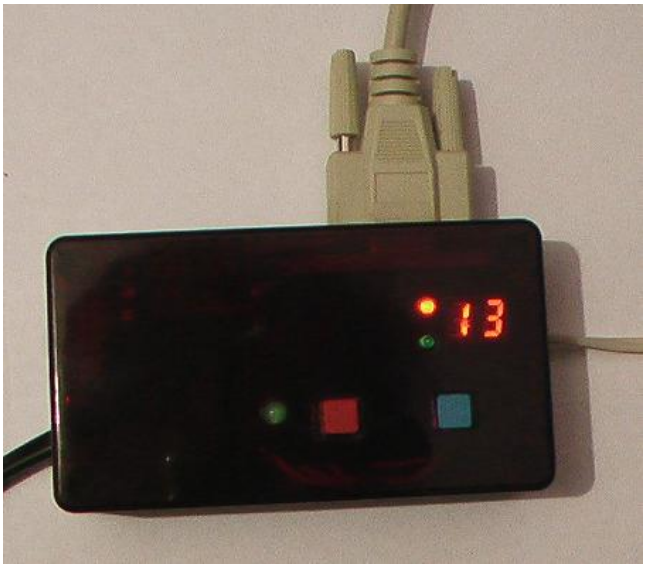
# Thermo-6

Thermostat with RS 232 connection

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# Introduction

Therno-6 is a high efficient thermostat with 220V/10A output. It can be used for control and monitoring temperatures from -40 C to + 60C.

The primary target of this device is the freezing process. The control box is designed to have maximum sensitivity (0,1C) in low temperatures and at the same time the output (relay) is designed to have normal open contacts when the temperature is lower then the preset threshold.

This device has one rs232 serial connection plug which is used as an output. Other outputs are on the main lid. The device has one green diode, showing the status of the relay and two small (3mm) diodes showing positive or negative temperature as well as two seven segment LEDs, showing the actual temperature. The two buttons on the main lid allow controlling different programs of the thermostat.

# Potential users

This device is primary developed to control freezing processes in cooling systems, freezers, thermodynamic processes in industry, experiments with cooling equipment, and all processes where slow control of the thermodynamics is needed. Despite the speed of the processor (1Mz), this device is not suitable for processes where very fast reaction (less then seconds) of the system is needed. The reason for this limitation is the specially designed subroutine, which does not allow quick response of the relay. This way the connected equipment (motor) is protected from overcharging.

In addition, heating processes can be controlled by using normal closed contact of the relay.

## Device construction

This device is based on a PIC microcontroller unit. It uses two 7 segment LEDs and rs232 connection as output and two buttons as input. It is based on measuring the resistance of thermistor (NTC 15k – 250mA in 25 C). The RS 232 output supports 9600 byte/sec connection and can be connected to any Windows terminal program or to the special software supporting this device. Thermo-6 has stable power supply 5V and controls 220V output device.
In order to control the hardware, