure is available. The HEAT3 main panel displays information about the degas state. From the setup menu it is possible to:

- configure the length of degas,
- turn degas on and off.

The following example shows how to change the duration of the degas procedure and how to enable degassing:

1. Go to: ***Setup Menu*** -> ***Pressure Chanel*** -> ***Degas***
2. Tap ***Time***.
3. Enter desired value on the numeric keyboard or using the knob .
4. Confirm by tapping ***Enter*** button.

5. Tap ***Degas*** in order to start the degas process.
6. Tap on ***Setup Exit*** button.
7. The vacuum level and state of vacuum degassing are now displayed alternately (for the time remaining until the end of the process.

3.4.8.5 SETTING SETPOINTS

In order to configure setpoints for the vacuum channel, the following parameters must be set:

1. Setpoint High – when reached, the Setpoint High value is indicated by the Setpoint LED associated with that measuring channel. Additionally, if one of the outputs has been linked to the setpoint high value, then the associated output relay is switched to open when the value is reached
2. Setpoint Low – when reached, the Setpoint Low value is indicated by the Setpoint LED switching off. Additionally, if one of the outputs has been linked to the setpoint low value, then the associated output relay is switched to closed when the value is reached

Configuration of the high and low setpoint must be made from the setup menu:

1. Go to: ***Setup Menu*** -> ***Pressure Chanel*** -> ***Setpoints***
2. Tap on desired setpoint in order to change it
3. Tap **Numeric keyboard** button
4. **Enter** desired setpoint value
5. Confirm by tapping **Enter** button
6. Tap on **Setup Exit** button
7. Tap on the Setpoint LED icon in order to see currently set setpoint levels

3.4.8.6 PG105 HEAD CALIBRATION

The PG105 head requires an initial calibration procedure, which is necessary for the correct vacuum display. This is a two-point calibration: at atmospheric pressure and under vacuum:

1. Go to: ***Setup Menu*** -> ***Pressure Chanel*** -> ***Gauge***
2. Tap arrow to scroll window down.
3. Tap on ***PG105*** gauge head.
4. You will be asked about calibration, tap ***Yes*** in order to enter into calibration menu.
5. Tap ***Atmosphere*** to start PG105 head calibration procedure.
6. Tap ***Ok***, then set the air pressure and wait ten minutes.
7. Tap ***Low pressure*** calibration.
8. Follow calibration information and wait 10 minutes.
9. Tap ***Done*** after calibration procedure.

3.4.8.7 GAUGE DAMAGE - MESSAGE "SENSOR BREAK"

When the message 'Sensor Break' appears either the vacuum gauge head is not connected to the Heat3 power supply or is damaged. This applies to all models supported by the Heat3 device with the exception of CTR90 and Baratron gauge heads. Neither of these gauge heads supports the re-transmission of an appropriate break signal to the Heat3 power supply which cannot therefore detect a disconnection of, or damage to, these gauge heads.

3.4.9 PRESSURE CHANNEL (OPTIONAL)

To change pressure channel settings go to: ***Setup Menu -> Pressure Channel***
The HEAT3 accommodates a pressure gauge head connection if the *analog card* option is installed. The sockets for connecting the gauge heads are located on the rear panel of the device. The device must be properly configured to ensure the correct operation of the connected gauge types. To do this, go to the configuration menu and then select *Pressure Channel*. Configuration options are described below:
Setup Menu -> Pressure Channel -> Setpoints:
Setpoint Low – when one of the outputs has been linked to the pressure channel, then the associated output relay is switched to close when the *Setpoint Low* is reached.
Setpoint High – when one of the outputs has been linked to the pressure channel, then the associated output relay is switched to open when the *Setpoint High* is reached.
Relay output configuration - look in subsection 3.4.12.1.

The *Setpoint* value is limited by the device to the range 1.00E-15 – 1.00E-2 mbar. The software does not allow setpoint values outside of this range. It is also not possible to set the *Setpoint Low* with a value greater than the *Setpoint High* and vice versa.
Settings of the *Pressure Setpoint* are related to *Vacuum Interlock* signal - look in subsection 3.4.10.

Setup Menu -> Pressure Channel -> Unit:
Unit - selection of the pressure display unit.

- **mbar** – the pressure is displayed in millibars.
- **Torr** – the pressure is displayed in Torr.
- **Pa** – the pressure is displayed in Pascals.
- **psia** – the pressure is displayed pound per square inch (psi).

Changing the displayed measurement units is also possible from the main panel, by tapping Unit field.
Setup Menu -> Pressure Channel -> Gauge:
Gauge - type of head selection. Please choose the specific type of head connected to the device. The following types of heads are currently supported - see subsection 1.4.4.
CTR90/91 and *Baratron* models require the additional parameter FS (Full Scale) according to the type of the head attached. This parameter defines the measuring range associated with the specific gauge type. For *CTR90/91* heads, the FS value is expressed in units of *Torr*. For *MKS970B* heads, the FS value is expressed in units of *Torr* and *psi*.
The *PG105* head requires an initial calibration procedure, which is necessary for the correct vacuum display. This is a two-point calibration: at atmospheric pressure and under vacuum. Continuation of the *PG105* head requires an additional amplifier (PGA13), shown in Fig. 3.64. The *PG105* is not part of a set HEAT3 and has to be ordered separately.

Setup Menu -> Pressure Channel -> Gas Type:
Gas Type – defines the process gas correction factor. Sensors are normally calibrated for measurement in nitrogen or in air. If pressure measurements are being performed with other gases,

Figure 3.64: Pirani PG105 amplifier

it will be necessary to correct the reading accordingly. The Gas Type parameter is used to adjust the correction factor for the respective gas type. The actual pressure is obtained by multiplying the measured pressure with the correction factor:

$$P = P_{AIR} \cdot R_g$$

Where:
P - pressure
P_{AIR} – pressure in air
R_g – gas correction factor

If the gas is not available on the included list it can be defined by the user by selecting *Define* and then manually entering the gas correction value.
Setup Menu -> Pressure Channel -> Filter:
Filter – filtering pressure value. Filtering is done by averaging the measured voltage. Depending on the selected parameter(**Low, Medium, High**) changes as the number of samples taken to averaging.
Setup Menu -> Pressure Channel -> Degas:
A degas procedure is available for ionization gauge heads *(ITR90, ITR100 ...)* . The HEAT3 main panel displays information about the degas state. From the setup menu it is possible to configure the duration of degas and turn degas on/off:
Time - duration of degas (1 - 30 min)
Degas - turn degas *on* and *off*

3.4.10 VACUUM INTERLOCK (OPTIONAL)

To turn vacuum interlock on/off go to: ***Setup Menu -> Vacuum Interlock***
Vacuum Interlock signal depends on the setting of *Pressure Setpoint* - look in subsection 3.4.9. This protection signal is provided to prevent accidental operation of the device when not under vacuum. When the *Vacuum Interlock* is activated, you can turn on the device in **OPERATE** state only if there is *Pressure Setpoint* reached. If the protection signal is missing (deterioration of the vacuum conditions), the HEAT3 rapidly returns to **STANDBY** mode and displays *'Vacuum Interlock Failure'* message accompanied by a flashing control failure LED. Loss of *Vacuum Interlock* signal can also be caused by removing the plug or damage the cable.

3.4.11 CONFIGURING ANALOG I/O

3.4.11.1 ANALOG OUTPUT CONFIGURATION

The rear panel connectors Analog Out 1 and Analog Out 2 each have a 0-10V analog signal available at their respective outputs. They can be used to control external devices or record data. The behaviour of the analogue outputs and the type of signal that will be converted to an analogue value and available at the output, are freely configured.
Available configuration options::

1. **SOURCE** - source to be converted to an analogue value:

   - **Process Value** – PID controller input signal
   - **PID Out** – PID controller output signal
   - **Ic actual** – actual value of cathode current
   - **Uc actual** - actual value of cathode voltage
   - **Ie actual** – actual value of emission current
   - **Ue actual** – actual value of emission voltage
   - **Tc1 Temp** – thermocouple temperature on channel 1
   - **Tc2 Temp** – thermocouple temperature on channel 2
   - **D1 Temp** – diode temperature on channel 1
   - **D2 Temp** – diode temperature on channel 2
   - **RTD Temp** – resistance temperature detector
   - **PRESSURE** - the measured pressure value from the head attached to Gauge input.
   - **None** – set 0V to output

2. **MODE** - selection of conversion method of the measured signal:

   - **1 to 1** - the signal is transmitted directly from input to output
   - **EXPO** - the mode used when pressure is the input signal. The output voltage is calculated using the exponent without taking mantissa into account. From 1E-14, the output increases by 0.5 V per decade. It is defined by the relation:

$$U_{OUT} = \frac{exponent + 14}{2}[V]$$

   - **User Range** - defines the measuring range which will be converted into voltage at the output

3. **RANGES** - defining the conversion range:

   - **Min. Range** - input signal value, which will correspond to **Min. Voltage** at the output. *Range* means any input signal - e.g. pressure.
   - **Max. Range** - input signal value, which will correspond to **Max. Voltage** at the output. *Range* means any input signal - e.g. pressure.

4. **SCALE** - selection of measured signal conversion type:

   - **LINEAR** - linear output. It is sometimes useful to retransmit the vacuum over a narrow range, covering several decades, or other linear signal. In this case, the output voltage is proportional to the input value. An input signal equal to the **Max. Range** corresponds to the upper limit of **Max. Voltage**, and an input signal equal to the **Min. Range** corresponds to the lower limit of the output voltage **Min. Voltage**:

$$U_{OUT} = \frac{(ReadingValue - MinRange)\cdot(MaxVoltage - MinVoltage)}{MaxRange - MinRange} + MinVoltage[V]$$

- **LOGARITHMIC** - logarithmic output It is often useful to retransmit the vacuum or other signal over a wide range, covering a dozen decades. In this case it is most convenient to operate with the input signal logarithm. The range of limits is defined according to the logarithmic relation:

$$U_{OUT} = \frac{Log\frac{ReadingValue}{MinRange}\cdot(MaxVoltage-MinVoltage)}{Log\frac{MaxRange}{MinRange}} + MinVoltage[V]$$

where:

$ReadingValue$ - current level of the input signal, e.g. pressure

$Min/MaxValue$ - output voltage range defined by the user

$Min/MaxRange$ - input signal range defined by the user

5. **MIN VOLTAGE** - output voltage corresponding to 0% of the assigned source signal value
6. **MAX. VOLTAGE** - output voltage corresponding to 100% of the assigned source signal value

3.4.11.2 SELECTING ANALOG OUTPUT

This section describes how to assign a parameter from some device to the analog output channel. The specific example below shows how to assign a Thermocouple on channel 1 to Analog Output 1:

1. Go to: ***Setup Menu*** -> ***Outputs Settings*** -> ***Analog Outputs***
2. Select channel 1 by tapping **Out 1**
3. Tap on **Source**
4. Tap **Arrow**
5. Select **Tc1 Temp**
6. Define ranges by tapping **Ranges**
7. Enter ranges for Thermocouple on channel 1

The next example describe how to assign pressure to analog output on channel 2:

1. Go to: ***Setup Menu*** -> ***Outputs Settings*** -> ***Analog Outputs***
2. Select channel 2 by tapping Out 2
3. Tap on Source
4. Tap Arrow
5. Select Pressure
6. Define ranges by tapping Ranges
7. Define mode to 1 to 1
8. Tap on Scale to edit value scaling mode
9. Tap Logarithmic

The final example describes how to transfer the PIDOut value to the analog output on channel 1:

1. Go to: ***Setup Menu*** -> ***Outputs Settings*** -> ***Analog Outputs***
2. Select channel 1 by tapping Out 1
3. Tap on Source
4. Select PID Out.
5. Define 0% Voltage
6. Define 100% Voltage

3.4.11.3 ANALOG INPUTS CONFIGURATION

Each of the inputs Analog Input 1 i Analog Input 2on the rear panel can be controlled with an analogue signal 0-10V. Those signals can be used to control the internal parameters of the device. To configure the analog inputs use the position ***Input settings/Analog inputs*** in the configuration menu. The following configuration options are available:

- **CONTROLLED VALUE** – the parameters available in this position (Ic limit, Uc, Ie limit, Ue), can be controlled by:
  - **None** – the parameter is not controlled with analog input
  - **Ain1** – the parameter is controlled by Ain1 input
  - **Ain2** – the parameter is controlled by Ain2 input

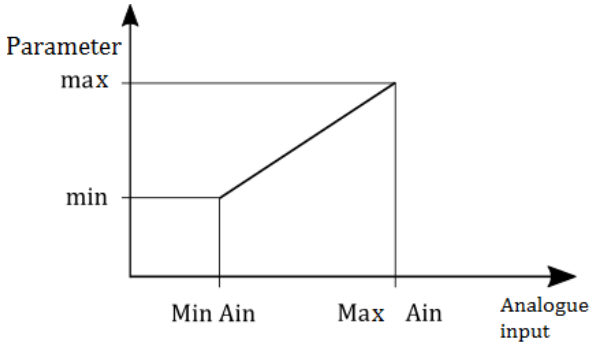


Figure 3.65: Controlling the power supply parameter by an analogue input

- **INPUT RANGE** – defining the range of control voltages:
  - **Min Ain 1** – the value of an input signal, which will correspond to the minimum value of a parameter controlled by Ain1 input
  - **Maks. Ain 1** – the value of an input signal, which will correspond to the maximum value of a parameter controlled by Ain1 input
  - **Min Ain 2** – the value of an input signal, which will correspond to the minimum value of a parameter controlled by Ain2 input
  - **Maks. Ain 2** – the value of an input signal, which will correspond to the maximum value of a parameter controlled by Ain2 input

  VOLTAGE->TEMP FUNCTION – conversion of voltage into temperature. The function active only when the analog input is connected with the ***Process value*** parameter, selected in the ***PID settings*** in the configuration menu.

3.4.11.4 SELECTING ANALOG INPUT

The example below describes how to assign the Analog Input 1 to cathode current limit:

1. Go to: ***Setup Menu*** -> ***Inputs Settings*** -> ***Analog Inputs***
2. Tap **Controlled value**
3. Select ***Ic limit***
4. Select ***Ain1***
5. Ain1 is now assigned to Ic limit.

The following example describes how to combine the analog input with Process Value of PID Controller:

1. Go to: ***Setup Menu*** -> ***PID Settings*** -> ***Process Value***
2. Select **Ain1**
3. To change temperature ranges for boundary voltage values (0V, 10V):
4. Go to: ***Setup Menu*** -> ***Inputs Settings*** -> ***Analog inputs***
5. Tap on **Function Voltage->Temp**
6. Change temperature ranges for boundary voltage values for channel **Ain1**

The final example describes how to use analog input to perform voltage stabilization:

1. Follow steps 1-6 from previous example
2. Change ***Ain1 0V Temp*** and ***Ain1 10V*** Temp to 0°C
3. The analog input is now used to perform voltage stabilization

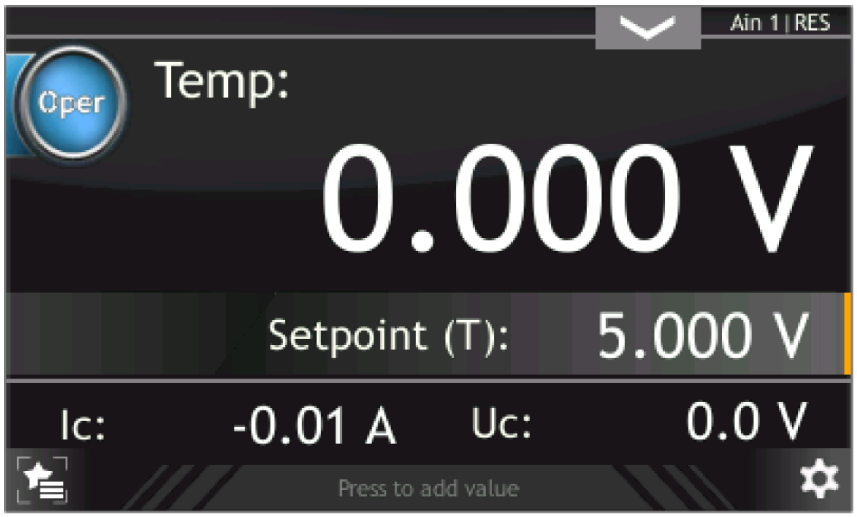


Figure 3.66: Analog input voltage stabilization

3.4.12 CONFIGURING DIGITAL I/O

The Digital Input/Output card has four digital inputs and six digital outputs.

3.4.12.1 RELAY OUTPUT CONFIGURATION

The HEAT3 has six relay outputs whose activity can be linked to the desired parameters. These outputs are physically isolated from the device (floating). The outputs are available on the **Digital I/O Card** which is located on the rear panel.

Relays can be configured in the Relay Outputs menu via the Setup Menu by selecting output from OUT1 to OUT6, and then assigning the desired output signal.
The following signal sources are available:

- **Setpoint** - the output is controlled by the temperature setpoint level
- **Pressure Setpoint** - the output is controlled by the temperature pressure setpoint level
- **Operate** - the output is controlled by the operate state
- **Shutter** - the output is controlled with a button on the heating panel
- **Cooling Valve** - the output is controlled by the cooling valve state
- **High Voltage** - the output is controlled by the high voltage state
- **Still OFF** - relay contacts are open
- **Still ON** - relay contacts are closed

Below is an example of the output assignment:

1. Go to: ***Setup Menu*** -> ***Outputs Settings*** -> ***Relay Outputs***
2. Tap one of the available outputs from the list
3. Tap one of the parameters to assign it with selected output
4. Parameter will be assigned to output
5. Parameter will appear in the **Relay Outputs** menu on chosen channel

3.4.12.2 LOGIC INPUT CONFIGURATION

The device has four digital inputs (0-24V). The inputs are available on the Digital Input/Output Card located on the rear panel. Digital inputs are normally active in the LOW state.

WARNING

Digital input maximum voltage
Logic inputs accept signals from a range of 0 to 24V. Exceeding these values may damage the input. Observe that these limits are not exceeded.

Input assignment The Assignment menu contains the following options:

- **Interlock** set interlock

- **Operate ON** turn Operate on
- **Operate OFF** turn Operate off
- **Pressure Emission ON** turn emission on
- **Pressure Emission OFF** turn emission off

In order to assign a Digital Input:

1. Go to: ***Setup Menu*** -> ***Inputs Settings*** -> ***Digital inputs*** -> ***Assignment of Inputs***
2. Tap desired position from the list
3. Tap one of the inputs
4. Selected **Input** will be assigned to chosen action
5. New input configuration will appear in **Assignment of Inputs** menu

Input configuration After assigning an appropriate action to the specified input, the activation type can be set. There are four activation types available:

- **Low Level** - the input is active by low state (0V or unplugged) (default)
- **High Level** - the input is active by high state (24V)
- **Falling Edge**- input is activated by the falling edge of the signal (change from 24V to 0V)
- **Rising Edge** - input is activated by the rising edge of the signal (change from 0V to 24V)

In order to set the inputs:

1. Go to: ***Setup Menu*** -> ***Inputs Settings*** -> ***Digital inputs*** -> ***Sence Control***
2. Tap desired input
3. Tap activation type
4. Activation type will be set
5. New input activation type will appear in **Sense Control Menu** menu

3.4.12.3 INTERLOCK AND REMOTE CONTROL INPUT DEFAULT ASSIGNMENT

Interlock by default is assigned to input1 with active high level. Remote Control by default is assigned to input2 with active high level. To see the connection diagram please refer to the installation chapter section on digital inputs.

3.4.12.4 COOLING VALVE

Assignment of a cooling valve to the digital output can be performed from the Setup Menu. Detailed information about the cooling valve can be found in Temperature control of PID Regulator subsection. In order to assign a digital output to a cooling valve:

1. Go to: ***Setup Menu*** -> ***Outputs Settings*** -> ***Relay Outputs***
2. Choose desired relay output channel and tap it
3. Navigate menu to Cooling Valve
4. Tap Cooling Valve
5. Cooling Valve will be assigned
6. Cooling Valve will appear in the Relay Outputs menu on chosen channel

3.4.13 ADVANCED OPTIONS

3.4.13.1 ZEWNĘTRZNY ZASILACZ HV DLA TRYBU EB

In case two DC modes that increase the power of resistance heating have been installed, it is not possible to install an internal mode of HV power supply for EB heating. However, in order to enable this type of heating, the device has been equipped with the option of controlling an external HV power supply. The external power supply must be able to control and read parameters through an analog interface with a maximum voltage of up to 10V. The analog interface of the external power supply should be connected to the analog input/output 2.4.11 card in the following way:

- Voltage control →Aout1
- Current control →Aout2
- Voltage monitor →Ain1
- Current monitor →Ain2
- External power supply GND →analog input/output card GND

If the external HV power supply is also equipped with a control input that switches on the output voltage, it should be properly connected to the relay output 1..6 2.4.10.2 which should be configured in the menu:
Setup Menu →Output Settings →Relay Outputs →Out1..6 →Operate
The details of the mentioned connection is strongly dependent on the control input logic in the used external HV power supply.

Options related to the external HV power supply:

External EB Power Supply On/Off - switching on / switching off the external HV power supply option. Switching this option on automatically switches HEAT3 to EB mode. In this mode, the analog inputs and outputs are used only to control the external power supply. Their previous functions are not active.
Nominal voltage (Ue) - (maximum) nominal voltage of the connected external HV power supply.
Nominal current (Ie) - (maximum) nominal current of the connected external HV power supply.

Aout1 (Max. Ue Set) - value of the control voltage, which causes the external HV power supply to set maximum (nominal) voltage

Aout2 (Max. Ie Set) - value of the control voltage, which causes the external HV power supply to set maximum (nominal) current

Aout1 (Max. Ue Read) - value of the input voltage, which corresponds to the set of the maximum (nominal) voltage by the external HV power supply

Aout2 (Max. Ie Read) - value of the input voltage, which corresponds to the set of the maximum (nominal) current by the external HV power supply

3.4.14 DEVICE SETTINGS

Setup menu →Device Settings
In the **Device Settings** submenu, the settings common for different types of devices with a touch screen are available, however, they are not specific for a particular model - in this case for the HEAT3.

3.4.14.1 COMMUNICATION SETTINGS - COMMUNICATION MENU

Setup menu →Device Settings →Communication
The communication menu is used to configure the remote control interface and communication protocol. The HEAT3 can communicate in one of two implemented protocols:

- **Modbus** - look 6.4
- **Prevac V2.x** - look 6.5

To change the communication protocol enter ***Setup menu →Device Settings →Communication →Protocol***

To change the communication interface enter ***Setup menu →Device Settings →Communication →Interface***. Available options:

- Ethernet
- RS232
- RS485

To change the **Interface** parameters enter ***Setup menu →Device Settings →Communication →Parameters***
Ethernet interface parameters:

- ***IP*** - adjusted manually if DHCP is disabled. Automatically set in the opposite case, when the device is turned on.
- ***Mask*** - subnetwork mask (logically subdivision of an IP network).
- ***Brama domyślna*** - default gateway on a TCP/IP network,
- ***DHCP*** - Dynamic "Host" Configuration:
  - ***enable*** - automatic configuration on connection (IP address, gateway, subnet mask),
  - ***disable*** -IP protocol parameters must be set manually,

- ***TCP server port*** - specifies the port number used in network socket created by TCP server, default - 502

Serial RS232/485 interfaces parameters:

- Baud Rate: 2400 bps, 4800 bps, 9600 bps, 19200 bps, 38400 bps, 57600 bps, 115200 bps,
- 8 bits of data, 1 stop bit and no parity parameters are fixed and cannot be changed,

The detailed description of the RS232/485 connection pins is in: 6.3
In the **Communication menu**, apart from the physical parameters of the communication interfaces, the following parameters can be configured:

- **Remote Control** - the option enables activation of the remote control mode. In the remote control mode changing the parameters through the touch panel is locked. It is only possible to view the parameters on the screen and view the device configuration. The device in the remote control mode displays in the upper part of the main window an information bar with text: "REMOTE: HEAT3 ".
  Activating the option does not mean that the device immediately switches to the remote control mode. It happens only after establishing communication with a remote control device. Then the edition of the Remote Control option is locked and local control via the touch panel is not possible. The remote control can be disabled only in two cases:
  - failure of communication for more than 10s.
  - sending a special command resulting in entering into the local control mode

  Entering the*Remote Control* mode is necessary if the device must be controlled through a communication interface. Reading of the parameters, however, is always possible and does not require the mode to be activated.
- **Address** - current communication address of the device. Depending on the type of the device this item can be edited, or can display the address that has been set on the DIP switch located on the rear panel of the device.
- **Host Address** (Parameter available only for "Prevac V2.x" protocol) - the device ID that have permission to control (set parameters and control functions).

3.4.14.2 DISPLAY SETTINGS

To change display settings go to: ***Setup Menu →Device Settings →Display***
In *Display* submenu it is possible to change the following parameters:
Brightness - display brightness value. Its value can be changed in the range of 10-100%.

Touch Screen Autolock - When the value is set to ON, the autolock function is active. If the touch panel is not used for longer than 3 min then the screen is locked. 3 minutes - screen is locked. Unlock the device by pressing "Yes" in the displayed message.

Customer Name - The device can be assigned an individual name that appears on the top of main window. This allows to distinguish between several devices of the same type.

System Date - The device has a built-in ***real time clock*** (RTC)(RTC). The menu allows to set the current date and time.
When setting a date separate the individual parts with the sign ".". Example: ***21-03-2014***
When setting a time separate the individual parts with the sign ":". Example: ***13:20:22***. Alternatively, the following time format is accepted: ***3:4:5 -> 03:04:05***, ***12:8:1 -> 12:08:01***

3.4.14.3 LANGUAGE MENU

This submenu allows to change the device language.
In order to select the language go to ***Setup menu →Device Settings →Language***.
To complete changing of the language the device must be restarted.

3.4.14.4 CHART ACTIVATION

Setup menu →Device Settings →Chart Activation

The submenu is used to activate the chart module. If the module is active this submenu is not available. For details see chapter 3.3.12.7.

3.4.15 SAVING/LOADING SETTINGS

All relevant parameters of the device may be saved automatically in a non-volatile memory and restored after turning the power back on. In addition, the current configuration of the device may be saved at any moment for restoration at a later time. Up to 6 different operation configurations of the device can be saved, and each configuration can be assigned an individual name. It is possible to return to the saved configuration or to the default settings at any time.

In order to turn on or turn off the autosave function of parameters, one should:

1. Go to menu ***Setup Menu →Save/Load*** .
2. Click on **Autosave** in order to change its status.

To save the configuration of the device:

1. Enter ***Setup Menu →Save/Load →Save***.
2. Choose a slot from the list where the settings will be saved (previous parameters will be deleted) and click on it.
3. Enter the required name using the keyboard.
4. Click ***Enter*** to confirm the name.
5. The current settings will be saved in the selected slot under the chosen name.

Saved device configuration can be restored also in the Setup menu. To load the previously saved settings:

1. Enter ***Setup Menu →Save/Load →Save***.
2. Choose one of the slots on the list from which device settings will be loaded and click on it.
3. The selected device settings will be loaded.

Default factory settings may also be loaded as follows:

1. Enter ***Setup Menu →Save/Load →Save***.
2. Choose ***Load Default*** to load the factory settings.

3.4.16 INFORMATION MENU

To display the information about the device go to:
Setup Menu →Information.
This menu contains information about the device name and version, the current software version, as well as the network parameters such as IP address, netmask and default gateway.

3.4.17 LOGS MENU

To display the history log go to: ***Setup Menu →Logs***.
This submenu displays the error history log. The displayed list of errors includes the description and date of their occurrence.

3.4.18 REBOOT

Restart the application running on the device. To restart the device enter the restart menu: ***Setup Menu →Reboot***.

4 STEP BY STEP

The following sections provide example scenarios for the resistance and electron bombardment heating modes. They contain a description of the steps that you must follow in order to heat sample in these modes.

4.1 RESISTANCE HEATING

Follow below steps in order to prepare device for resistance heating:

1. Install the device to the system (Chapter 2. Installation)
2. Turn on the device (Chapter 3 . Operating, ***Turn on device*** section)
3. Select RES heating mode (Chapter 3 . Operating, ***Selecting resistance heating mode section***)
4. Set up limits (see technical parameters of the sample holder) (Chapter 3 . Operating, **RES** => ***Setting limits section***)
5. Set up ramps (especially STBY ramps) (Chapter 3 . Operating, **RES** => ***Setting ramps section***)
6. Select the type of temperature measurement sensor (Chapter 3 . Operating - ***Selecting the type of temperature measurement*** section)
7. Set up all the outputs (analog and digital) (Chapter 3 . Operating - ***Analog output configuration*** section and ***Relay output configuration*** section)
8. Set up all the inputs (especially the interlock). (Chapter 3 . Operating - ***Analog input configuration*** section and ***Logic input configuration*** section)
9. Initiate the interlock signal

4.1.1 MANUAL REGULATION

In order to manually control heating, follow the steps below:

1. Pick up the MANUAL type of regulation (Chapter 3 . Operating, ***RES => Manual regulation*** section)
2. Reset cathode voltage (Uc = 0) (Chapter 3 . Operating, ***Device interaction*** section)
3. Turn on OPERATE (Tap ***Operate*** button in the left top corner of main panel)
4. Increase the cathode voltage (the cathode current limit may determinate the value of Ic) to heat the sample holder (Chapter 3 . Operating, ***Device interaction*** section)

4.1.2 PID REGULATION

In order to regulate heating using PID controller:

1. Pick up the PID type of regulation (Chapter 3 . Operating, ***RES => PID regulation*** section)
2. Set up PID, trigger temp and end temp parameters (Chapter 3 . Operating, ***PID Controller => T mode parameters*** and ***dT mode parameters*** section)
3. Set up the process value (Chapter 3 . Operating – ***Controlled channel selection*** section)
4. Reset cathode voltage (Uc = 0) (Chapter 3 . Operating, ***Device interaction*** section)
5. Turn on OPERATE (Tap ***Operate*** button in the left top corner of main panel)
6. Manipulate the type (T or dT) and value of setpoint (Interact with main panel)

4.2 ELECTRON BOMBARDMENT HEATING

Follow below steps in order to prepare device for electron bombardment heating:

1. Install the device to the system (Chapter 2. Installation)
2. Turn on the device (Chapter 3 . Operating, ***Turn on device*** section)
3. Select EB heating mode (Chapter 3 . Operating, ***Selecting electron bombardment heating mode*** section)
4. Set up limits (see technical parameters of the sample holder)) (Chapter 3 . Operating, **EB => *Setting limits*** section)
5. Set up ramps (especially STBY ramps) (Chapter 3 . Operating, **EB => *Setting ramps*** section)
6. Select the type of temperature measurement sensor (Chapter 3 . Operating - ***Selecting the type of temperature measurement*** section)
7. Set up all the outputs (analog and digital)) (Chapter 3 . Operating - ***Analog output configuration*** section and ***Relay output configuration*** section)
8. Set up all the inputs (especially the interlock)) (Chapter 3 . Operating - ***Analog output configuration*** section and ***Relay output configuration*** section)
9. Initiate the interlock signal

4.2.1 MANUAL REGULATION

In order to manually control heating, follow the steps below:

1. Pick up the MANUAL type of regulation (Chapter 3 . Operating, **RES => *Manual regulation section***)
2. Reset cathode voltage (Uc = 0) (Chapter 3 . Operating, ***Device interaction*** section)
3. Turn on OPERATE (Tap ***Operate*** button in the left top corner of main panel)
4. Increase the cathode voltage (the cathode current limit may determinate the value of Ic) to heat the sample holder
5. Increase the emission voltage (Ue) to initiate the flow of emission current (Chapter 3 . Operating, ***Device interaction*** section)

4.2.2 PID REGULATION

In order to regulate heating using PID controller:

1. Pick up the PID type of regulation (Chapter 3 . Operating, ***EB => PID regulation*** section)
2. Set up PID, trigger temp and end temp parameters (Chapter 3 . Operating, ***PID Controller => T mode parameters*** and ***dT mode parameters*** section)
3. Set up the process value (Chapter 3 . Operating – ***Controlled channel selection*** section)
4. Reset cathode voltage (Uc = 0) (Chapter 3 . Operating, ***Device interaction*** section)
5. Turn on OPERATE (Tap **Operate** button in the left top corner of main panel)
6. Increase the cathode voltage (the cathode current limit may determinate the value of Ic) to heat the sample holder
7. Manipulate the type (T od dT) and value of setpoint (Interact with main panel)

5 TROUBLESHOOTING

5.1 NO INTERLOCK SIGNAL

- There is no connection to external interlock or interlock is not properly configured. Refer to the Digital input section of the “Installation“ chapter

5.2 NO EMISSION CURRENT Ie=0mA

- No high voltage bridge cable between DC module (socket HV IN) and HV module (socket HV OUT). Check that the link cable is connected as show below.

Figure 5.1: Bridge connection

- During manual operating of emission voltage **UE** for EB heating mode the **UE** can be set too low.
- Operate of power supply is OFF. Please refer to the Operating chapter
- Limit of IE is set to 0,1mA
- IE limit is set to external analog control and external control voltage is 0V.
- No power going to the DC Module. Switch off the HEAT3-PS wait half minute and switch on again if the problem still exist contact Prevac

5.3 HV SHORT CIRCUIT

Emission current reaches limit and high voltage output is close to 0V then:

- Short circuit to ground on heater of EB type sample. To check, disconnect the high voltage bridge cable shown on photo (see above section) and observe if the problem still exists. If yes then it’s likely that the problem concerns the high voltage module.

5.4 HV FAIL – “HV POWER SUPPLY IS DAMAGED”

- High voltage UE read from device is close to 0V, for **UE** set > 0V and emission current **IE** close to 0mA
- No power going to the HV Module. Switch off the HEAT3-PS wait half minute and switch on again if the problem still exist contact Prevac

5.5 DC NO LOAD OR THE CONNECTION IS BROKEN

Messages can appear when operating is turning on

- DC load is disconnected from the device
- DC load is broken (electrical break)

5.6 DC CURRENT LIMIT

Messages can appear during normal operation, there could be several possibilities:

- DC load current has reached limit, check the limits set for appropriate sample heater type
- Short circuit in DC load or connections

5.7 DC SUPPLY FAILURE

- DC module load is short circuit => check load connections
- DC module is damaged => Contact Prevac

5.8 DC MODULE IS NOT AVAILABLE

- No DC module available or wrong module inserted to main board bus of Heat3
- Wrong contact between module and main board bus.
- Main board is damaged => contact Prevac

5.9 BUS CONNECTION FAIL

- Internal connection between the bus and the motherboard has been lost. Switch off, wait 30 seconds, then switch on again.
- If the problem appears again, it may indicate internal main board damage => contact Prevac

5.10 DEVICE COMMUNICATION ERROR

Internal connection on main board device has been lost

- Switch off, wait a 30 seconds and switch on again.
- If the problem appears again, it may indicate internal main board damage => contact Prevac

5.11 LOW DISC SPACE

- Disc space on USB flash drive is lower than 50 megabytes. This is suggestion to delete videos from the device

5.12 CRITICAL DISC SPACE

- Disc space on USB flash drive is lower than 2 megabytes. Please remove videos from device

6 COMMUNICATION

6.1 INTRODUCTION

This chapter is intended for users who want to use Modbus RTU or Modbus TCP (Ethernet). These are communication protocols used to control the functioning of the HEAT3 .
The following chapter includes general information about standards, wiring and electrical connections. It presents the connectors and wiring for serial links RS232, RS485 (Modbus RTU protocols) and Ethernet (Modbus TCP).
In addition, it includes advances issues, such as access to full resolution of floating point data and user interface permissions.

6.1.1 CABLE SELECTION

This section includes general information about types of cables that should be used in the serial communication system.

It is recommended that the digital communication network cable have the following electrical parameters:

- Rated DC resistance should be max. 100Ω/km. Generally 0.14mm^2 (24AWG) cables or thicker.
- Rated impedance 100Ω at 100kHz.
- With differential communication screened twisted pair should be used.
- Mutual capacitance of a pair should be max. 60pF/m (capacitance between two conductors in a pair).
- Stray capacitance max. 120pF/m (capacitance between one conductor and all other connected with ground).

Of course, selection of a cable entails compromise between costs and quality of the cable (damping or quality of screening). For applications in an environment with high likelihood of occurrence high levels of electrical interference it is recommended to use a cable with copper screen and ground it. For long-distance communication use a cable with low damping.

6.1.1.1 GENERAL WIRING RULES

1. Communication cables should be laid separately and as far as possible from the power supply cables or cables supplying power to external equipment such as contactors, relays or motors.
2. Communication cables may be laid together with signal cables if those cables are not exposed to sources of interference. Signal cables are cables connected with analogue or logic inputs and outputs of any control instruments.
3. **Do not use the remaining conductors in a communication cable for other signals.**
4. Ensure sufficient slack of the laid cable so that its movement do not damage the insulation.
5. Make sure that the cable is connected in series with the devices. This means that the cable runs from one instrument to the next one and so on, until the last device in the chain.

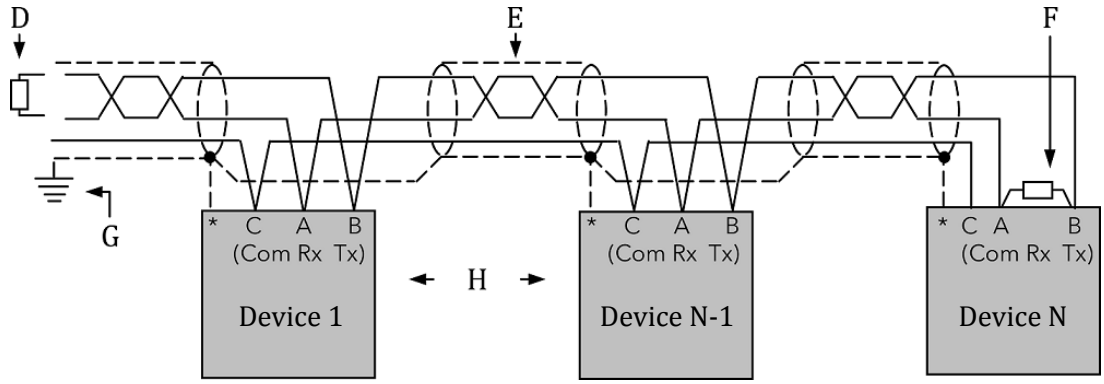


Figure 6.1: Example of 3-conductor (+ screen) EIA485 connection

* Some devices are equipped with a terminal for connecting screen. If the terminal is not available, ignore this connection.

- **A,B** - Differential communication terminals (A+, B-)
- **C** - Terminal C is usually an insulated device ground (GND)
- **D** - Resistor 220Ω at the first device in the bus
- **E** - Screened conductor - twisted pair
- **F** - Resistor 220Ω at the last device in the bus
- **G** - Single grounding - see chapter 6.1.3
- **H** - Intermediate device connected in series

6.1.2 PRECAUTIONS

In some applications with excessive static accumulation it is recommended to add high-resistance resistor (e.g. 1MΩ) between the chassis ground (terminal C) and ground. In the case of connecting devices via RJ45 interfaces, a cable must have plugs with metal shield connected with the cable shield (metal casing clamped on the braided cable shield).

6.1.3 GROUNDING

The EIA standards suggest that both end of a screen should be connected with protective grounding. When, however, using such a connection, take special care and make sure that the differences of the local ground potentials are not sufficient to enable circulating current to flow. They may cause not only large values of common signals in the data line, which may result in communication breakdown, but also overheating of the cable. In case of any doubts it is recommended to ground the screen of conductors only in one point. The length of a grounding connection should be as short as possible.

6.2 REMOTE ENABLE MODE

In the *REMOTE ENABLE* mode changing the parameters through the touch panel is locked. It is only possible to view the parameters on the screen and view the settings in the device setup menu. The device in the remote control mode displays in the upper part of the window an information bar with text: *"HEAT3 - REMOTE"*.

The remote control mode can be activated in the device only via software.

To enter the REMOTE mode via software use the ***REMOTE ENABLE*** option in the *COMMUNICATION* sub-menu. If Remote Enable ***ON*** is selected, then the device switches to the RC mode and stays in this mode until switched again to the local mode by selecting the ***OFF*** option.
Communication in the software mode is carried out according to the following principles:

- At a given moment the device can be controlled only from one place (device panel or remote computer with *MASTER* rights).
- After taking over the control by the *MASTER* device, return to the local control from the device menu is locked (the ***REMOTE ENABLE*** position is greyed).
- *MASTER* has the right as long as it maintains communication with the device (pauses between the frames are not longer than 10 s), or do not resigns from the rights to write: (Modbus protocol: address 1000; data field= 0, see tab 6.12. Prevac protocol: order 0xFFF1; data field= 0).
- In the event of loss of communication between *MASTER* and the device for more than 10s the ***REMOTE ENABLE*** position becomes active and it is possible to return to the local control by switching the ***REMOTE ENABLE*** position to ***OFF***.

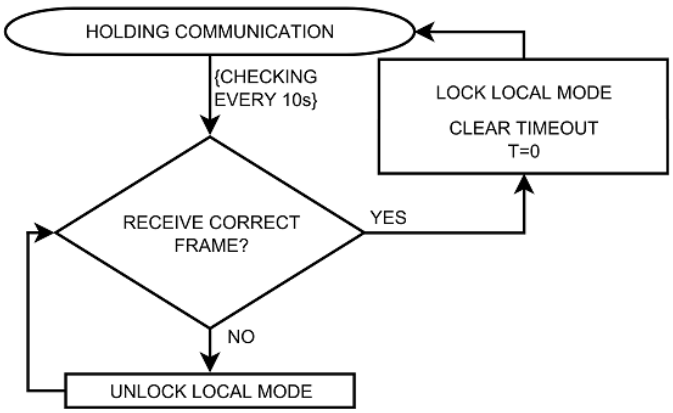


Figure 6.2: Maintaining communication - sequence diagram

6.3 COMMUNICATION INTERFACES

Serial communication is possible in different standards. Depending on the protocol chosen, there are different communication connections. Descriptions of the connections for individual protocols are presented below.

CAUTION

The RS232/RS485, ETH ports of the MG15 are not optically isolated. Therefore, it is necessary to ensure the same potentials between the controller(s) and other devices in this bus (common power supply chassis ground). Otherwise problems with communication and even damage to the device may occur.

6.3.1 RS232/RS485 CONNECTOR

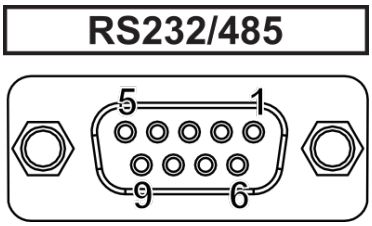


Figure 6.3: Female socket of RS232/RS485 (Modbus RTU) interface

PIN NUMBER	FUNCTION	DESCRIPTION
2	RX	RS232 - Data reception signal from the device
3	TX	RS232 - Data transmission signal to the device
5	C (GND)	Common signal (ground)
8	A+	RS485 - Data signal (positive)
9	B-	RS485 - Data signal (negative)
1,4,6,7	N/C	Not connected

Table 6.1: Pins description of ”RS232/RS485” connector

6.3.2 ETHERNET CONNECTOR

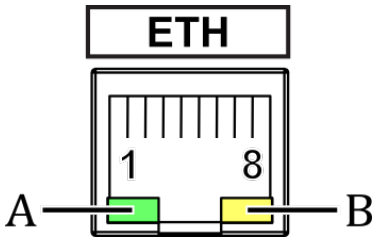


Figure 6.4: Female socket of Ethernet 10baseT (Modbus TCP) interface

PIN NUMBER	FUNCTION	DESCRIPTION
1	TX+	Data transmission - differential pair positive conductor
2	TX-	Data transmission - differential pair negative conductor
3	Rx+	Data reception - differential pair positive conductor
6	Rx-	Data reception - differential pair negative conductor
4,5,7,8	N/C	Not connected
DIODE	**FUNCTION**	**DESCRIPTION**
A (green)	Connection status	disabled - no connection, activity always on - connection in the network, no traffic blinking - connection active, traffic in the network
B (yellow)	Network status	disabled - no voltage or IP address not assigned always on - network active

Table 6.2: Pins description of ”ETH” connector

6.4 MODBUS PROTOCOL

6.4.1 INTRODUCTION

This implementation is used to provide a popular format od data exchange between the devices in the network. Modbus enables communication between up to 248 devices connected to the same network. Each SLAVE device has its unique address set from comminication menu (details in chapter 3.4.14.1). It identifies unequivocally the device during communication over the RTU Modbus protocol. During communication with the device through the Ethernet (Modbus TCP) network its IP address is the unique address.
The data register map is unique for the HEAT3 device and its definition is given in the tables starting from 6.4.8.

The data transmission protocol describes the rules and structure of the messages used by all the devices in the data exchange network. This protocol determines also the sequence of data exchange, error detection and defines that in serial networks only the Master device can initiate transmission, and in Ethernet networks any device may send commands, but this is usually done by the Master device. It enables creating a single- or multi-branch network structure. These two types of network are presented in fig. 6.5.

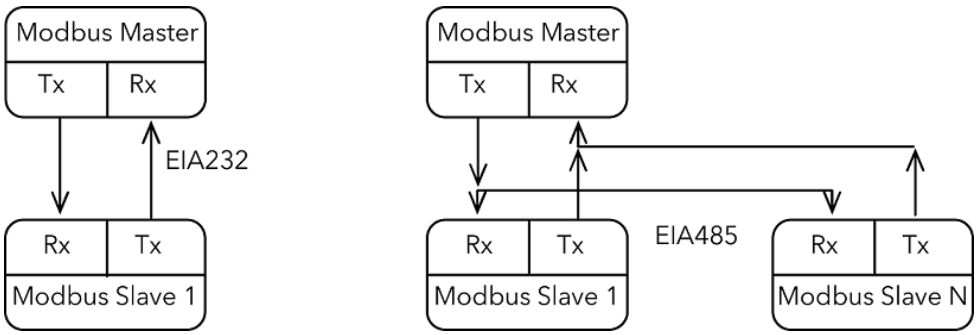


Figure 6.5: Modbus RTU network structures model

- Each Slave device in the network has its unique address.
- The HEAT3 device supports subset of Modbus codes.
- Refer through “parameter address” to the HEAT3 parameters.
- Sending queries with the device unique address results in response only of the device from this address. Then the Slave device will check errors, execute the required task, and send a response with its own address, data and correct checksum.
- Address ”0” of the device is a special case. It used for messages send to all the Slave devices and is used only for writing.
- Sending a query with the device address = “0” activates broadcast communication. This means that the information will be received by all the devices in the network. Each of them will execute the requested action, but not send a response.

The data link layer includes the following properties/behaviours:

- identification of the Slave device address,
- detection of beginning/end of a frame,
- generation of CRC-16 checksum (Modbus RTU),
- transmission/reception of ”time-out” messages,
- detection of buffer thrashing,
- detection of frame errors,
- detection of line idleness.

6.4.2 INTERFACE CONFIGURATION

There are four communication interfaces - RS232, RS485 and Ethernet.
For standard HEAT3 devices with a display, selection of interface, preview and change of its parameters is available in the menu, and their complete configuration is described in subchapter 3.4.14.1.

Communication over Modbus TCP protocol is configured using relevant commands of the Modbus RTU protocol.

CAUTION

It is recommended to make all the settings of the communication interface before connecting device to the Ethernet or EIAxxx network.
It is not necessary, however, the HEAT3 default settings may cause conflicts with the devices already connected to the network.
In the Modbus RTU protocol there is only one parameter - device address. In case of the Ethernet network there are several other parameters: IP address, subnet mask, network, default gate address and DHCP.

6.4.3 MODBUS RTU

The serial communication for the Modbus RTU is make through EIA232, EIA485 (formerly RS232 and RS485) or optionally ProfiNet (as encapsulation of the data frame) transmission. The EIA standards have been introduced by the Electronics Industry Association and describe the electrical characteristics of communication networks. Table 6.3 includes the summary of different physical layers described by these two standards.

EIA Standard	EIA232C	EIA485 3-wire
Transmission type	From point to point, nominally ±12Volt (min 3V, max 15V)	One or Two Pairs of wires. Differential Mode. Half duplex - communication occurs in both directions but not at the same time. Typically once a unit begins receiving a signal it must wait for the transmitter to stop sending before it can reply.
Electrical connections	3 wires: Tx, Rx, GND(common)	3 wires: A, B, C(common)
Number of devices in the line	1 transmitter, 1 receiver	31 receivers, 1 transmitter
Maximum data rate	115,2Kb/s	10Mb/s
Maximum cable length	15m	1200m

Table 6.3: EIA Standard

Note 1: The EIA232C standard enables connecting **one** device to a computer, PLC controllers or similar devices with a cable max. **15m** long.
Note 2: The EIA485 standard enables connecting **at least one** device to a computer, with a cable max. **1200m** long. In this way up to 31 receivers (SLAVE) and one transmitter (MASTER) can be connected. EIA485 is a balanced two-conductor transmission system, which means that information is carried out by the difference in voltage between two conductors, instead of the voltage in relation to the common conductor or ground, as it is done in EIA232C. One voltage polarity indicates logic "1", reverse polarity indicates logic "0". The difference must be at least ±200mV. The EIA485 differential transmission is less vulnerable to influence of external signals and if the device is in an environment with substantial interference, it should be used instead of the EIA232C. Even though the EIA485 standard is commonly described as a two-conductor connection, a chassis ground/screen two-conductor connection as a "common" signal should be used to ensure additional protection against interference.
Note 3: The HEAT3 works in a half-duplex system, which does not enable transmission and reception of data in the same time. Data are transmitted interchangeably, once query, once response.
Note 4: Most PC computers is equipped with an EIA232 port for communication. A limit of 32 devices may be bypassed by dividing most networks into segments, which are electrically isolated. When communication with more than 32 devices on the same bus is require, a PC computer with a special EIA485 attachment is required for buffering EIA485 networks. It can also be used to change a 3-conductor EIA485 to a 5-conductor EIA485.
Note 5: For EIA485 connection between the HEAT3 devices and a MASTER device, in particular at greater distances and transmission speeds (>38400bps, >10m) it is recommended to use a 2-conductor twisted pair, preferably, with an additional screen. Remember also to add a terminator (120Ω...470Ω resistor connected between lines A and B) at the beginning and the end of the EIA485 bus.

Note 6: The HEAT3 enables communication with a MASTER device with a write/read speed not exceeding 100 frames/second.

6.4.3.1 CONNECTION PARAMETERS

PARAMETER	VALUE
Data bits	8
Parity	None
Stop bits	1
Flow control	None
Baudrate	57600 (default)

Table 6.4: Connection parameters

6.4.3.2 FRAME FORMAT

Typical data exchange consists in sending a query from the MASTER device and a response to this query from the SLAVE device.
A typical message in both directions should consist of the following information:

Start	Device address	Function code	Data	CRC	EOT
3 bytes	1 byte	1 byte	n bytes	2 bytes	3 bytes

Table 6.5: Modbus RTU frame format

- **Start** - is an inactivity period, which equals to at least 3.5 times of the transmission time of a single character. E.g. for baudrate 9600bps with 1 start bit, 1 stop bit and 8 bits of data, the Start time is 3.5ms. Very often Start time results from the EOT time of the previous frame.
- **Device address** - unique 1-byte device address set in main menu. Address 0 is a broadcast address.
- **Function code** - 1-byte code unequivocally identifying action to be executed by the Slave device.
- **Data** - length and type of data depends on the function code. Usually, a data segment will contain the parameter address and number of data to read or write.
- **CRC** - 2-byte checksum used to check the correctness of data in a communication frame. Calculation of checksum see chapter 6.4.3.3.
- **EOT** - the segment at the end of a frame showing to the slave devices that a new message will be transmitted next. As a standard, at least 3.5 times of the transmission time of a single character.

6.4.3.3 CRC CHECKSUM

The CRC checksum is a test of data correctness, and its length equals to 2 bytes (16 bites). After constructing a message (data field) the transmitting device calculates the CRC checksum and attaches it to the end of the message. The slave device calculates the CRC checksum out of the received message, and after that it check the correctness with the one received in the frame.
If the CRC checksum differs from the one sent in the frame, this means that a communication error occurred.
If the HEAT3 detects an error in the message, it ignores such frame (leaves without a response).
The CRC checksum is generated in the following steps:

1. Enter value 0xFFFF to 16-bit CRC register.
2. Execute XOR operation of the first byte of the message with the oldest byte (MSB) of the CRC register. Save the result in the CRC register.
3. Shift the CRC register right by one bit.
4. If an overflow bit or flag equals to 1, execute the XOR operation of the CRC register with value 0xA001 and enter the result in the CRC register.
5. If an overflow bit or flag equals to 0, repeat step 3.
6. Repeat steps 3 and 4, until the overall number of shifts is 8.
7. Execute XOR operation of the next byte of the message with the oldest byte (MSB) of the CRC register. Save the result in the CRC register.
8. Repeat steps 3 to 7 until all the message bytes will be XOR with the CRC register and shifted 8 times.
9. In the CRC register there are two bytes of the checksum, which are added to the message where the most significant bit is added first.

Figure 6.6 illustrates this algorithm of checking CRC errors.
Symbol '⊕' indicates XOR operation. "n" means a number of data bits.

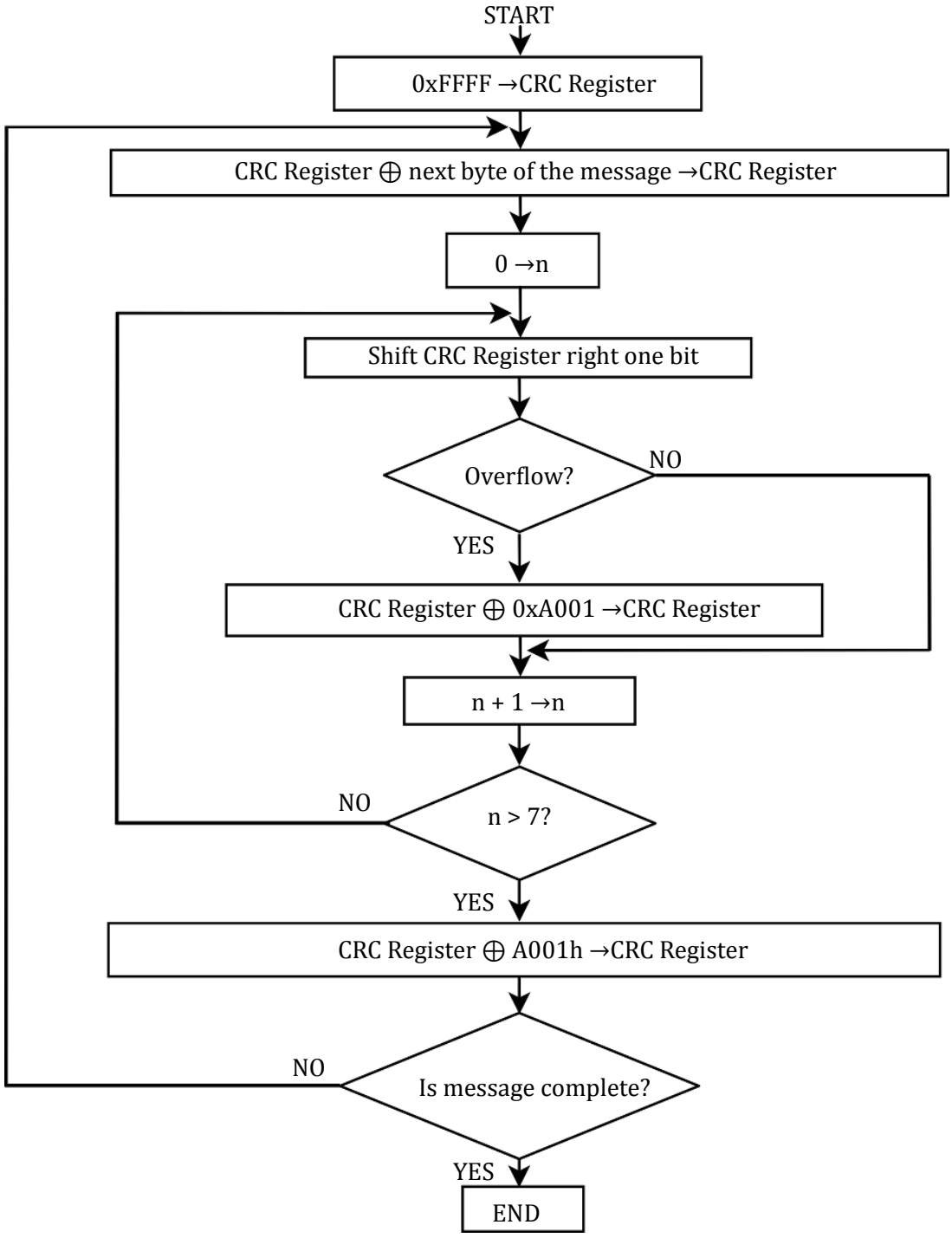


Figure 6.6: Checksum calculation algorithm

CRC CHECKSUM CALCULATION - EXAMPLE IN C LANGUAGE

The example uses data of "uint16" and "uint8" types. The signs correspond, in turn, 16-bit integer number without sign (usually for most types of compilers "unsigned short int") and 8-bit integer number without sign ("unsigned char"). "z_p" indicates Modbus data messages, and "z_message_length" means their length without CRC checksum.

```
uint16 calculate_crc(char *z_p, uint16 z_message_length)
/* CRC runs cyclic Redundancy Check Algorithm on input z_p */
/* Returns value of 16 bit CRC after completion and */
/* always adds 2 crc bytes to message */
/* returns 0 if incoming message has correct CRC */
{
  uint16 next, carry, n, CRC= 0xffff;
  uint8 crch, crcl;
  while (z_message_length--) {
    next = (uint16)*z_p;
    CRC ^= next;
    for (n = 0; n < 8; n++) {
      carry = CRC & 1;
      CRC >>= 1;
      if (carry) {
        CRC ^= 0xA001;
      }
    }
    z_p++;
  }
  crch = CRC / 256;
  crcl = CRC % 256
  z_p[z_message_length++] = crcl;
  z_p[z_message_length] = crch;
  return CRC;
}
```

6.4.4 MODBUS TCP

The HEAT3 supports the Modbus TCP protocol via Ethernet connection. It is a protocol version used for communication in TCP/IP networks. The connection is executed in port 502 by default. The checksum is not placed in the frame, due to the fact that the lower layers of the TCP/IP protocol ensures error control and identification of the device.

6.4.4.1 CONNECTION PARAMETERS

All the interface parameters are saved in the non-volatile memory of the HEAT3 . The DHCP protocol option is enabled by default and the device should be assigned with the last parameters such as an IP address, subnet mask and network default gate address.

The HEAT3 supports standard "ping" tool to test the connection. Other protocols such as http, ftp or telnet are not supported.

6.4.4.2 PARAMETER SETTINGS

In the event when the device must have a permanent, previously established IP address, this can be done by changing the parameters in the device menu, see subchapter 3.4.14.1.

CAUTION

It is recommended to make all the settings of the communication interface before connecting to the Ethernet network. It is not necessary, however, the HEAT3 default settings may cause conflicts with the devices already connected to the network.
In case of the Modbus TCP network there are several other parameters: IP address, subnet mask, network default gate address and DHCP. Changing any of these parameters may assign immediately a new network address to the device. Therefore, it is recommended to make such changes when the device is in the "offline" mode, i.e. disconnected from the communication network.

Each HEAT3 device has its own unique MAC address, usually as a 12-digit hexadecimal number in the "aa-bb-cc-dd-ee-ff" format. The MAC address can be viewed in the device menu or through the communication interface according to the data in the table of chapter 6.4.8.

6.4.4.3 FRAME FORMAT

Typical data exchange consists in sending a query from the MASTER device and a response to this query from the SLAVE device.
A typical message in both directions should consist of the following information:

Transaction Id	Protocol Id	Data length	Device address	Function code	Data
2 bytes	2 bytes	2 bytes	1 byte	1 byte	n bytes

Table 6.6: Modbus TCP frame format

- **Transaction ID** - used to synchronise messages between the server and client.
- **Protocol ID** - identifier of data exchange protocol, which is always 0 for Modbus TCP.
- **Data length** - number of bytes in a frame excluding transaction Id and protocol Id.
- **Device address** - device address to which a frame is directed or response to an address.
- **Function code** - 1-byte code unequivocally identifying action to be executed by the Slave device.
- **Data** - length and type of data depends on the function code. Usually, a data segment will contain the parameter address and number of data to read or write.

DEVICE IDENTIFICATION IN MODBUS TCP NETWORK
The Modbus TCP specification enables also addressing the device as a part of the Modbus protocol frame ("Device address" byte). In the Ethernet network is it however oversized (the address is set to 0x01), and the main and fully sufficient device identification is executed through the IP address of the device in the network.

6.4.5 FUNCTION CODES

The function codes have 1-byte length. These are instructions for Slave devices describing action to be executed.
The following function codes are supported through the HEAT3 device.

FUNCTION CODE	FUNCTION
0x03	Read n-words
0x06	Write word
0x10	Write n-words

Table 6.7: Modbus protocol function codes

It is recommended to use the 0x03 function to read data, and the 0x10 function to write. It applies also to logic data. Other function codes are supported to ensure compatibility with the Modbus documentation. Exchange of information between the Master and Slave devices is executed through data words. These data consist of parameters. The definitions of individual words for the MG15 are presented in tables, starting from 6.4.8.
Communication frame formats for individual function codes are described below.

6.4.5.1 0x03 - READ N-WORDS

It enables sequential reading of a number of parameters within one query.
It is necessary to define the address of the first parameter and number of words to be read after this address.
Query:

Device address	Function code 0x03	First word address	Number of words to read	CRC
1 byte	1 byte	MSB LSB	MSB LSB	MSB LSB

The maximum number of read words is 125. The first two bytes are the data for the first parameter (first MSB in organisation). The subsequent byte pairs are the data for the following parameters.

Response:

Device address	Function code 0x03	Number of read bytes	Value of first word	...	Value of last word	CRC
1 byte	1 byte	1 byte	MSB LSB	...	MSB LSB	MSB LSB

Example: Read 3 words from address 0x0000.
Query:
TX: 01 03 00 00 00 03 05 CB
Response:
RX: 01 03 06 3A 83 12 6F 00 00 54 94
Received data: 3A 83 12 6F 00 00

6.4.5.2 0x06 - WRITE WORD

Query:

Device address	Function code 0x06	Address of word to be written	Value to be written	CRC
1 byte	1 byte	MSB LSB	MSB LSB	MSB LSB

Response:

Device address	Function code 0x06	Address of word to be written	Value to be written	CRC
1 byte	1 byte	MSB LSB	MSB LSB	MSB LSB

Slave device is identical with query. Except when transmission error or incorrect data occur. Possible responses in case of error are described in table 6.4.6.

Example: Write word to address 0x004A.
Query:
TX: 01 06 00 4A 02 00 A9 7C
Response:
RX: 01 06 00 4A 02 00 A9 7C

6.4.5.3 0x10 - WRITE N-WORDS

It enables sequential writing of a number of parameters within one transmission.
It is necessary to define the address of the first parameter and number of words to be written after this address.
Query:

Device address	Function code 0x10	First word address	Number of words to be written	Number of data bytes	Data	...	CRC
1 byte	1 byte	MSB LSB	MSB LSB	1bajt	MSB LSB	...	MSB LSB

Response:

Device address	Function code 0x10	First word address	Number of written words	CRC
1 byte	1 byte	MSB LSB	MSB LSB	MSB LSB

The maximum number of words to be written is 125 which corresponds to 250 bytes. The first two bytes are the data for the first parameter (first MSB in organisation). The subsequent byte pairs are the data for the following parameters. Trying to write using function 0x10 of data blocks containing non-configured (empty) cells, or read only, results in communication error and discarding of the data. All the further values in the block will also be discarded.

Example: Write 2 words from address 0x0005.
Query:
TX: 01 10 00 05 00 02 04 22 33 44 55 3A D8
Response:
RX: 01 10 00 05 00 02 51 C9

6.4.6 RESPONSE IN CASE OF ERROR

The Modbus protocol defines the reaction if errors occurs. The Slave device is able to detect a damaged query or a query which contains incorrect data. It responds then with error code.
However, transmission errors may occur to which Slave devices cannot respond. Then after waiting the Master device will interpret the lack of response as a communication error. The Master should then resend the query.

6.4.6.1 ERROR AND WARNING CODES

The Slave device, which detected a damaged query, or a query which contains incorrect data will respond with an error message. An error message consists of the following elements.

Device address	Function code	Error code	CRC
1 byte	1 byte	1 byte	MSB LSB

The function code byte contains a transmitted function code, but with the most significant bit set at 1 (it is the result of adding 128 to the function code - binary 10000000).
In response the error code indicates the type of the error detected.
The HEAT3 supports the type of the detected error:

Error code	Error type	Description
0x01	Incorrect function	Function code is incorrect for Master (or slave) device.
0x02	Incorrect address	Address out of range or start/end write/read in incorrect place of table.
0x03	Incorrect data / argument	Data value of is inadmissible for the word addressed.
0x04	Device error	Error occurred in the Master or Slave device when executing the operation.
0x05	Acknowledge	The Master (or Slave) device accepted the command and the operation is being executed. Its execution takes too long and the response is sent back, to prevent the time limit error in the inquired device. The Slave (or Master) may send a message in the next loop, to determine whether the operation has been completed successfully.

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Error code	Error type	Description
0x06	Busy / Message discarded	The server (Slave) is busy for long time with processing the programme commands. The Client (Master) should try again to send the message later, when the server (Slave) is free.
0x07	Not acknowledge	The response of the device inquired when the required action cannot be executed.
0x0A	Network path unavailable	Applies to network gates. It indicates that the network gate cannot allocate an internal communication path from the input port to the output port to execute the command.
0x0B	No response	Applies to network gates. This means that no response has been received from the target device. It usually means that the device is not present in the network.

Table 6.8: Erros codes

6.4.7 TYPE OF DATA USED IN COMMUNICATION

One of the main limitations of the Modbus protocol is the fact that the device memory is visible as a variable 16-bit integral numbers table. In most cases it is sufficient, because scaling to the appropriate value without losing precision can be used. In fact it has a disadvantage consisting in the fact that the scaling factor must be known for the devices at both ends of the communication link.
The next problem are variables, for which 16-bit representation is not sufficient, e.g. value of vacuum. To solve these problem, different types of variables have been implemented in the MG15, enabling the full resolution of data.
The most precise data type is 32-bit float in the ”IEEE-754” standard. This format is written in the memory as two consecutive words (4 bytes) in the order: “MSB first”. The rules determining the organisation of data in two consecutive words depends on the type of a given parameter.
Other data types used in the Modbus protocol variables:

- Enumerating parameters are parameters, which have their own text representation in the user interface, e.g.: “Type of gauge:” - ”CTR90, TTR91, TTR211,...”, etc.
- Parameters of ”bool” type are parameters which may be ”0” or ”1”. These parameters are described in the table as “bool”.
- Parameters of ”integer” type are integral parameters, without decimal points. They include parameters such as “Degassing power” or “Sensitivity”. They can be 8- or 16-bit parameters and are marked in the table as ”uint8” or ”uint16” for integer numbers without sign and ”int8” or ”int16” for integer numbers with sign.
- Parameters of ”float” type are parameters with a decimal point. These are parameters such as “Vacuum value” or “Setpoint” settings. These parameters are marked in the table as ”float32” and their writing is compatible with the 4-bytes ”IEEE-754” standard.

6.4.7.1 ENUMERATED, BOOL AND INTEGER PARAMETERS

These variables are always occupying one word in the memory. For variables smaller than: 2 bytes, the upper byte is filled with 0x00 value.
These variables are read via 0x03 function, and they can be recorded via 0x06 or 0x10 function. Remember to fill with 0x00 the upper byte (MSB) of variables smaller than 2 bytes during writing.

6.4.7.2 FLOAT TYPE

The format is compatible with the IEEE-754 standard and is used in almost every programming language of higher level such as C, C++. In addition, most of automatics equipment or built-in systems allows for their automatic decoding.
Variables written in this format are organised as 4-byte data in two consecutive table word in the "MSB first" order. Writing and reading of these variables is possible only via 0x03 and 0x10 commands. An attempt to write or read such variable in half will be discarded and an error message will be generated.

CAUTION

Note that in practice, when using C, IEEE floats may usually be decoded by placing the values returned over comms into memory and 'casting' the region as a float, although some compilers may require that the area be byte swapped high to low before casting (e.g. MSB B2 B1 LSB →LSB B1 B2 MSB).

MODBUS ADDRESS		MODBUS ADDRESS + 1	
MSB	LSB	MSB	LSB
Bits 31 - 24	Bits 23 - 16	Bits 15 - 8	Bits 7 - 0

Table 6.9: Float IEEE-754 format in Modbus table

For example, to transfer the value 1.001, the following values are transmitted (hexadecimal):

MODBUS ADDRESS		MODBUS ADDRESS + 1	
MSB	LSB	MSB	LSB
0x3F	0x80	0x20	0xC5

Table 6.10: Example float IEEE-754 value in Modbus table

6.4.8 TABLE OF MODBUS VARIABLES - MAP OF REGISTERS

FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
HEAT3 POWER SUPPLY SETTINGS					
Status: bit0: Device state for CH1: 0-STANDBY, 1-OPERATE bit1: PID Autotune status for CH1 bit2: DC module type: 0-constatnt current, 1-constant voltage (*) / No external DC1 interlock (**) bit3: Channel TC1 - no thermocouple bit4: Channel TC2 - no thermocouple bit5: Channel D1 - no diode bit6: Channel D2 - no diode bit7: Channel RTD - no sensor bit8: No external master interlock bit9: No vacuum interlock bit10: No external HV interlock (*) / No external DC2 interlock (**) bit11: Presence of internal main power bit12: DC1 no load or the connection is broken bit13: DC1 power supply is damaged bit14: HV power supply failure (*) / DC2 no load or the connection is broken (**) bit15: HV power supply short circuit (*) / DC2 power supply is damaged (**)	0	R	INT16		bit field
PID state for CH1: 0 - Off 1 - Run 2 - Hold	1	R	UINT8		0..2
Process value for CH1	2	R	INT32	100	[K]
Channel TC1 temperature	4	R	INT32	100	[K]
Channel TC2 temperature	6	R	INT32	100	[K]
Channel D1 temperature	8	R	INT32	100	[K]
Channel D2 temperature	10	R	INT32	100	[K]
Channel RTD temperature	12	R	INT32	100	[K]
PID setpoint (T mode) for CH1	14	R/W	INT32	100	such as measurement range of sensor assigned to process value
PID setpoint (ΔT mode) for CH1	16	R/W	INT16	10	-5.0 .. 5.0 [K/s]
Trigger temperature(ΔT mode) for CH1	17	R/W	INT32	100	such as measurement range of sensor assigned to process value
End temperature (ΔT mode) for CH1	19	R/W	INT32	100	such as measurement range of sensor assigned to process value
Work mode for CH1: 0 - Manual 1 - Auto 2 - Extern (read only) 3 - PID out (read only)	21	R/W	UINT8		0..3
Heating mode: (*) 0 - RES - resistive 1 - EB - electron bombarded	22	R/W	UINT8		0..1
PID regulation type for CH1: 0 - Control of temperature (T mode) 1 - Control of temperature ramp (ΔT mode)	23	R/W	UINT8		0..1

(*) - if HV module is installed

(**) - if two DC modules are installed

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Input selection for process value for CH1: 0 - Thermocoulpe channel TC1 1 - Thermocoulpe channel TC2 2 - Diode channel D1 3 - Diode channel D2 4 - Resistance channel RTD 5 - Analog input channel 1 6 - Analog input channel 2	24	R/W	UINT8		0..6
Channel TC1 thermocouple type: 0 - K 1 - C 2 - E 3 - N	25	R/W	UINT8		0..3
Channel TC2 thermocouple type: 0 - K 1 - C 2 - E 3 - N	26	R/W	UINT8		0..3
Channel D1 diode type: 0 - DT670 1 - DT470	27	R/W	UINT8		0..1
Channel D2 diode type: 0 - DT670 1 - DT470	28	R/W	UINT8		0..1
Channel RTD sensor type: 0 - PT100	29	R/W	UINT8		
Process value unit for CH1: 0 - Kelvin 1 - degree Celsius 2 - degree Fahrenheit 3 - Volt (read only)	30	R/W	UINT8		0..1
Cathode current ramp at RES mode at OPERATE state for CH1 ('RES mode' - version dependent)	31	R/W	INT16	100	0.01..200
Cathode current ramp unit at RES mode at OPERATE state for CH1 ('RES mode' - version dependent): 0 - A/s 1 - A/min 2 - A/h	32	R/W	UINT8		0..2
Cathode current ramp at RES mode at STANDBY state for CH1 ('RES mode' - version dependent)	33	R/W	INT16	100	0.01..200
Cathode current ramp unit at RES mode at STANDBY state for CH1 ('RES mode' - version dependent): 0 - A/s 1 - A/min 2 - A/h	34	R/W	UINT8		0..2
Cathode current ramp at EB mode at OPERATE state (*) / Cathode current ramp at OPERATE state for CH2 (**)	35	R/W	INT16	100	0.01..200
Cathode current ramp unit at EB mode at OPERATE state (*) / Cathode current ramp unit at OPERATE state for CH2 (**): 0 - A/s 1 - A/min 2 - A/h	36	R/W	UINT8		0..2
Cathode current ramp at EB mode at STANDBY state (*) / Cathode current ramp at STANDBY state for CH2 (**)	37	R/W	INT16	100	0.01..200

(*) - if HV module is installed

(**) - if two DC modules are installed

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Cathode current ramp unit at EB mode at STANDBY state (*) / Cathode current ramp unit at STANDBY state for CH2 (**): 0 - A/s 1 - A/min 2 - A/h	38	R/W	UINT8		0..2
Emission voltage ramp at OPERATE state (*)	39	R/W	INT16	10	1..1000
Emission voltage ramp unit at OPERATE state (*): 0 - V/s 1 - V/min 2 - V/h	40	R/W	UINT8		0..2
Emission voltage ramp at STANDBY state (*)	41	R/W	INT16	10	1..1000
Emission voltage ramp unit at STANDBY state (*): 0 - V/s 1 - V/min 2 - V/h	42	R/W	UINT8		0..2
PID setpoint ramp for CH1	43	R/W	INT16	10	0..1000
PID setpoint ramp unit for CH1: 0 - Process value unit/s 1 - Process value unit/min 2 - Process value unit/h	44	R/W	UINT8		0..2
P parameter in T mode for CH1	45	R/W	INT16	10	0.1..1000
I parameter in T mode for CH1	46	R/W	INT16		0..1000
D parameter in T mode for CH1	47	R/W	INT16		0..1000
P parameter in ΔT mode for CH1	48	R/W	INT16	10	0.1..1000
I parameter in ΔT mode for CH1	49	R/W	INT16		0..1000
D parameter in ΔT mode for CH1	50	R/W	INT16		0..1000
Cathode current limit at RES mode for CH1 ('RES mode' - version dependent)	51	R/W	INT16	100	0.00 .. 19.00 [A]
Cathode voltage limit at RES mode for CH1 ('RES mode' - version dependent)	52	R/W	INT16	100	0.00 .. 50.00 [V]
Cathode current limit at EB mode (*) / Cathode current limit for CH2 (**)	53	R/W	INT16	100	0.00 .. 12.00 [A]
Cathode voltage limit at EB mode (*) / Cathode voltage limit for CH2 (**)	54	R/W	INT16	100	0.00 .. 40.00 [V]
Emission current limit (*)	55	R/W	INT16	10	[mA]
Emission voltage limit (*)	56	R/W	INT16	10	[V]
PID output signal (*): 0 - Ue - emission voltage is controlled by PID controller 1 - Ic - cathode current is controlled by PID controller	57	R/W	UINT8		0,1
Set value of cathode current for CH1	58	R/W	INT16	100	0.00 .. 4.00 [A]
Read value of cathode current for CH1	59	R	INT16	100	[A]
Read value of cathode voltage for CH1	60	R	INT16	10	[V]
Set value of emission voltage (*) / Set value of cathode current for CH2 (**)	61	R/W	INT16	10 / 100	0.0..1000[V] / 0.00..17.00[A]
Read value of emission voltage (*) / Read value of cathode current for CH2 (**)	62	R	INT16	10 / 100	[V] / [A]

(*) - if HV module is installed

(**) - if two DC modules are installed

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Read value of emission current (*) / Read value of cathode voltage for CH2 (**)	63	R	INT16	1000 / 10	[A] / [V]
Cooling valve mode for CH1: 0 - Still off 1 - Still on 2 - Auto	64	R/W	UINT8		0..2
Cooling valve trigger temperature for CH1	65	R/W	INT32	100	such as measurement range of sensor assigned to process value
Ramp of output controlled by PID for CH1	67	R/W	INT16	10	
Ramp of output controlled by PID unit for CH1: 0 - %/s 1 - %/min 2 - %/h	68	R/W	UINT8		0..2
Vaccum interlock: 0 - off 1 - on	69	R/W	UINT8		0,1
Go to OPERATE for CH1	70	R/W	UINT8		1
Go to STANDBY for CH1	71	R/W	UINT8		1
Switch PID controller to RUN state for CH1	72	R/W	UINT8		1
Switch PID controller to HOLD state for CH1	73	R/W	UINT8		1
Turn AUTOTUNE on for CH1	74	R/W	UINT8		1
Turn AUTOTUNE off for CH1	75	R/W	UINT8		1
Timer counting direction for CH1: 0 - down 1 - up	76	R/W	UINT8		0, 1
Actual operate time for CH1	77	R	INT32		sek
Operate time setpoint for CH1	79	R/W	INT32		sek
PID actual setpoint (T mode) for CH1	81	R	INT32	100	[K]
for the future use	83	R	INT16		
Status 2 (version dependent): (**) bit0: Device state for CH2: 0-STANDBY, 1-OPERATE	84	R	INT16		bit field
Status 3 (version dependent): (**) bit0: Presence of Digital card bit1: Internal Bus connection fail bit2: No Interlock for CH1 bit3: No Interlock for CH2 bit4: DC1 voltage limit bit5: DC2 voltage limit bit6: DC1 current limit bit7: DC2 current limit bit8: Presence of DC1 module bit9: Presence of DC2 module bit10: No sensor for process value for CH1 bit11: No sensor for process value for CH2 bit12: AUTOTUNE fail for CH1 bit13: AUTOTUNE fail for CH2 bit14: State of cooling valve for CH1 bit15: State of cooling valve for CH2	85	R	INT16		bit field

(*) - if HV module is installed

(**) - if two DC modules are installed

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Configuration of DC module connection (**): 1 - one DC module is presence 2 - two DC module works independently 3 - serial connection 4 - parallel connection 5 - incorrect connection	86	R	UINT8		
PID state for CH2: (**) 0 - Off 1 - Run 2 - Hold	87	R	UINT8		0..2
Process value for CH2 (**)	88	R	INT32	100	[K]
PID setpoint (T mode) for CH2 (**)	90	R/W	INT32	100	such as measurement range of sensor assigned to process value
PID setpoint (ΔT mode) for CH2 (**)	92	R/W	INT16	10	-5.0 .. 5.0 [K/s]
Trigger temperature(ΔT mode) for CH2 (**)	93	R/W	INT32	100	such as measurement range of sensor assigned to process value
End temperature (ΔT mode) for CH2 (**)	95	R/W	INT32	100	such as measurement range of sensor assigned to process value
Work mode for CH2: (**) 0 - Manual 1 - Auto 2 - Extern (read only) 3 - PID out (read only)	97	R/W	UINT8		0..3
PID regulation type for CH2: (**) 0 - Control of temperature (T mode) 1 - Control of temperature ramp (ΔT mode)	98	R/W	UINT8		0..1
Input selection for process value for CH2: (**) 0 - Thermocoulpe channel TC1 1 - Thermocoulpe channel TC2 2 - Diode channel D1 3 - Diode channel D2 4 - Resistance channel RTD 5 - Analog input channel 1 6 - Analog input channel 2	99	R/W	UINT8		0..6
Process value unit for CH2: (**) 0 - Kelvin 1 - degree Celsius 2 - degree Fahrenheit 3 - Volt (read only)	100	R/W	UINT8		0..1
PID setpoint ramp for CH2 (**)	101	R/W	INT16	10	0..1000
PID setpoint ramp unit for CH2: (**) 0 - Process value unit/s 1 - Process value unit/min 2 - Process value unit/h	102	R/W	UINT8		0..2
P parameter in T mode for CH2 (**)	103	R/W	INT16	10	0.1..1000
I parameter in T mode for CH2 (**)	104	R/W	INT16		0..1000
D parameter in T mode for CH2 (**)	105	R/W	INT16		0..1000
P parameter in ΔT mode for CH2 (**)	106	R/W	INT16	10	0.1..1000
I parameter in ΔT mode for CH2 (**)	107	R/W	INT16		0..1000
D parameter in ΔT mode for CH2 (**)	108	R/W	INT16		0..1000

(*) - if HV module is installed

(**) - if two DC modules are installed

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Cooling valve mode for CH2: (**) 0 - Still off 1 - Still on 2 - Auto	109	R/W	UINT8		0..2
Cooling valve trigger temperature for CH2 (**)	110	R/W	INT32	100	such as measurement range of sensor assigned to process value
Ramp of output controlled by PID for CH2 (**)	112	R/W	INT16	10	
Ramp of output controlled by PID unit for CH2: (**) 0 - %/s 1 - %/min 2 - %/h	113	R/W	UINT8		0..2
Go to OPERATE for CH2 (**)	114	R/W	UINT8		1
Go to STANDBY for CH2 (**)	115	R/W	UINT8		1
Switch PID controller to RUN state for CH2 (**)	116	R/W	UINT8		1
Switch PID controller to HOLD state for CH2 (**)	117	R/W	UINT8		1
Turn AUTOTUNE on for CH2 (**)	118	R/W	UINT8		1
Turn AUTOTUNE off for CH2 (**)	119	R/W	UINT8		1
Timer counting direction for CH2: (**) 0 - down 1 - up	120	R/W	UINT8		0, 1
Actual operate time for CH2 (**)	121	R	INT32		sek
Operate time setpoint for CH2 (**)	123	R/W	INT32		sek
PID actual setpoint (T mode) for CH2	125	R	INT32	100	[K]
Enable safe setpoint for CH1	128	R/W	UINT8		0,1
Safe setpoint value for CH1	129	R/W	INT16	10	0.0 .. 473.1 [K]
Value of temperature increase rate in the SAFE mode for CH1	130	R/W	INT16	10	1..1000
Unit of temperature increase rate in the SAFE mode for CH1: 0 - Aktualna jednostka procesu/s 1 - Aktualna jednostka procesu/min 2 - Aktualna jednostka procesu/h	131	R/W	UINT8		0..2
Normal Setpoint Auto Return for CH1	132	R/W	UINT8		0,1
Enable safe setpoint for dla CH2	133	R/W	UINT8		0,1
Safe setpoint value for CH2	134	R/W	INT16	10	0.0 .. 473.1 [K]
Value of temperature increase rate in the SAFE mode for CH2	135	R/W	INT16	10	1..1000
Unit of temperature increase rate in the SAFE mode for CH2: 0 - Aktualna jednostka procesu/s 1 - Aktualna jednostka procesu/min 2 - Aktualna jednostka procesu/h	136	R/W	UINT8		0..2
Normal Setpoint Auto Return for CH2	137	R/W	UINT8		0,1
Enable EB mode with an external HV power supply	138	R/W	UINT8		0,1
Nominal voltage of external HV power supply	139	R/W	INT16		1..1500[V]
Nominal current of external HV power supply	140	R/W	INT16		1..5000[mA]
Value of control voltage Aout1 for the nominal voltage of external HV power supply	141	R/W	INT16	1000	1.000..11.000[V]

(*) - if HV module is installed

(**) - if two DC modules are installed

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Value of control voltage Aout2 for the nominal current of external HV power supply	142	R/W	INT16	1000	1.000..11.000[V]
Value of input voltage Ain1 for the nominal voltage of external HV power supply	143	R/W	INT16	1000	1.000..11.000[V]
Value of input voltage Ain2 for the nominal current of external HV power supply	144	R/W	INT16	1000	1.000..11.000[V]
(*) - if HV module is installed (**) - if two DC modules are installed					

Table 6.11: **Map of HEAT3 Power Supply**

FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
GLOBAL DEVICE SETTINGS					
Release remote control	1000	R/W	UINT8		
Product number	1001	R	15·CHAR		
Serial number	1009	R	13·CHAR		
Software version - TAG number	1016	R	80·CHAR		
Software version - HASH cocd	1056	R	80·CHAR		
Device name	1096	R	16·CHAR		
Customer name	1104	R/W	18·CHAR		
Touch screen autolock	1113	R/W	UINT8		0, 1
System date	1114	R/W	10·CHAR		format: yyyy.MM.dd
System time	1119	R/W	8·CHAR		format: hh:mm:ss
Panel timer time	1123	R/W	8·CHAR		format: hh:mm:ss
Panel timer actual time	1127	R	8·CHAR		format: hh:mm:ss
Error codes - 10 successive codes in a size 2BYTE	1131	R	20·UINT8		look. tab 6.21, 6.24
Warning codes - 10 successive codes in a size 2 BYTE	1141	R	20·UINT8		look. tab 6.22 , 6.25
Status of remote control enable	1151	R	UINT8		0, 1

Table 6.12: Map of global settings registers

FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
DIGITAL INPUTS SETTINGS					
Channel number to which the digital input would be assigned. For example, if the device supports two vacuum gauges this parameter should be set to 1 or 2 respectively.	1200	R/W	UINT8		1 ..
Logical function code to which the digital input would be assigned: 1 - Interlock 2 - Operate ON. 3 - Operate OFF. 4 - Pressure Emiss ON 5 - Pressure Emiss OFF 6 - Open Shutter 7 - Close Shutter 8 - Zero Thickness 9 - Zero shutter time 10 - Remote Control Availability of functions is device dependent.	1201	R/W	UINT8		

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
The number of the digital input that is assigned to the selected channel and the logical function	1202	R/W	UINT8		1 .. n
Digital input 1 sense control: 0 - low level 1 - high level 2 - falling edge 3 - rising edge 4 - rising/falling edge 5 - falling/rising edge	1203	R/W	UINT8		1 .. 5
Digital input 2 sense control: *look sense control input 1*	1204	R/W	UINT8		1 .. 5
Digital input 3 sense control: *look sense control input 1*	1205	R/W	UINT8		1 .. 5
Digital input n sense control: *look sense control input 1*	1202 + n	R/W	UINT8		1 .. 5

Table 6.13: Map of digital inputs registers

FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
RELAYS SETTINGS					
Function code assigned to relay (digital output) number 1: Code corresponds to the position of function in the menu *'Relay Outputs/Out x'*. For example, if the menu looks as below: ◦ *Relay Outputs* ◦ *Out 1* ◦ *Setpoint 1* ◦ *Setpoint 2* ◦ *Still OFF* ◦ *Still ON* ◦ *None* Code of function *Still OFF* is 3	1300	R/W	UINT8		
Operating mode of the relay(digital output) number 1: Description: 0 - Normal Open contact 1 - Normal Close contact	1301	R/W	UINT8		
Function code assigned to relay (digital output) number 2: Description - look output 1	1302	R/W	UINT8		
Operating mode of the relay(digital output) number 2: Description - look operating mode output 1	1303	R/W	UINT8		
Function code assigned to relay (digital output) number n: Description - look output 1	1300 + 2·(n-1)	R/W	UINT8		
Operating mode of the relay(digital output) number n: Description - look operating mode output 1	1301 + 2·(n-1)	R/W	UINT8		

Table 6.14: Map of relays settings registers

FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
ANALOG INPUTS SETTINGS					
Controlled function code to which the analog input would be assigned: Code corresponds to the position of function in the menu: *Analog Inputs/Controlled Value*. For example, if the menu looks as below: ◦ *Analog Inputs* ◦ *Controlled Value* ◦ *U source* ◦ *I emis* Code of function *I emis* is 2	1400	R/W	UINT8		1 ..
The number of analog input assigned to the controlled function. 0 - no input assigned	1401	R/W	UINT8		0 .. n
Input range minimum value 1	1402	R/W	INT16	1000	0 .. 10 [V]
Input range maximum value 1	1403	R/W	INT16	1000	0 .. 10 [V]
Input range minimum value n	1402 + 2·(n-1)	R/W	INT16	1000	0 .. 10 [V]
Input range maximum valueo n	1403 + 2·(n-1)	R/W	INT16	1000	0 .. 10 [V]

Table 6.15: Map of analog inputs registers

FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
ANALOG OUTPUTS SETTINGS					
Signal source for analogue output 1: Corresponds to the position of signal source in the menu *Source* of Analog out channel. For example, if the menu looks as below: ◦ *Source* ◦ *Pressure 1* ◦ *Pressure 2* ◦ *Usource* ◦ *Iemis.* ◦ *None* Code of signal source *Iemis* is 4	1500	R/W	UINT8		
Retransmission mode for analog output 1: 0 - 1 to 1 1 - exponent 2 - range	1501	R/W	UINT8		
Retransmission scale for analog output 1: 0 - linear 1 - logarithmic	1502	R/W	UINT8		
Minimum value of retransmitted parametter for analog output 1. It corresponds to the minimum output voltage.	1503	R/W	FLOAT		Unit and min/max is signal source dependent.
Maximum value of retransmitted parametter for analog output 1. It corresponds to the maximum output voltage.	1505	R/W	FLOAT		Unit and min/max is signal source dependent.
Minimum value of the output voltage for analog output 1	1507	R/W	INT16	1000	0 .. 10 [V]
Minimum value of the output voltage for analog output 1	1508	R/W	INT16	1000	0 .. 10 [V]
Signal source for analogue output n: Description - look output 1	1500 + 9·(n-1)	R/W	UINT8		
Retransmission mode for analog output n: Description - look output 1	1501 + 9·(n-1)	R/W	UINT8		
Retransmission scale for analog output n: Description - look output 1	1502 + 9·(n-1)	R/W	UINT8		

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Minimum value of retransmitted parametter for analog output n. It corresponds to the minimum output voltage.	1503 + 9·(n-1)	R/W	FLOAT		Unit and min/max is signal source dependent
Maximum value of retransmitted parametter for analog output n. It corresponds to the maximum output voltage.	1505 + 9·(n-1)	R/W	FLOAT		Unit and min/max is signal source dependent
Minimum value of the output voltage for analog output n	1507 + 9·(n-1)	R/W	INT16	1000	0 .. 10 [V]
Minimum value of the output voltage for analog output n	1508 + 9·(n-1)	R/W	INT16	1000	0 .. 10 [V]

Table 6.16: Map of analog outputs registers

FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
PRESSURE CHANNELS SETTINGS					
Actual pressure value in channel 1	1600	R	FLOAT		[mbar]
Status of pressure channel 1: bit0: sensor break bit1: emission state bit2: degasing state bit3: setpoint state bit4..7: not used	1602	R	UINT8		bit field
State of pressure channel 1: 0xFF - Sensor Break 0 - vacuum is displayed 1 - Wait for emission 2 - No Emission 3 - Wait for ignition 4 - Not Calibrated 5 - voltage is displayed 6 - degasing 7 - Exter. Setpoint 8 - Low Pressure 9 - High Pressure 10 - 0.00e+00	1603	R	UINT8		
Pressure unit in channel 1: 0 - mbar 1 - Torr 2 - Pa 3 - psia	1604	R/W	UINT8		
Low setpoint for channel 1	1605	R/W	FLOAT		1.00e-14 .. 1.00e+8 [mbar]
High setpoint for channel 1	1607	R/W	FLOAT		1.00e-14 .. 1.00e+8 [mbar]
Degass possibility for channel 1: 0 - degas possible 1 - sensor break 2 - vacuum gauge doesn't support degas 3 - too low vacuum in chamber, to start the degassing	1609	R	UINT8		
Actual degas time in channel 1	1610	R	INT16		[s]

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Vacuum gauge type in channel 1: 0 - CTR90/91 1 - TTR90 2 - TTR211 3 - PTR225 4 - PTR90 5 - ITR90 6 - ITR100 7 - Baratron 8 - ANALOG IN 9 - MKS 937A 10 - PG105 11 - MG13/14 12 - PKR 251/360/361 13 - PCR280/TPR28x 14 - ATMION 15 - reserved 16 - IKR360/361	1611	R/W	UINT8		
Full scale parameter for channel 1: *If vacuum gauge type is **CTR90/91**:* 0 - 0.1 Torr 1 - 1 Torr 2 - 10 Torr 3 - 100 Torr 4 - 1000 Torr *If vacuum gauge type is **Baratron**:* 0 - 10 Torr 1 - 50 Torr 2 - 100 Torr 3 - 500 Torr 4 - 1000 Torr 5 - 20 psia 6 - 30 psia 7 - 50 psia 8 - 60 psia 9 - 100 psia 10 - 250 psia 11 - 500 psia 12 - 725 psia 13 - 1000 psia 14 - 2000 psia 15 - 3000 psia	1612	R/W	UINT8		
Type of gas - correction parameter for channel 1: 0 - Air 1 - He 2 - Ne 3 - Ar 4 - Kr 5 - Xe 6 - H2 7 - CO 8 - define	1613	R/W	UINT8		
Defined gas factor for channel 1	1614	R/W	INT16	100	0.01 .. 9.99
Filtration level of vacuum measurement in channel 1: 0 - low 1 - medium 2 - high	1615	R/W	UINT8		
Degas time for channel 1	1616	R/W	UINT8		1 .. 30 [min]
Actual voltage value in channel 1	1617	R	FLOAT		[V]
Low setpoint for sensor type **ANALOG IN** in channel 1	1619	R/W	FLOAT		0 .. 10 [V]
High setpoint for sensor type **ANALOG IN** in channel 1	1621	R/W	FLOAT		0 .. 10 [V]
Start degasing in channel 1	1623	R/W	UINT8		1
Stop degasing in channel 1	1624	R/W	UINT8		1

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FUNCTION	ADDRESS	TYPE	FORMAT	MUL	RANGE [UNIT]
Emission ON for channel 1	1625	R/W	UINT8		1
Emission OFF for channel 1	1626	R/W	UINT8		1
Actual pressure value in channel n	1600 + 27·(n-1)	R	FLOAT		[mbar]
Status of pressure channel n: Description - look channel 1 (adres: 1602)	1602 + 27·(n-1)	R	UINT8		
State of pressure channel n: Description - look channel 1 (adres: 1603)	1603 + 27·(n-1)	R	UINT8		
Pressure unit in channel n: 0 - mbar 1 - Torr 2 - Pa 3 - psia	1604 + 27·(n-1)	R/W	UINT8		
Low setpoint for channel n	1605 + 27·(n-1)	R/W	FLOAT		1.00e-14 .. 1.00e+8 [mbar]
High setpoint for channel n	1607 + 27·(n-1)	R/W	FLOAT		1.00e-14 .. 1.00e+8 [mbar]
Degass possibility for channel n: 0 - degas possible 1 - sensor break 2 - vacuum gauge doesn't support degas 3 - too low vacuum in chamber, to start the degassing	1609 + 27·(n-1)	R	UINT8		
Actual degas time in channel n	1610 + 27·(n-1)	R	INT16		[s]
Vacuum gauge type in channel n: Description - look channel 1 (adres: 1611)	1611 + 27·(n-1)	R/W	UINT8		
Full scale parameter for channel n: Description - look channel 1 (adres: 1612)	1612 + 27·(n-1)	R/W	UINT8		
Type of gas - correction parameter for channel n: Description - look channel 1 (adres: 1613)	1613 + 27·(n-1)	R/W	UINT8		
Defined gas factor for channel n	1614 + 27·(n-1)	R/W	INT16	100	0.01 .. 9.99
Filtration level of vacuum measurement in channel n: 0 - low 1 - medium 2 - high	1615 + 27·(n-1)	R/W	UINT8		
Degas time for channel n	1616 + 27·(n-1)	R/W	UINT8		1 .. 30 [min]
Actual voltage value in channel n	1617 + 27·(n-1)	R	FLOAT		[V]
Low setpoint for sensor type **ANALOG IN** in channel n	1619 + 27·(n-1)	R/W	FLOAT		0 .. 10 [V]
High setpoint for sensor type **ANALOG IN** in channel n	1621 + 27·(n-1)	R/W	FLOAT		0 .. 10 [V]
Start degasing in channel n	1623 + 27·(n-1)	R/W	UINT8		1
Stop degasing in channel n	1624 + 27·(n-1)	R/W	UINT8		1
Emission ON for channel n	1625 + 27·(n-1)	R/W	UINT8		1
Emission OFF for channel n	1626 + 27·(n-1)	R/W	UINT8		1

Table 6.17: Map of pressure channels registers

6.5 PREVAC V2.x PROTOCOL

This chapter describes communication with a HEAT3 using the Prevac V2.x protocol.

6.5.1 CONNECTION PARAMETERS

PARAMETER	VALUE
Data bits	8
Parity	None
Stop bits	1
Flow control	None
Baud rate	57600 (default value)

Table 6.18: Connection parameters

6.5.2 DATA FRAME

DATA FRAME	
Byte	**Description**
1 - HEADER	First byte is responsible for identifying the serial protocol. Header in hexadecimal is 0xBB
2 - DATA LENGTH	Length of the data field. Maximum data file length is 0xFF (256 bytes). Prevac Serial Protocol
3 - DEVICE ADDRESS	Identification of hardware device address. Default value is 0xC8
4 - HOST ADDRESS	Host identification address. Assigned to host during the registration process (using a unique ID).
5 - FUNCTION CODE - MSB	First procedure function code byte 8th (MSB) bit is the read(0)/write(1) select bit
6 - FUNCTION CODE - LSB	Second procedure function code byte
7 .. [7 + DATA LENGTH] - DATA FIELD	Data capture needed to realize defined functions.
[7 + DATA LENGTH] + 1(last frame position) - CRC	CRC is simple module 256 calculated without protocol header byte(see section 6.5.2.4)

Table 6.19: Data frame

6.5.2.1 ORDER TYPES

There are two types of commands:

- write orders,

- read orders.

Type the command defines the most significant bit of command code (see 6.8). If the bit is a logical ”1”, then the function code is interpreted as a command Save/Set. Otherwise, the order read. For example: order 0x7F06(set customer Name) allow read customer Name, and order 0xFF06(MSB set to ”1”) allow set customer Name.

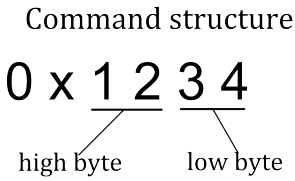

Figure 6.7: Command structure

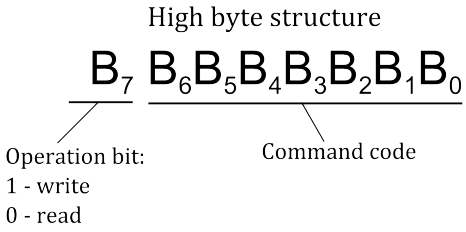

Figure 6.8: High byte command structure

For a read command, the device returns the value in a specific data type assigned to the command (see tables of orders).
For orders write the answers may be as follows:

- write command is correct (proper type, has the appropriate length and value), the device responds 0x00 value in the last byte in the data field.
- write order is incorrect, the device return error code in the last data field byte as shown in Table ref Global communication status codes.

WARNING

Read/Write Parameters.
Reading the parameters of the device is always allowed (even if the device is not in REMOTE CONTROL mode).
Writing parameters to the device requires:

- switching device in REMOTE CONTROL mode,
- registration using a unique ID
- receive permission to control as *Master*.

The registration procedure host is described in subsection 6.9

6.5.2.2 APPLIED DATA TYPES

DATA TYPE	DESCRIPTION	EXAMPLE
ASCII	The text value of the length specified in the *DATA LENGTH*	”CUSTOMER”
Long	4 bytes integer value in *Big endian* format(The most significant byte is placed first in data field)	0x000082AC
Byte	1 byte integer value, used for enumerate type and control command(ON/OFF)	0x05
Bool	true/false value (0 = false, 1 = true)	0x01, 0x00
Double	8 bytes value in IEEE 754 double-precision binary floating-point in *Big endian* format(The most significant byte is placed first in data field)	0x4028 A4DD 2F1A 9FBE

Table 6.20: Data types

6.5.2.3 INDEXING

There are 3 types of orders because of the type of indexing:

- indexed - require an index on firs byte of data fields in order to appeal to a particular object (module) on the device. On the following bytes to put the data in a format compatible with the type of order.
- indexed (no matter) - the index does not matter, but it is necessary to provide an index (eg. 1) on first byte data field. On the following bytes to put the data in a format compatible with the type of order
- without an index - only orders from the global group (see global commands table). The value we put from the first byte of the data field.

For example, reading the vacuum level from device that has 2 vacuum channels, needs to be sent command 0x0101 with the index 0x01 to read the value of the first channel:
TX: BB 01 C8 01 01 01 01 CD
Index and 0x02 to read the value of the second channel:
TX: BB 01 C8 01 01 01 02 CE.

WARNING

Index out of range.
If the index value is outside the range defined for a given command, the device returns the error code 0x93 in the last position of the data field.

If the order requires indexing, the table specified item *index* with with the scope of change. If the order does not apply to index this field *Index* is not specified in the table.

6.5.2.4 CRC

CRC is simple modulo 256 calculate without protocol header byte. Below is a sample code for the enumerator checksum value.

```
quint8 mod256_CRC = 0;
for(i= 1; i <= InputFrame->size; i++) mod256_CRC += InputFrame(i);
```

6.5.3 EXAMPLES

6.5.3.1 READ PARAMETERS FROM DEVICES

Read FG pressure value (Function code 0x0101, data field: 0x01 (index): **Request:**
TX: BB 01 C8 01 01 01 01 CD
Answer (CH1=6.25 E-2):
RX: BB 09 C8 01 01 01 01 3F B0 00 00 00 00 00 00 C4

6.5.3.2 SETUP PARAMETERS

Shutter control(Function code 0x8207, data field: 0x01 (index), 0x01 (1-ON / 0-OFF)
Request:
TX: BB 02 C8 01 82 07 01 01 56
Answer:
RX: BB 02 C8 01 82 07 01 00 55
Command executed correctly: last byte in data field equal 0.

Setting the target temperature out of range(Function code 0x8706, data field: 0x01[index], 1500.0 [target temperature])
Request:
TX: BB 09 C8 01 87 06 01 40 97 70 00 00 00 00 00 A7
Answer:
RX: BB 02 C8 01 87 06 01 91 EA
The order not executed: returned error code 0x91 in last byte data field (value too high - see 6.23).

6.5.3.3 TAKING OVER CONTROL AS MASTER

Request:
TX: BB 01 C8 01 FF F1 01 BB
Answer:
RX: BB 01 C8 01 FF F1 00 BA
The data field equal to 0 - to take control goes correctly.

6.5.4 UNIQUE ID

For proper operation of mechanism for the allocation numbers of hosts is necessary to ensure that each computer using the unique ID during the registration process host(command 0x7FF0). A unique string of characters can be extracted from the operating system using the codes explained the program.

6.5.4.1 WINDOWS OPERATING SYSTEM

```
#define _WIN32_DCOM
#include <comdef.h>
#include <comutil.h>
#include <Wbemidl.h>
#pragma comment(lib, "wbemuuid.lib")
```

```
6
7  long get_uuid(char** uuid, int* size)
8  {
9          HRESULT hr = CoInitializeEx(0, COINIT_MULTITHREADED);
10         if (FAILED(hr))
11                 return 1;
12
13         hr = CoInitializeSecurity(
14                 NULL,
15                 -1,                              // COM authentication
16                 NULL,                            // Authentication services
17                 NULL,                            // Reserved
18                 RPC_C_AUTHN_LEVEL_DEFAULT,       // Default authentication
19                 RPC_C_IMP_LEVEL_IMPERSONATE,     // Default Impersonation
20                 NULL,                            // Authentication info
21                 EOAC_NONE,                       // Additional capabilities
22                 NULL                             // Reserved
23                 );
24
25         if (FAILED(hr)) {
26                 CoUninitialize();
27                 return 1;
28         }
29
30         IWbemLocator *pLoc = NULL;
31
32         hr = CoCreateInstance(
33                 CLSID_WbemLocator,
34                 0,
35                 CLSCTX_INPROC_SERVER,
36                 IID_IWbemLocator, (LPVOID *)&pLoc);
37
38         if (FAILED(hr)) {
39                 CoUninitialize();
40                 return 1;
41         }
42
43         IWbemServices *pSvc = NULL;
44
45         hr = pLoc->ConnectServer(
46                 _bstr_t(L"ROOT\\CIMV2"), // Object path of WMI namespace
47                 NULL,                    // User name. NULL = current user
48                 NULL,                    // User password. NULL = current
49                 0,                       // Locale. NULL indicates current
50                 NULL,                    // Security flags.
51                 0,                       // Authority (for example, Kerberos)
52                 0,                       // Context object
53                 &pSvc                    // pointer to IWbemServices proxy
54                 );
55
56         if (FAILED(hr)) {
57                 pLoc->Release();
58                 CoUninitialize();
59                 return 1;
60         }
61
62         hr = CoSetProxyBlanket(
63                 pSvc,                            // Indicates the proxy to set
64                 RPC_C_AUTHN_WINNT,               // RPC_C_AUTHN_xxx
65                 RPC_C_AUTHZ_NONE,                // RPC_C_AUTHZ_xxx
66                 NULL,                            // Server principal name
67                 RPC_C_AUTHN_LEVEL_CALL,          // RPC_C_AUTHN_LEVEL_xxx
68                 RPC_C_IMP_LEVEL_IMPERSONATE,     // RPC_C_IMP_LEVEL_xxx
```

```
69                  NULL,                           // client identity
70                  EOAC_NONE                       // proxy capabilities
71                  );
72
73          if (FAILED(hr)) {
74                  pSvc->Release();
75                  pLoc->Release();
76                  CoUninitialize();
77                  return 1;
78          }
79
80          IEnumWbemClassObject* pEnumerator = NULL;
81          hr = pSvc->ExecQuery(
82                  bstr_t("WQL"),
83                  bstr_t("SELECT * FROM Win32_ComputerSystemProduct"),
84                  WBEM_FLAG_FORWARD_ONLY | WBEM_FLAG_RETURN_IMMEDIATELY,
85                  NULL,
86                  &pEnumerator);
87
88          if (FAILED(hr)) {
89                  pSvc->Release();
90                  pLoc->Release();
91                  CoUninitialize();
92                  return 1;
93          }
94
95          IWbemClassObject *pclsObj = NULL;
96          ULONG uReturn = 0;
97
98          while (pEnumerator)
99          {
100                 HRESULT hr =pEnumerator->Next(WBEM_INFINITE, 1, &pclsObj, &
                       uReturn);
101
102                 if (uReturn == 0)
103                         break;
104
105                 VARIANT vtProp;
106
107                 hr = pclsObj->Get(L"UUID", 0, &vtProp, 0, 0);
108                 *size = SysStringLen(vtProp.bstrVal);
109                 *uuid = _com_util::ConvertBSTRToString(vtProp.bstrVal);
110                 // ConvertBSTRToString allocates a string you must delete!
111                 VariantClear(&vtProp);
112
113                 pclsObj->Release();
114         }
115
116         pSvc->Release();
117         pLoc->Release();
118         pEnumerator->Release();
119         CoUninitialize();
120
121         return 0;
122 }
123
124 // Usage example:
125 //      char* uuid;
126 //      int size;
127 //      get_uuid(&uuid, &size);
128 //      // do sth with uuid
129 //      delete[] uuid;
```

6.5.4.2 LINUX - OPEARATING SYSTEM

```
#include <stdio.h>
#include <stdlib.h>

// First make a copy of /sys/class/dmi/id/product_uuid to your source directory.
// Type: sudo cp /sys/class/dmi/id/product_uuid ./product_uuid
// Then change file attributes of the file you've copied.
// Type: sudo chmod 777 ./product_uuid

long get_uuid(char** uuid, int* size)
{
 long error = -1;
 FILE *file = popen("cat ./product_uuid | egrep
 '[A-Fa-f0-9]{8}\-[A-Fa-f0-9]{4}\-[A-Fa-f0-9]{4}\
 -[A-Fa-f0-9]{4}\-[A-Fa-f0-9]{12}'", "r");
 if (file != NULL) {
     *size = 36;
     *uuid = (char*)malloc(*size+1);
        // Allocated buffer you must free!
     if (*uuid != NULL) {
         fread(*uuid, 1, *size, file);
         (*uuid)[*size] = 0;
         error = 0;
     }
     pclose(file);
 }
 return error;
}

// Usage example:
//      char* uuid;
//      int size;
//      get_uuid(&uuid, &size);
//      // do sth with uuid
//      free(uuid);
```

6.5.4.3 ORDERS TYPES

There are two types of commands:

- Read/Write orders,
- Read only orders,

For read commands, the device returns the requested value in the specified data format.
For write commands, the depends on the send value:

- When send value is correct(correct type, has the correct length and value), then device sends 0x00 value into data field. The answer is located in last byte of the data field,
- When send value is incorrect, an appropriate error code is sent in the last byte of the data field.

6.5.4.4 REGISTER NEW HOST

If the remote controller connects to the device first time, follow the procedure for obtaining a host address according to the diagram below.

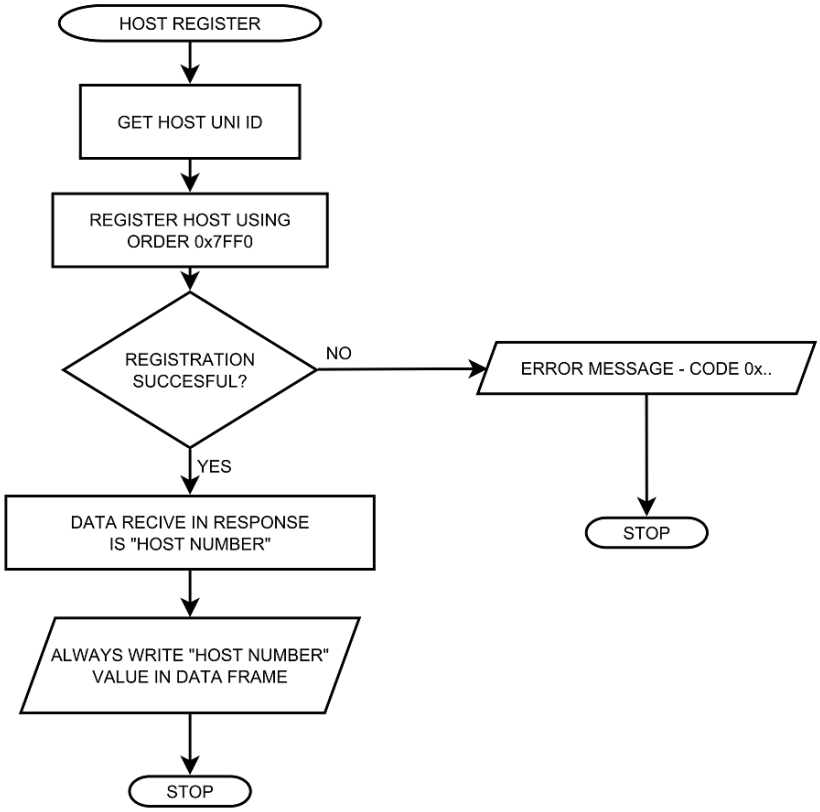

Figure 6.9: Host assign - diagram

Description of the allocation host number order is contained in the table 6.47.

Below is an example procedure for the preparation of a new host address. And then send a command set to Setpoint Low value.

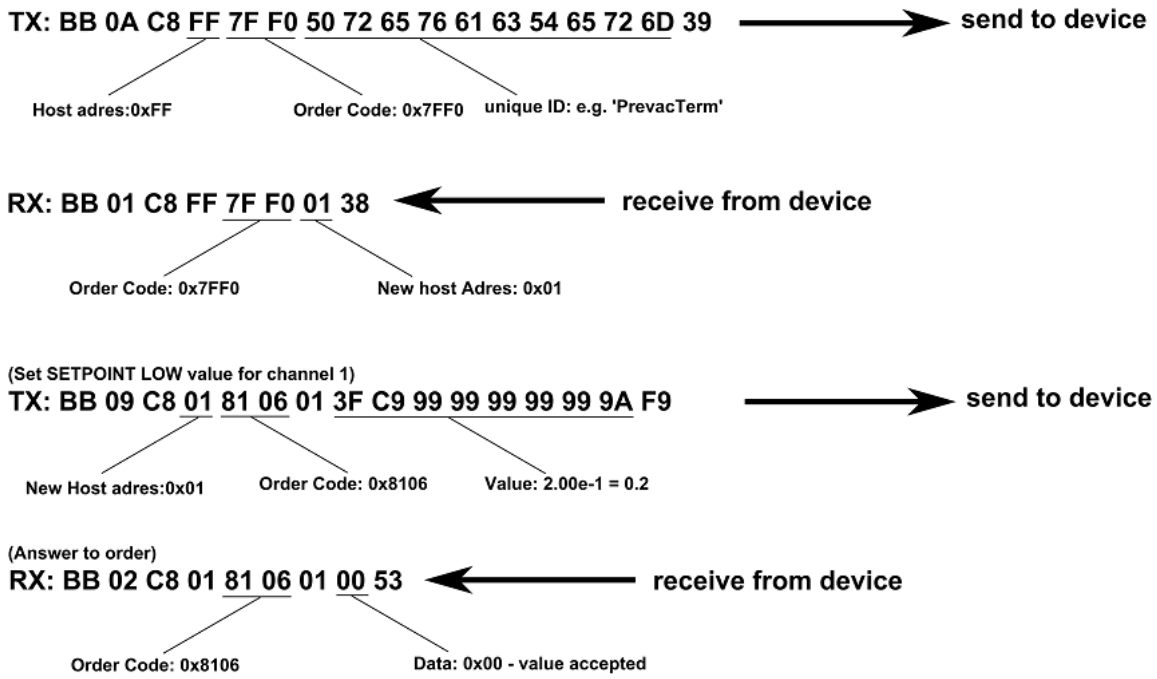

Figure 6.10: Host assign example

6.5.5 GLOBAL DEVICE STATUSES

There are two types of device status: errors and warnings. Status appear in the bar at the right of the main screen of the device. To read the error status, use the command 0x7F51, for warning status use command 0x7F52. In response we receive a code whose meaning is contained in the tables below.

Error code	Description
7F01	Internal communication error
7F02	Communication with Anybus module error
7F03	Communication with Bluetooth Anybus module error
7F04	Critically low disk space

Table 6.21: Global error status

Warning code	Description
7F80	Low disk space.
7F06	Invalid read the internal temperature of the device.
7F07	The internal temperature of the device is above safe level.
7F08	The internal temperature of the unit is too high. Switching to standby mode.

Table 6.22: Global warning status

6.5.6 GLOBAL ERROR CODES

In response to the write command, it is possible to obtain the specifying error status code, which makes impossible execution of the order. The table 6.23 lists the global error codes (apply to all orders). Additionally, the device can return specific error codes, depending on the module in which it is equipped.

Status code	Description
0x00	No errors, order executed correctly
0x91	Value is too large
0x92	Value is too small
0x93	Wrong parameter (probably wrong data format or index out of range)
0x95	Read only parameter, write prohibited
0x96	Host not know and not registered
0x97	Host know but not selected to remote control
0x98	Device configured to work in local mode
0x99	Operation or parameter is not available

Table 6.23: Global status codes

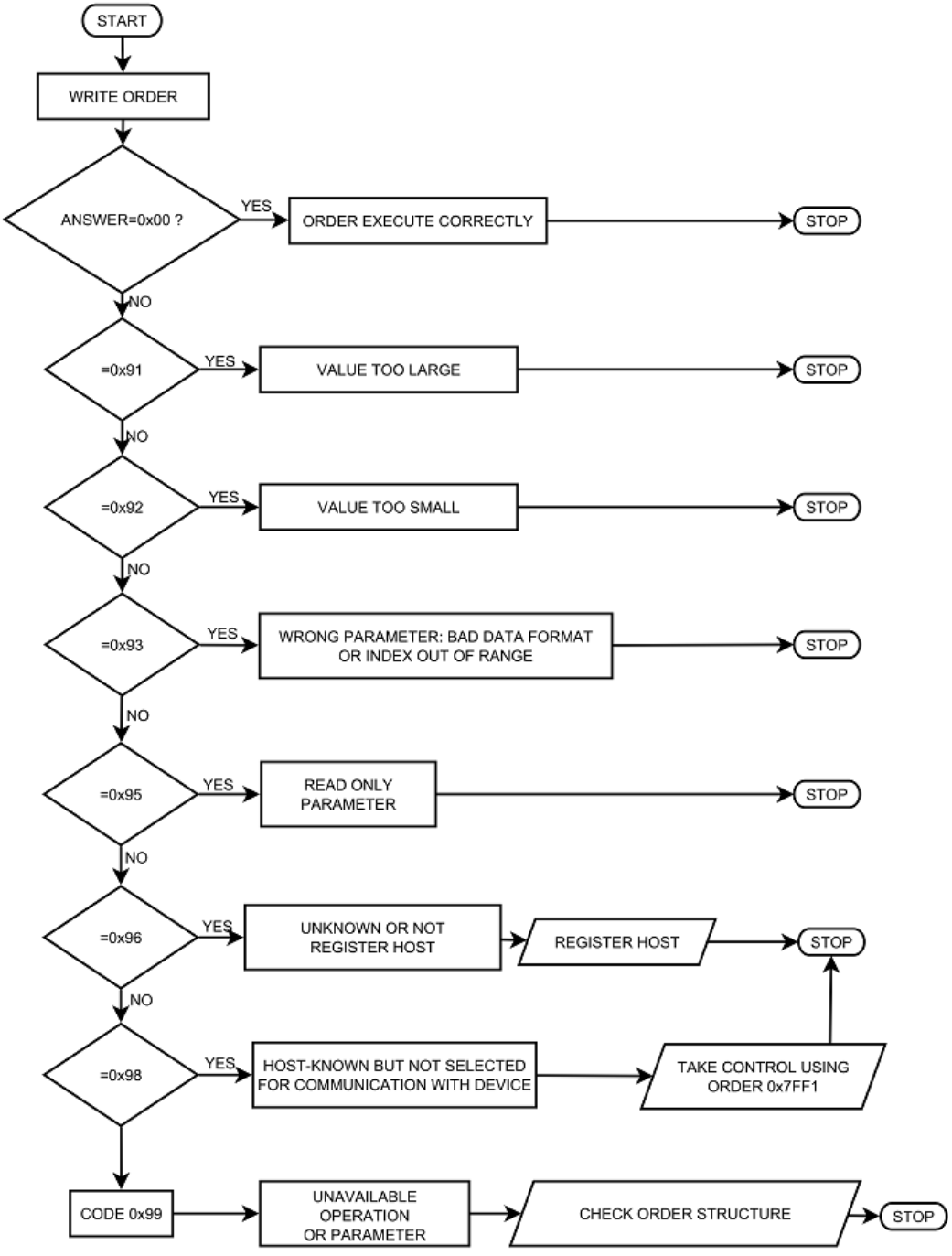

Figure 6.11: Write order example- diagram

6.5.7 HEAT3 STATUS CODES

Error code	Description
4101	DC1 module is not available
4102	The connection to Bus has been lost
4103	DC power supply is damaged or short circuit
4104	HV power supply is damaged
4105	HV power supply has short circuit
4106	Main power failure
4107	Safety relay failure
4108	No Digital Card in the device
4109	DC incorrect configuration
410A	External Interlock Failure
410B	No interlock in channel 1
410C	No interlock in channel 2
410D	No external DC interlock
410E	No external DC1 interlock
410F	No external DC2 interlock
4110	No external DC1 interlock required by module DC2 for proper operation
4111	Vacuum Interlock Failure
4112	Sensor to the PID controller is broken
4113	DC1 power supply is damaged
4114	DC2 power supply is damaged
4115	No external HV interlock
4116	Incorrect connection of output connectors. Swap the output plug

Table 6.24: HEAT3 error status

Warning code	Description
4180	DC1 no load or the connection is broken
4181	DC1 current has reached the limit
4182	Emission current has reached the limit
4183	No external interlock
4184	No vacuum interlock
4185	DC1 voltage has reached the limit
4186	No external HV interlock
4187	Internal calibration module failur.
4188	DC2 no load or the connection is broken
4189	DC2 voltage has reached the limit
418A	DC2 current has reached the limit
418B	No interlock in channel 1
418C	No interlock in channel 2

Table 6.25: HEAT3 warning status

6.5.7.1 HEAT3 COMMUNICATION ERROR CODES

Error code	Description
0x51	Operate is ON
0x52	Internal communication error
0x53	Internal communication error with Bus
0x54	DC module is not available
0x55	No external interlock
0x56	Operate ON is currently controlled by a digital input
0x57	Temperature sensor failure
0x58	Main power failure
0x59	Operate is OFF
0x5A	Actual work mode is Manual or External Control
0x5B	HV module is controlled by Analog Input
0x5C	HV module is not available
0x5D	Actual work mode is External Control
0x5E	Actual work mode is PID OUT
0x5F	Actual work mode is Manual
0x60	Actual regulation mode is dT mode
0x61	Autotune is ON
0x62	Temperature Cart is not available
0x63	Analog Cart is not available
0x64	Device is not in EB mode
0x65	Actual work mode is PID OUT and RES mode
0x66	Actual work mode is PID OUT and EB mode with Output Signal set on Uc(Ic)
0x67	Actual work mode is PID OUT and EB mode with Output Signal set on Ue
0x68	There is no DC module with voltage control
0x69	There is no DC module with current control
0x6A	No vacuum interlock

Table 6.26: HEAT3 communication error codes

Error code	Description
VACUUM GAUGES COMMUNICATION ERROR CODES:	
0x80	CTR90 head not selected to set FS.
0x81	MKS870 head not selected to set FS.
0x82	Not selected ”define” gas type.
0x83	Meter damaged.
0x84	Selected head does not support degas function.
0x85	Vacuum is too low to start system degassing.
0x86	Selected head does not support emission function.

Table 6.27: Vacuum gauges communication error codes

6.5.8 ORDERS LIST

6.5.8.1 GLOBAL ORDERS - FUNCTION CODE 0x7F..

ORDER NUMBER 0x7F01 READ PRODUCT NUMBER					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1-15	Product number	ASCII			

Table 6.28: Read product number

ORDER NUMBER 0x7F02 READ SERIAL NUMBER					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1-13	Serial number	ASCII			

Table 6.29: Read serial number

ORDER NUMBER 0x7F03 READ DEVICE VERSION					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1 - [DATA LENGTH]	Device version	ASCII			

Table 6.30: Read device version

ORDER NUMBER 0x7F04 READ HASH CODE VERSION					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1 - [DATA LENGTH]	Hash code	ASCII			

Table 6.31: Read hash code version

ORDER NUMBER 0x7F05 READ DEVICE NAME					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1 - [DATA LENGTH]	Device name	ASCII			

Table 6.32: Read device name

ORDER NUMBER 0x7F06 CUSTOMER NAME					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1 - [DATA LENGTH]	Customer name (max 17 characters)	ASCII			

Table 6.33: Customer name

ORDER NUMBER 0x7F50 DEVICE STATUS					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Number of device errors 0 - no errors			0	255
2	Number of device warnings 0 - no warnings			0	255

Table 6.34: Read device status

ORDER NUMBER 0x7F51 ERROR CODES					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index of device error	BYTE		0	255
2 - 5	Device error code				

Table 6.35: Read error status code

ORDER NUMBER 0x7F52 WARNING CODES					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index of device warning			0	255
2 - 5	Device warning code				

Table 6.36: Read warning status code

ORDER NUMBER 0x7F60 VOLTAGE VALUE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: 1 - U_c 2 - U_e 3 - U_{f1} 4 - U_{f2} 6 - U_{ext} 7 - U_{erg} 8 - U_{wehn} 9 - U_x 10 - U_y	BYTE			
2-9	Value	DOUBLE	V		

Table 6.37: Voltage value

ORDER NUMBER 0x7F61 ACTUAL VOLTAGE VALUE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: 1 - U_c 2 - U_e 3 - U_{f1} 4 - U_{f2} 6 - U_{ext} 7 - U_{erg} 8 - U_{wehn} 9 - U_x 10 - U_y	BYTE			
2-9	Value	DOUBLE	V		

Table 6.38: Actual voltage value

ORDER NUMBER 0x7F62 CURRENT VALUE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: 1 - I_c 2 - I_e 3 - I_{flux} 4 - I_{fil1} 5 - I_{fil2} 6 - I_{fil3} 7 - I_{fil4}	BYTE			
2-9	Value	DOUBLE	V		

Table 6.39: Current value

ORDER NUMBER 0x7F63 ACTUAL CURRENT VALUE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: 1 - I_c 2 - I_e 3 - I_{flux} 4 - I_{fil1} 5 - I_{fil2} 6 - I_{fil3} 7 - I_{fil4}	BYTE			
2-9	Value	DOUBLE	V		

Table 6.40: Actual current value

ORDER NUMBER 0x7F70 RTC DATA SETTINGS					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1-10	Data value in format *yyyy.mm.dd*	ASCII			

Table 6.41: RTC data settings

ORDER NUMBER 0x7F71 RTC TIME SETTINGS					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1-8	Time value in format *hh:mm:ss*	ASCII			

Table 6.42: RTC time settings

ORDER NUMBER 0x7F72 PANEL TIMER TIME SETTINGS					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1-8	Set panel timer value in format *hh:mm:ss*	ASCII			

Table 6.43: Panel Timer time settings

ORDER NUMBER 0x7F73 PANEL TIMER ACTUAL TIME					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1-8	Actual panel timer value in format *hh:mm:ss*	ASCII			

Table 6.44: Actual panel timer value

ORDER NUMBER 0x7F74 PANEL TIMER START/STOP					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Panel Timer Start/Stop (Start=1, Stop=0)	BYTE			

Table 6.45: Panel timer start/stop

ORDER NUMBER 0x7F0C TOUCH SCREEN AUTOLOCK					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	0 - Touch screen autolock OFF 1 - Touch screen autolock ON				

Table 6.46: Touch screen autolock

ORDER NUMBER 0x7FF0 HOST NUMBER ASSIGN					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
QUERY:					
1 - [DATA LENGTH]	Unique ID	ASCII			
RESPONSE:					
1	Assigned host address	BYTE		1	255

Table 6.47: Host address assign

ORDER NUMBER 0x7FF1 MASTER MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
FOR WRITE ORDER:					
1	Assignment/release *MASTER* mode control 1 - Assignment control, 0 - Relase control,	Byte		0	1
FOR READ ORDER:					
1	*MASTER* control status (bit field) - status returned on particular bits from B0(LSB) to B7(MSB). **B0:** Working as *MASTER* (0 - no, 1 - yes) **B1:** Take control as *MASTER*(0 - forbidden, 1 - permitted). Bit B1=1 if and only if B2=1, B3=1 i B4=0. **B2:** Device *REMOTE CONTROL* mode(0 - inactive, 1 - activate) **B3:** Host registration status(0 - not registered, 1 - registred) **B4:** Other *MASTER* host device in system (0 - no, 1- yes)	Byte			

Table 6.48: Assignment/release of Master mode

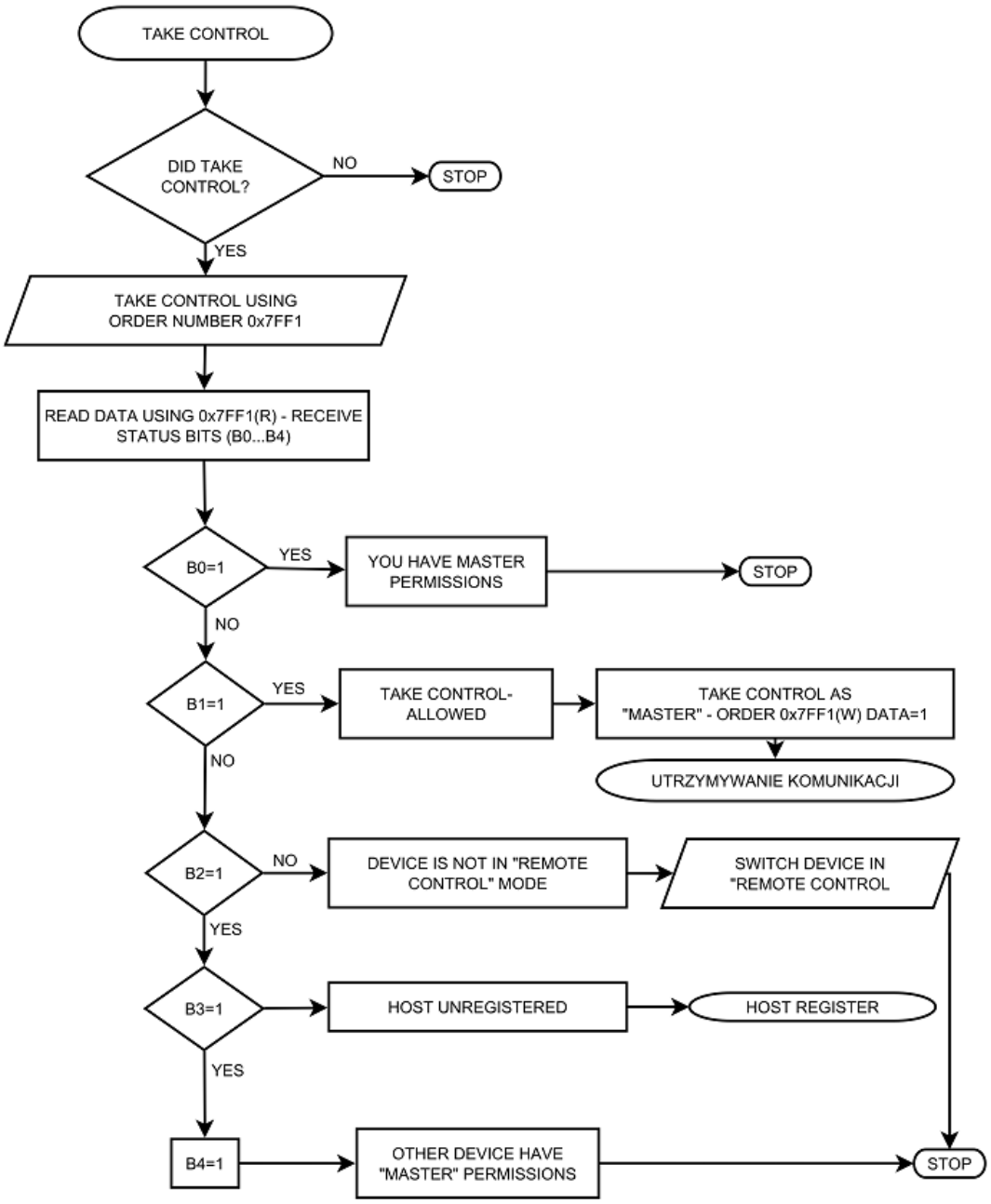

Figure 6.12: Assignment/release of Master mode - sequence diagram

ORDER NUMBER 0x7FAA SEND COMMAND TO DEVICE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1-5	Command (5 characters)	ASCII			
6 - [DATA LENGTH]	Command data (max 32 characters)	ASCII			

Table 6.49: Send command

6.5.8.2 ORDERS HEAT3 - FUNCTION CODE 0x41..

Index value is without function.

ORDER NUMBER 0x4101 OPERATE CONTROL					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	OPERATE controll 0 - Operate OFF 1 - Operate ON	INT		0	1

Table 6.50: OPERATE controll

ORDER NUMBER 0x4102 RUN/HOLD CONTROLL					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	RUN/HOLD controll 0 - HOLD 1 - RUN	INT		0	1

Table 6.51: RUN/HOLD controll

ORDER NUMBER 0x4103 PROCESS VALUE UNIT					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Process Value unit 0-Kelvin 1-Celsjusz 2-Farenheight 3-Volt (read only)	INT		0	3

Table 6.52: Process Value Unit

NUMER ROZKAZU 0x4104 TEMPERATURE READINGS FROM THERMOCOUPLE CHANEL					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index 1- Tc 1 2- Tc 2	INT		1	2
2-9	Temperature readings from thermocouple channel	Double	Kelvin		

Table 6.53: Temperature readings from thermocouple channel

ORDER NUMBER 0x4105 TEMPERATURE READINGS FROM DIODE CHANNEL					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index 1- D 1 2- D 2	INT		1	2
2-9	Temperature readings from diode channel	Double	Kelvin		

Table 6.54: Temperature readings from diode channel

ORDER NUMBER 0x4106 TEMPERATURE READINGS FROM RESISTANCE CHANNEL					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Temperature readings from resistance channel	Double	Kelvin		

Table 6.55: Temperature readings from resistance channel

ORDER NUMBER 0x4107 THERMOCOUPLE TYPE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index 1 - Tc1 2 - Tc2	INT		1	2
2	Type of thermocouple attached to the channel 0 - K-type thermocouple 1 - C-type thermocouple 2 - E-type thermocouple 3 - N-type thermocouple	INT		0	3

Table 6.56: Thermocouple type

ORDER NUMBER 0x4108 DIODE TYPE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index 1 - D1 2 - D2	INT		1	2
2	Type of diode attached to the channel 0 - diode DT670 1 - diode DT470	INT		0	1

Table 6.57: Type of diode attached to the channel

ORDER NUMBER 0x4109 RESISTANCE SENSOR TYPE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	INT			
2	Type of resistance sensor attached to the channel 0 - PT100	INT		0	0

Table 6.58: Type of resistance sensor attached to the channel

ORDER NUMBER 0x410A REGULATION TYPE (T/dT)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Regulation type (T/dT) 0 - T mode 1 - dT mode	INT		0	1

Table 6.59: Regulation type (T/dT)

ORDER NUMBER 0x410B HEATING MODE EB/RES (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2	Heating mode EB/RES 0 - RES heating (resistive) 1 - EB heating (electron bombarded)	INT		0	1

Table 6.60: Heating mode EB/RES

ORDER NUMBER 0x410C WORK MODE (AUTO/MANUAL)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Work mode (AUTO/MANUAL) 0- Manual 1- PID Auto 2- External Controll (read only) 3- PID Out (read only)	INT		0	3

Table 6.61: Work mode (AUTO/MANUAL)

ORDER NUMBER 0x410D AUTOTUNE ON/OFF					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	AUTOTUNE ON/OFF 0- Autotune OFF 1- Autotune ON	INT		0	1

Table 6.62: AUTOTUNE ON/OFF

ORDER NUMBER 0x410E INPUT SELECTION FOR PROCES VALUE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Input selection for Process Value 0- Thermocoulpe Channel 1 (Tc1) 1- Thermocoulpe Channel 2 (Tc2) 2- Diode Channel 1 (D1) 3- Diode Channel 2 (D2) 4- Resistance Channel (RTD) 5- Analog Input Channel 1 (Ain1) 6- Analog Input Channel 2 (Ain2)				

Table 6.63: Input selection for Process Value

ORDER NUMBER 0x410F CATHODE RAMP AT RES MODE AT OPERATE MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Cathode ramp at RES mode at OPERATE mode	Double	V(A)/ time unit	0,01	200

Table 6.64: Cathode ramp at RES mode at OPERATE mode

ORDER NUMBER 0x4110 CATHODE RAMP UNIT AT RES MODE AT OPERATE MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Cathode ramp unit at RES mode at OPERATE mode 0 - V(A)/s 1 - V(A)/min 2 - V(A)/h	INT		0	2

Table 6.65: Cathode ramp unit at RES mode at OPERATE mode

ORDER NUMBER 0x4111 CATHODE RAMP AT RES MODE (DURING TRANSMITION: STANDBY -> MANUAL)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Cathode ramp at RES mode (during transmition: STANDBY->MANUAL)	Double	V(A)/ Time Unit	0,01	200

Table 6.66: Cathode ramp at RES mode (during transmition: STANDBY->MANUAL)

ORDER NUMBER 0x4112 CATHODE RAMP UNIT AT RES MODE (DURING TRANSMISTION STANDBY->MANUAL)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Cathode ramp unit at RES mode (during transmition: STANDBY->MANUAL) 0 - V(A)/s 1 - V(A)/min 2 - V(A)/h	INT		0	2

Table 6.67: Cathode ramp unit at RES mode (during transmition: STANDBY->MANUAL)

ORDER NUMBER 0x4113 CATHODE RAMP AT EB MODE AT OPERATE MODE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Cathode ramp at EB mode at OPERATE mode	Double	V(A)/ time unit	0,01	200

Table 6.68: Cathode ramp at EB mode at OPERATE mode

ORDER NUMBER 0x4114 CATHODE RAMP UNIT AT EB MODE AT OPERATE MODE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2	Cathode ramp unit at EB mode at OPERATE mode 0 - V(A)/s 1 - V(A)/min 2 - V(A)/h	INT		0	2

Table 6.69: Cathode ramp unit at EB mode at OPERATE mode

ORDER NUMBER 0x4115 CATHODE RAMP AT EB MODE (DURING TRANSMITION: STANDBY -> MANUAL) (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Cathode ramp at EB mode (during transmition: STANDBY->MANUAL)	Double	V(A)/ Time Unit	0,01	200

Table 6.70: Cathode ramp at EB mode (during transmition: STANDBY->MANUAL)

ORDER NUMBER 0x4116 CATHODE RAMP UNIT AT EB MODE (DURING TRANSMITION: STANDBY -> MANUAL) (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2	Cathode ramp at EB mode (during transmition: STANDBY->MANUAL) 0 - V(A)/s 1 - V(A)/min 2 - V(A)/h	INT		0	2

Table 6.71: Cathode ramp at EB mode (during transmition: STANDBY->MANUAL)

ORDER NUMBER 0x4117 EMISSION VOLTAGE RAMP AT OPERATE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Emision voltage ramp at OPERATE mode	Double	V/time unit	0,01	200

Table 6.72: Emision voltage ramp at OPERATE mode

ORDER NUMBER 0x4118 UNIT OF EMISSION VOLTAGE RAMP AT OPERATE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2	Unit of emision voltage ramp at OPERATE mode 0 - V/s 1 - V/min 2 - V/h	INT		0	2

Table 6.73: Unit of emision voltage ramp at OPERATE mode

ORDER NUMBER 0x4119 EMISSION VOLTAGE RAMP (DURING TRANSMITION: STANDBY -> MANUAL) (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Emision voltage ramp (during transmition: STANDBY->MANUAL)	Double	V/ time unit	0,01	200

Table 6.74: Emision voltage ramp (during transmition: STANDBY->MANUAL)

ORDER NUMBER 0x411A UNIT OF EMISSION VOLTAGE RAMP (DURING TRANSMITION: STANDBY -> MANUAL) (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Unit of emision voltage ramp (during transmition: STANDBY->MANUAL) 0 - V/s 1 - V/min 2 - V/h	INT		0	2

Table 6.75: Unit of emision voltage ramp (during transmition: STANDBY->MANUAL)

ORDER NUMBER 0x411B SETPOINT FOR T MODE					R/W
Bajt	**Opis**	**Typ**	**Jednostka**	**Min**	**Max**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Setpoint for T mode	Double	Kelvin	0,0	9999,9

Table 6.76: Setpoint for T mode

ORDER NUMBER 0x411C RAMP RATE FOR T MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Ramp Rate for T mode	Double	Actual unit	0,0	1000,0

Table 6.77: Ramp Rate for T mode

ORDER NUMBER 0x411D RAMP RATE UNIT FOR T MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Ramp Rate unit for T mode 0 - Actual proces unit/s 1 - Actual proces unit/min 2 - Actual proces unit/h	INT		0	2

Table 6.78: Ramp Rate unit for T mode

ORDER NUMBER 0x411E SETPOINT FOR dT MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Setpoint for dT mode	Double	Kelvin/s	-5,0 K	+5,0 K

Table 6.79: Setpoint for dT mode

ORDER NUMBER 0x411F TRIGGER TEMPERATURE FOR dT MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Trigger temperature fot dT mode	Double	Kelvin	0,0K	9999,9K

Table 6.80: Trigger temperature fot dT mode

ORDER NUMBER 0x4120 END TEMPERATURE FOR T MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	End Temperature for T mode	Double	Kelvin	0,0K	9999,9K

Table 6.81: End Temperature for T mode

ORDER NUMBER 0x4121 THE P PARAMETER OF PID REGULATOR AT T MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	P Parameter of PID regulator at T mode	Double	Actual Unit	0,1	1000

Table 6.82: P Parameter of PID regulator at T mode

ORDER NUMBER 0x4122 THE I PARAMETER OF PID REGULATOR AT T MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	The I parameter of PID regulator at T mode	Double	second	0	1000

Table 6.83: The I parameter of PID regulator at T mode

ORDER NUMBER 0x4123 THE D PARAMETER OF PID REGULATOR AT T MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	The D parameter of PID regulator at T mode	Double	second	0	1000

Table 6.84: The D parameter of PID regulator at T mode

ORDER NUMBER 0x4124 THE P PARAMETER OF PID REGULATOR AT dT MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	The P parameter of PID regulator at dT mode	Double	Actual unit	0,1	1000

Table 6.85: The P parameter of PID regulator at dT mode

ORDER NUMBER 0x4125 THE I PARAMETER OF PID REGULATOR AT dT MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	The I parameter of PID regulator at dT mode	Double	sekundy	0	1000

Table 6.86: The I parameter of PID regulator at dT mode

ORDER NUMBER 0x4126 THE D PARAMETER OF PID REGULATOR AT dT MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	The D parameter of PID regulator at dT mode	Double	second	0	1000

Table 6.87: The D parameter of PID regulator at dT mode

ORDER NUMBER 0x4127 Ic LIMIT FOR RES MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Ic limit for RES mode	Double	Amper	0	12

Table 6.88: Ic limit for RES mode

ORDER NUMBER 0x4128 Uc LIMIT FOR RES MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Uc limit for RES mode	Double	Volt	0	40

Table 6.89: Uc limit for RES mode

ORDER NUMBER 0x4129 Ic LIMIT FOR EB MODE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Ic limit for EB mode	Double	Amper	0	12

Table 6.90: Ic limit for EB mode

ORDER NUMBER 0x412A Uc LIMIT FOR EB MODE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Uc limit for EB mode	Double	Volt	0	40

Table 6.91: Uc limit for EB mode

ORDER NUMBER 0x412B Ie LIMIT FOR EB MODE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Ie limit for EB mode	Double	mA	0	300

Table 6.92: Ie limit for EB mode

ORDER NUMBER 0x412C Ue LIMIT FOR EB MODE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Ue limit for EB mode	Double	Volt	1	1000

Table 6.93: Ue limit for EB mode

ORDER NUMBER 0x412D OUTPUT SIGNAL Ue/Uc(Ic) (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2	Output signal Ue/Uc(Ic) 0- output Ue 1- output Uc/Ic (module dependent)	INT		0	1

Table 6.94: Output signal Ue/Uc(Ic)

ORDER NUMBER 0x412E READ/WRITE OF Uc TARGET VALUE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Read/Write of Uc target value	Double	V	0	40

Table 6.95: Read/Write of Uc target value

ORDER NUMBER 0x412F READ ACTUAL VALUE OF Uc					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Read actual value of Uc	Double	V	0	40

Table 6.96: Read actual value of Uc

ORDER NUMBER 0x4130 READ/WRITE OF Ue TARGET VALUE (* only with HV module)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Read/Write of Ue target value	Double	V	0	1000

Table 6.97: Read/Write of Ue target value

ORDER NUMBER 0x4131 READ ACTUAL VALUE OF Ue (* only with HV module)					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Read actual value of Ue	Double	V	0	1000

Table 6.98: Read actual value of Ue

ORDER NUMBER 0x4132 READ/WRITE OF Ic TARGET VALUE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Read/Write of Ic target value	Double	A	0	12

Table 6.99: Read/Write of Ic target value

ORDER NUMBER 0x4133 READ ACTUAL VALUE OF Ic					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Read actual value of Ic	Double	A	0	12

Table 6.100: Read actual value of Ic

ORDER NUMBER 0x4134 READ ACTUAL VALUE OF Ie (* only with HV module)					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2-9	Read actual value of Ie	Double	A	0	0,3

Table 6.101: Read actual value of Ie

ORDER NUMBER 0x4135 COOLING VALVE MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Cooling Valve mode 0-Still OFF 1-Still ON 2-Auto	INT		0	2

Table 6.102: Cooling Valve mode

ORDER NUMBER 0x4136 COOLOING VALVE TRIGER TEMPERATURE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Cooling Valve trigger temperature	Double	Kelvin	0,0K	9999,9K

Table 6.103: Cooling Valve trigger temperature

ORDER NUMBER 0x4137 RAMP OF OUTPUT CONTROLLED BY PID					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Ramp of outlet controlled by PID	Double	%/Unit	0,0%	100,0%

Table 6.104: Ramp of outlet controlled by PID

ORDER NUMBER 0x4138 RAMP UNIT OF OUTLET CONTROLLED BY PID					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2	Ramp unit of outlet controlled by PID 0-%/s 1-%/min 2-%/h	INT		1	2

Table 6.105: Ramp unit of outlet controlled by PID

ORDER NUMBER 0x4139 VACUUM INTRELOCK ON/OFF					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index (irrelevant)	INT			
2	Vaccum Interlock ON/OFF 0-Vacuum Interlock WYŁ. 1-Vacuum Interlock WŁ.	INT		0	1

Table 6.106: Vaccum Interlock ON/OFF

ORDER NUMBER 0x413A ACTUAL PROCESS VALUE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Indeks: 0, 1 - channel CH1; 2 - channel CH2	BYTE		0	2
2-9	Actual Process Value	Double	Kelvin or Voltage		

Table 6.107: Actual Process Value

6.5.8.3 VACUUM GAUGE ORDERS - FUNCTION CODE 0x01..

ORDER NUMBER 0x0101 ACTUAL VACUUM GAUGE VALUE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-9	Value	DOUBLE	mbar		

Table 6.108: Read actual vacuum gauge value

ORDER NUMBER 0x0102 ACTUAL VACUUM GAUGE ANALOG VALUE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-9	Value	DOUBLE	V		

Table 6.109: Read actual vacuum gauge analog value

ORDER NUMBER 0x0103 VACUUM GAUGE UNIT					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	Unit: 0 - mbar 1 - Torr 2 - Pa 3 - psia				

Table 6.110: Vacuum gauge unit

ORDER NUMBER 0x0104 NO SENSOR IN THE VACUUM GAUGE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	State: 0 - False, 1 - True	Bool		0	1

Table 6.111: Read no sensor state

ORDER NUMBER 0x0105 VACUUM GAUGE STATUS					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	Status: -1 - ”Sensor Break!” 0 - Vacuum 1 - ”Wait for emission” 2 - ”No Emission” 3 - ”Wait for ignition” 4 - ”Not Calibrated” 5 - Voltage 6 - ”Degasing ” + time 7 - ”Exter. Setpoint” 8 - ”Low Pressure” 9 - ”High Pressure” 10 - ”0.00e+00”	BYTE			

Table 6.112: Read vacuum gauge status

ORDER NUMBER 0x0106 LOW SETPOINT IN MBAR					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-9	Setpoint value	DOUBLE	mbar		

Table 6.113: Set/Read LOW Setpoint in mbar

ORDER NUMBER 0x0107 HIGH SETPOINT IN MBAR					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-9	Setpoint value	DOUBLE	mbar		

Table 6.114: Set/Read HIGH Setpoint in mbar

ORDER NUMBER 0x0108 LOW SETPOINT IN VOLTS					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-9	Setpoint value	DOUBLE	V		

Table 6.115: Set/Read LOW Setpoint in volts

ORDER NUMBER 0x0109 HIGH SETPOINT IN VOLTS					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-9	Setpoint value	DOUBLE	V		

Table 6.116: Set/Read HIGH Setpoint in volts

ORDER NUMBER 0x010A TRIGGER STATE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	State: 0 - Off, 1 -	Bool		0	1

Table 6.117: Read trigger state

ORDER NUMBER 0x010B GAUGE TYPE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	Type: 0 - CTR90 1 - TTR90 2 - TTR211 3 - PTR225 4 - PTR90 5 - ITR90 6 - ITR100 7 - Baratron 8 - ANALOG IN 9 - MKS 937A 10 - PG105 11 - MG13/14 12 - PKR 251 13 - PCR 280/TPR 28x 14 - ATMION 15 - reserved 16 - IKR360/361	BYTE			

Table 6.118: Set/Read gauge type

ORDER NUMBER 0x010C CTR90/91 FULL SCALE PARAMETER					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	FS: 0 - 0.1 Torr 1 - 1 Torr 2 - 10 Torr 3 - 100 Torr 4 - 1000 Torr	BYTE			

Table 6.119: Set/Read full scale parameter for CTR90/91 gauge unit

ORDER NUMBER 0x010D Baratron FULL SCALE PARAMETER					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	FS: 0 - 10 Torr 1 - 50 Torr 2 - 100 Torr 3 - 500 Torr 4 - 1000 Torr 5 - 20 psia 6 - 30 psia 7 - 50 psia 8 - 60 psia 9 - 100 psia 10 - 250 psia 11 - 500 psia 12 - 725 psia 13 - 1000 psia 14 - 2000 psia 15 - 3000 psia	BYTE			

Table 6.120: Set/Read full scale parameter for Baratron gauge unit

ORDER NUMBER 0x010E TYPE OF GAS					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	Typ of gas: 0 - Air 1 - He 2 - Ne 3 - Ar 4 - Kr 5 - Xe 6 - H2 7 - CO 8 - define	BYTE			

Table 6.121: Set/Read type of gas

ORDER NUMBER 0x010F DEFINED GAS FACTOR					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-9	Gas factor value	DOUBLE			

Table 6.122: Set/Read defined gas factor

ORDER NUMBER 0x0110 DEGASS POSSIBILITY					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	Possibility: 0 - degas possible 1 - vacuum gauge damaged 2 - meter does not support degas 3 - too low vacuum in chamber, to start the degassing	BYTE		0	3

Table 6.123: Read degas possibility

ORDER NUMBER 0x0111 DEGAS STATE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	0 - OFF, 1 - ON	BYTE		0	3

Table 6.124: Set/Read degas state

ORDER NUMBER 0x0112 DEGAS TIME					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-5	Time	LONG	Seconds		

Table 6.125: Set/Read degas time

ORDER NUMBER 0x0113 READ REMAINING DEGAS TIME					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2-5	Time	LONG	Seconds		

Table 6.126: Read remaining degas time

ORDER NUMBER 0x0114 EMISSION STATE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	Emission: 0 - OFF, 1 - ON	BYTE			

Table 6.127: Set/Read emission state

ORDER NUMBER 0x0115 READ EMISSION STATE FROM VACUUM GAUGE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	Emission: 0 - OFF, 1 - ON	BYTE			

Table 6.128: Read emission state from vacuum gauge

ORDER NUMBER 0x0116 FILTRATION LEVEL OF VACUUM MEASUREMENT					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE		1	2
2	Filtration level: 0 - low 1 - medium 2 - high	BYTE			

Table 6.129: Set/Read filtration level of vacuum measurement

6.5.8.4 DIGITAL OUTPUTS ORDERS - FUNCTION CODE 0x03..

ORDER NUMBER 0x0301 ASSIGNMENT OF RELAYS FUNCTION					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Relay (Out) number. From 1 to number of all relays	BYTE			
2	Assigned function code: Code corresponds to the position of function in the menu ”Relay Outputs/Out x”. For example, if the menu looks as below: *Relay Outputs* *Out 1* *Setpoint 1* *Setpoint 2* *Still OFF* *Still ON* *None* Code of function *Still OFF* is 3	BYTE			

Table 6.130: Assigning of relays function

6.5.8.5 DIGITAL INPUTS ORDERS - FUNCTION CODE 0x04..

ORDER NUMBER 0x0401 ASSIGNMENT OF FUNCTION TO THE INPUT					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index 1: Channel number	BYTE	1		
2	Index 2: Function code. 1 - Interlock 2 - Operate On 3 - Operate Off 4 - Pressure Emiss ON 5 - Pressure Emiss OFF 6 - Open Shutter 7 - Close Shutter 8 - Zero Thickness 9 - Zero Time 10 - Remote Control Availability of functions is device dependent.	BYTE			
3	Digital Input number. From 1 to number of all inputs	BYTE		1	

Table 6.131: Assignment of functions to the input

ORDER NUMBER 0x0402 DIGITAL INPUTS SENSE CONTROL					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Digital Input number. From 1 to number of all inputs	BYTE		1	
2	Sense: 1 - Low level 2 - High level 3 - Falling edge 4 - Rising edge			1	4

Table 6.132: Digital inputs sense control

6.5.8.6 ANALOG OUTPUTS ORDERS - FUNCTION CODE 0x05..

ORDER NUMBER 0x0501 SIGNAL SOURCE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Out number. From 1 to number of all analog outs	BYTE		1	
2	Assigned signal source: Corresponds to the position of signal source in the menu ”Source” of Analog out channel. For example, if the menu looks as below: *Source* *Pressure 1* *Pressure 2* *Usource* *Iemis* *None* Code of signal source *Iemi* is 4	BYTE		1	

Table 6.133: Set/Read signal source

ORDER NUMBER 0x0502 RETRANSMISSION MODE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Out number. From 1 to number of all analog outs	BYTE		1	
2	Retransmission mode: 1 - range 2 - 1 to 1 3 - exponent	BYTE		1	3

Table 6.134: Set/Read work mode

ORDER NUMBER 0x0503 RETRANSMISSION SCALE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Out number. From 1 to number of all analog outs	BYTE		1	
2	Retransmission scale: 1 - linear 2 - logarithmic	BYTE		1	2

Table 6.135: Set/Read retransmission scale

ORDER NUMBER 0x0504 MINIMUM VALUE OF RETRANSMITTED PARAMETER					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Out number. From 1 to number of all analog outs	BYTE		1	
2-9	Minimum value Unit and min/max is signal source dependent	DOUBLE			

Table 6.136: Set/Read minimum value of the retransmitted parameter.

ORDER NUMBER 0x0505 MAXIMUM VALUE OF RETRANSMITTED PARAMETER					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Out number. From 1 to number of all analog outs	BYTE		1	
2-9	Maximum value Unit and min/max is signal source dependent	DOUBLE			

Table 6.137: Set/Read maximum value of the retransmitted parameter.

ORDER NUMBER 0x0506 MINIMUM VALUE OF THE OUTPUT VOLTAGE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Out number. From 1 to number of all analog outs	BYTE		1	
2-9	Output voltage	DOUBLE	V	0	10

Table 6.138: Set/Read minimum value of the output voltage.

ORDER NUMBER 0x0507 MAXIMUM VALUE OF THE OUTPUT VOLTAGE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Out number. From 1 to number of all analog outs	BYTE		1	
2-9	Output voltage	DOUBLE	V	0	10

Table 6.139: Set/Read maximum value of the output voltage.

6.5.8.7 ANALOG INPUTS ORDERS - FUNCTION CODE 0x06..

ORDER NUMBER 0x0601 ASSIGNMENT OF INPUT TO THE FUNCTION					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index: Code controlled function Code corresponds to the position of function in the menu "Analog Inputs -> Controlled Value". For example, if the menu looks as below: *Analog Inputs* *Controlled Value* *U source* *I emis* Code of function *I emis* is 2	BYTE	1	1	
2	The number of analog input assigned to the function *0 - no input assigned*	BYTE		0	

Table 6.140: Assignment of input to the function

ORDER NUMBER 0x0602 INPUT RANGE MINIMAL VALUE (0V)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Analog Input number	BYTE		1	
2-9	Value	DOUBLE	V	0	10

Table 6.141: Analog inputs minimal input range

ORDER NUMBER 0x0603 INPUT RANGE MAXIMAL VALUE (10V)					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Analog Input number	BYTE		1	
2-9	Value	DOUBLE	V	0	10

Table 6.142: Analog inputs maximal input range

6.5.8.8 PID REGULATOR ORDERS - FUNCTION CODE 0x09..

ORDER NUMBER 0x0901 SETPOINT VALUE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	Setpoint value	DOUBLE	K		

Table 6.143: Setpoint value

ORDER NUMBER 0x0902 ACTUAL SETPOINT VALUE					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	Actual setpoint value	DOUBLE	K		

Table 6.144: Actual setpoint value

ORDER NUMBER 0x0903 PID REGULATOR TYPE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2	Regulator type 0 - T 1 - delta T	BYTE			

Table 6.145: Regulator type

ORDER NUMBER 0x0904 P parameter - T mode					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	P parameter	DOUBLE	K		

Table 6.146: Regulator T mode - P parameter

ORDER NUMBER 0x0905 I parameter - T mode					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	I parameter	DOUBLE	sec		

Table 6.147: Regulator T mode - I parameter

ORDER NUMBER 0x0906 D parameter - T mode					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	D parameter	DOUBLE	sec		

Table 6.148: Regulator T mode - D parameter

ORDER NUMBER 0x0907 P parameter - dT mode					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	P parameter	DOUBLE	K		

Table 6.149: Regulator dT mode - P parameter

ORDER NUMBER 0x0908 I parameter - dT mode					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	I parameter	DOUBLE	sec		

Table 6.150: Regulator dT mode - I parameter

ORDER NUMBER 0x0909 D parameter - dT mode					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	D parameter	DOUBLE	sec		

Table 6.151: Regulator dT mode - D parameter

ORDER NUMBER 0x090A ASSIGNMENT OF THE INPUT PARAMETER					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2	Input parameter	BYTE			

Table 6.152: Input parameter

ORDER NUMBER 0x090B SETPIONT MAX VALUE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	Setpiont max value	DOUBLE	K		

Table 6.153: Setpoint max value

ORDER NUMBER 0x090C SETPIONT MIN VALUE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	Setpiont min value	DOUBLE	K		

Table 6.154: Setpoint min value

ORDER NUMBER 0x090D RAMP RATE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	Ramp rate value	DOUBLE	K		

Table 6.155: Ramp rate value

ORDER NUMBER 0x090E RAMP RATE UNIT					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2	Ramp rate unit	BYTE			

Table 6.156: Setpoint max value

ORDER NUMBER 0x090F TRIGGER TEMPERATURE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	Trigger temperature	DOUBLE	K		

Table 6.157: Trigger temperature

ORDER NUMBER 0x0910 END TEMPERATURE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	End temperature	DOUBLE	K		

Table 6.158: End temperature

ORDER NUMBER 0x0911 PID OUTPUT					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-9	PID Output	DOUBLE	%		

Table 6.159: PID Output

ORDER NUMBER 0x0912 SET AUTOTUNE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2	Autotune	BYTE			

Table 6.160: Set autotune

ORDER NUMBER 0x0913 AUTOTUNE STATE					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2	Autotune state	BYTE			

Table 6.161: Autotune state

6.5.8.9 OPERATE TIMER ORDERS - FUNCTION CODE 0x11..

ORDER NUMBER 0x1101 TIMER COUNTING DIRECTION					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2	Counting direction 0 - down 1 - up	BYTE		0	1

Table 6.162: Timer counting direction

ORDER NUMBER 0x1102 OPERATE TIME					R
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-5	Operate time	LONG	sec		

Table 6.163: Operate time

ORDER NUMBER 0x1103 OPERATE TIME SETPOINT					R/W
Byte	**Description**	**Type**	**Unit**	**Min value**	**Max value**
1	Index	BYTE	1		
2-5	Operate time setpoint	LONG	sec		

Table 6.164: Operate time setpoint

7 MAINTENANCE AND SERVICE

7.1 MAINTENANCE

The HEAT3 does not require any special maintenance work.

7.2 CLEANING

For cleaning of the outside of the device, a slightly moistened cloth will usually do. Do not use any aggressive or abrasive cleaning agents.

DANGER

Mains voltage.
Components inside of the HEAT3 are components at mains voltage. Do not insert any objects through the louvers of the device. Protect the device from liquids. Do not open the device.

7.3 FIRMWARE UPGRADE

On the pictures below we will use the names of {device_name} and {version}:

- {device_name} in this case means HEAT3 .
- {version} is in numerical form and contains 3 digits separated by a dots. E.g: 1.0.0 or 3.1.5

WARNING

Firmware upgrade

During the upgrade, do not turn off the HEAT3 or disconnect it from the wall outlet. Failure to do so may cause damage to the HEAT3 , with the result that the unit is not unfit for use and will require repair.

In order to update the software/firmware via USB the USB memory stick must be formatted as FAT / FAT32. Then simply copy the update file received from us to the memory stick and insert into the USB slot on the front of the HEAT3 . The “New USB Device Detected” hint will appear on the bottom of the screen.

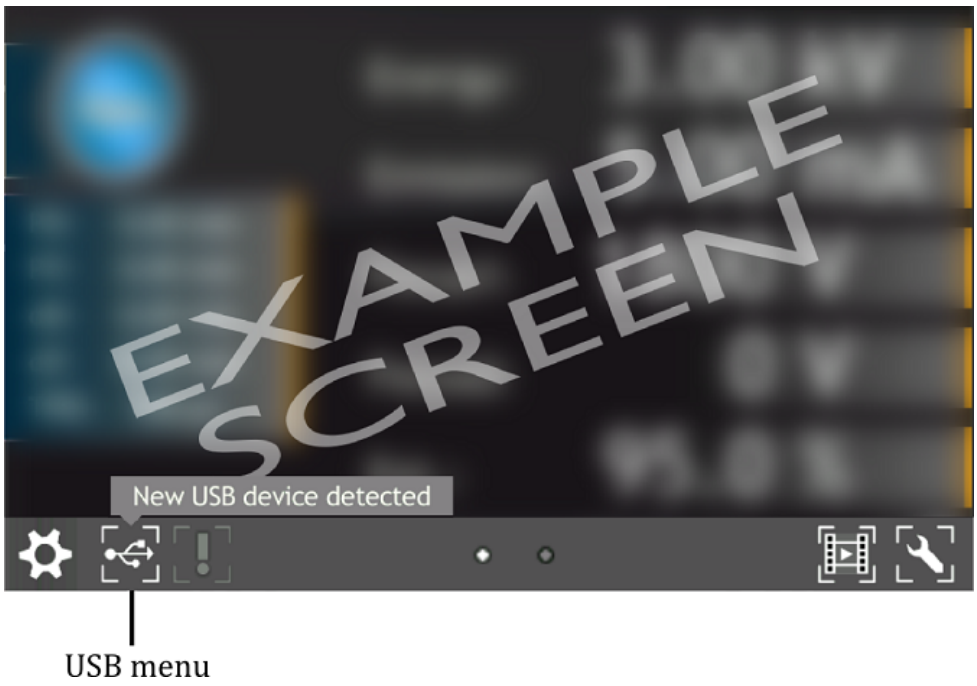

Figure 7.1: USB detected hint

The USB menu is accessed by clicking the USB icon on the bottom of the screen. This displays several options:

- see list of found firmware,
- copy user manual to USB,
- un-mount USB drive,
- export log file onto USB,
- see list of videos on USB,
- copy new language to device,

Figure 7.2: USB menu

To update the current version to a newer version, select the Firmware Updates option. To accelerate the search for updates on the USB drive, delete all files except the updates.

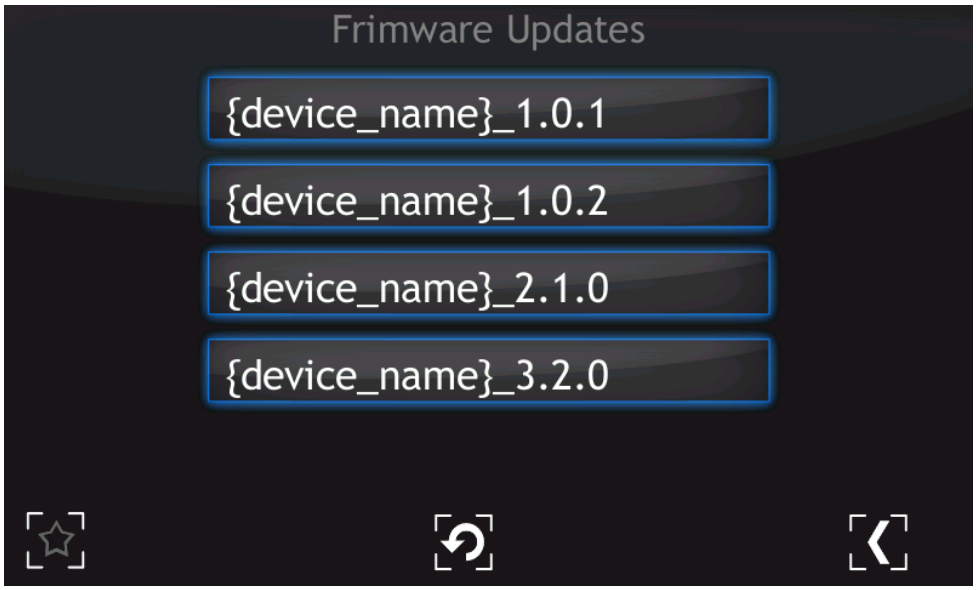

Figure 7.3: Firmware list

In order to choose one of the updates simply click on the name. The “Do you want to update firmware to selected version? After whole procedure device will be rebooted” phrase will appear. Selecting No returns the user to the main menu of Firmware Updates. It is highly recommended to finish all the work on the device and save your data before pressing the “Yes” button.

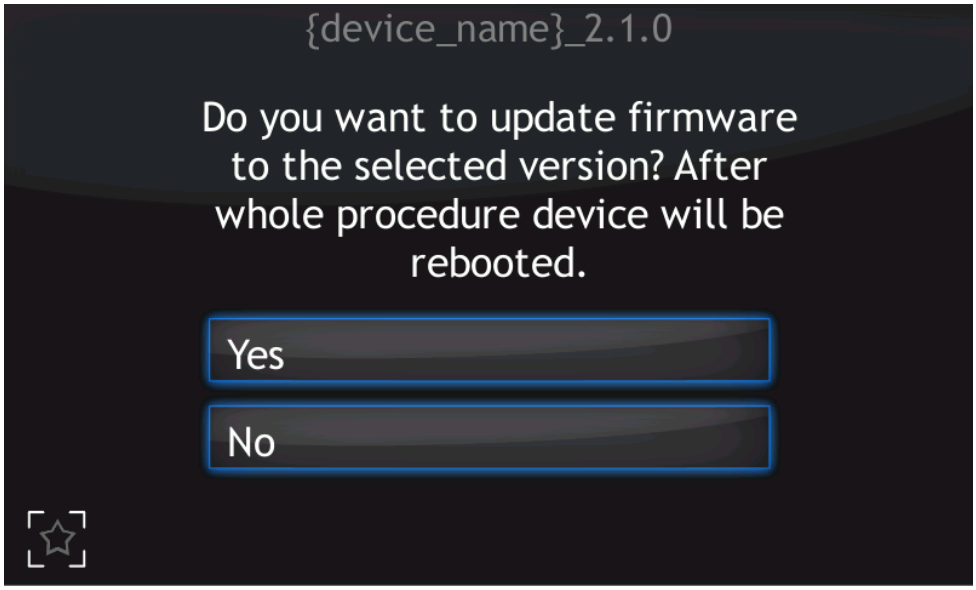

Figure 7.4: Restart message

After selecting to proceed with the update, the device will stop and the updating procedure will be initiated. The update process takes a few minutes during which time the screen below is displayed.

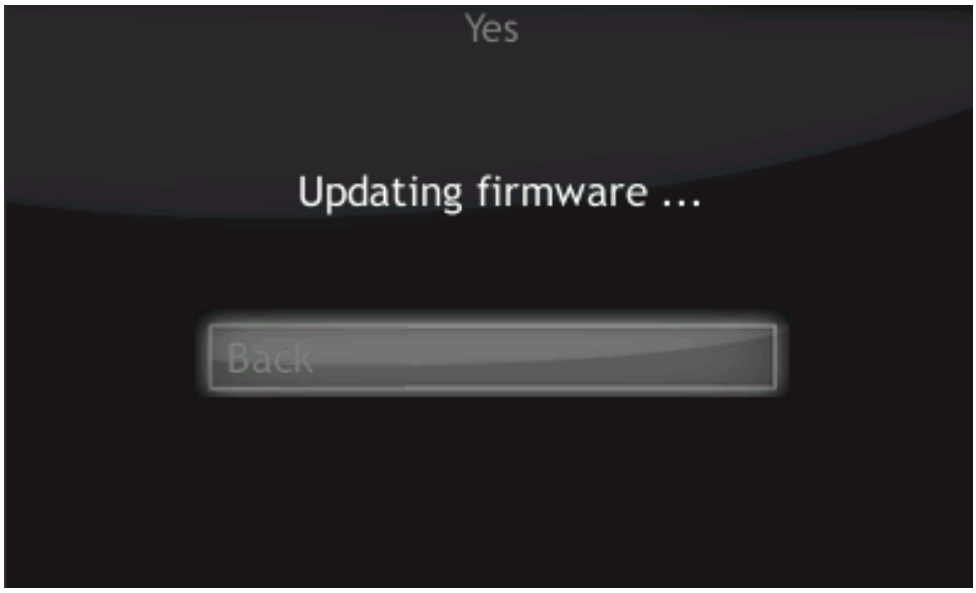

Figure 7.5: Updating firmware

Upon successful installation, the message with ”updated” statuses should be displayed.

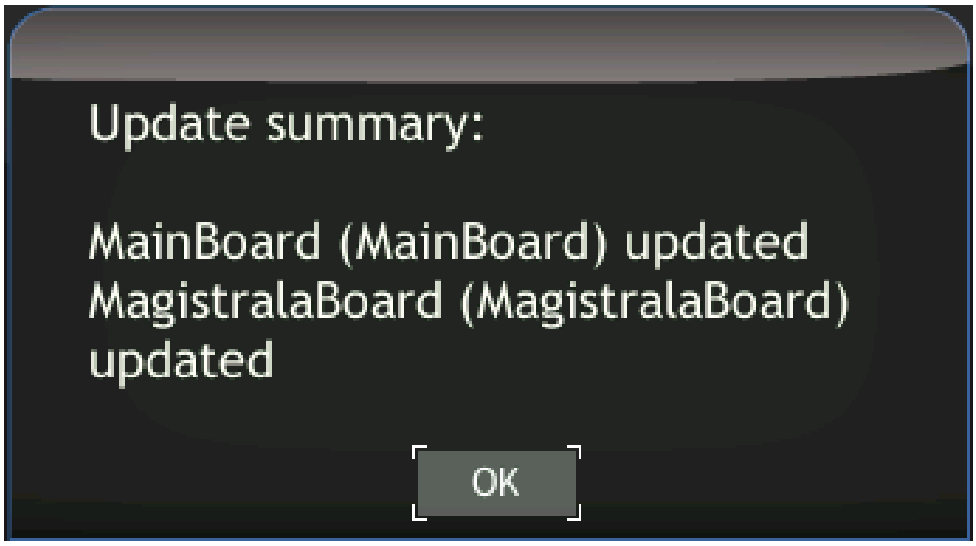

Figure 7.6: Update summary example

Select “OK” to reboot the device and finish the upgrade.

7.3.1 AUTO UPDATE

The auto-update feature compares the current version of main-board and bus firmware with software. In case of any mismatch (for example if the micro SDHC card was swapped) the user will be informed with a blinking exclamation icon.

- To synchronize the firmware, select the exclamation icon.
- The screen below is displayed. If the “Recommended Updates” message is visible, tap the “Auto Update” button in order to synchronize firmware and software. Then follow the procedure from the previous section Upgrading firmware via USB.

Figure 7.7: Auto update 1

Figure 7.8: Auto update 2

7.4 PREBOOT ENVIRONMENT

To run the Preboot application press on the logo at HEAT3 startup (7.9).

Figure 7.9: Enter into preboot environment

The Preboot Environment is an application to boot the HEAT3 . Its main task is to launch the device in the version selected by the user. It can also be used to run other tools, such as the gauge calibration application.
The main menu consist three options:

- Reboot – rebooting HEAT3 .
- Continue booting – close Preboot Environment and continue starting HEAT3 .
- Continue booting (photo mode) – allow to run device with screenshot function.

7.4.1 BOOT MENU

Boot menu allows the user set which version of the HEAT3 and Preboot Environment will be run after the start of device. In order to switch software version, click on “Software boot version” combo box.

Figure 7.10: Boot menu

Then select one of the available versions, for example default.

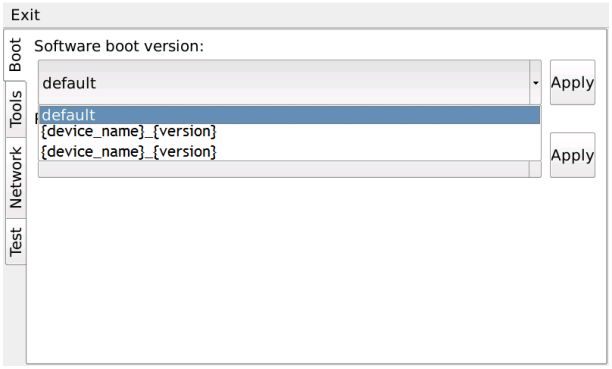

Figure 7.11: Switch software version

To apply changes press Apply button. From now the default version will be automatically run after restarting HEAT3 .

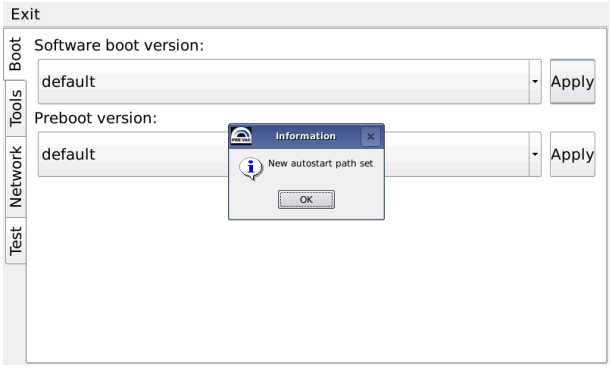

Figure 7.12: Message box confirming the changed settings

7.4.2 TOOLS MENU

The Tools menu allows the user to run applications such as touch screen or power supply calibration.

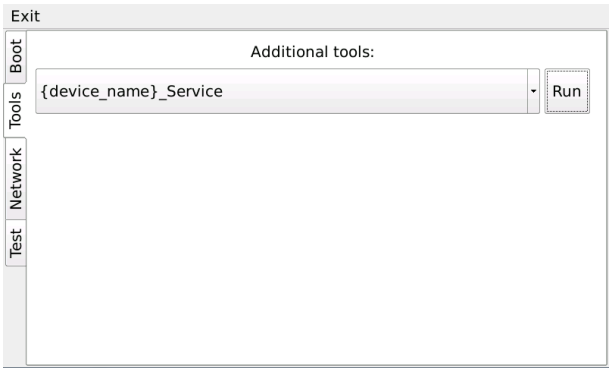

Figure 7.13: Tools menu

In order to select one of the applications, tap the desired application from the tools combo box and tap the Run button.

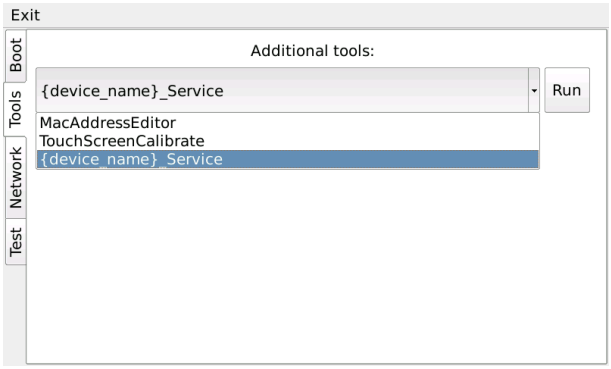

Figure 7.14: Selecting additional tool

7.4.3 NETWORK TAB

From this tab the user can configure the IP address, netmask and enable / disable DHCP.

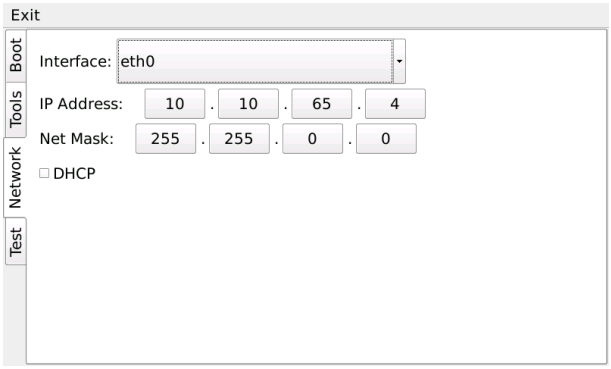

Figure 7.15: Network tab

After tapping on one of the editable fields, the numeric panel for editing values will appear . Input values can be completed by tapping X button in the upper-left corner of the screen.

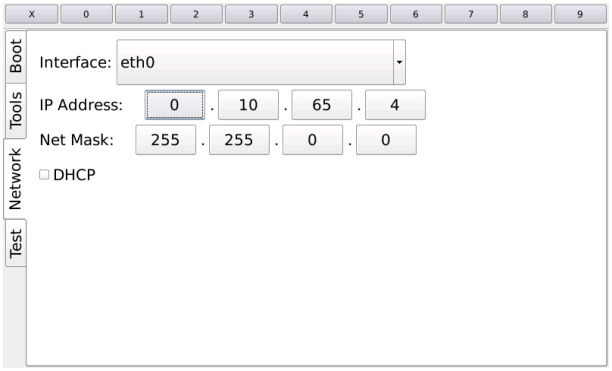

Figure 7.16: Numeric panel

7.4.4 TEST TAB

From this tab the user can test the speaker.

Figure 7.17: Test tab

8 STORAGE AND DISPOSAL

8.1 PACKING

Please retain the original packaging. The packaging is required for storing the HEAT3 and for shipping it to an authorized PREVAC service center.

8.2 STORAGE

The HEAT3 should only be stored in a dry room. The following requirements must be met:

PARAMETER	VALUE
Ambient temperature	-20...50°C
Humidity	As low as possible. Preferably in an airtight plastic bag with a desiccant.

Table 8.1: Storage parameters

8.3 DISPOSAL

The product purchased by you was manufactured from recyclable materials. The product is marked in accordance with European regulations pertaining to waste of electrical and electronic equipment – WEEE2.
Waste of electrical and electronic equipment must not be thrown away together with regular domestic waste. According to the European Union WEEE Directive, waste of electrical and electronic equipment is subject to separate utilization procedures.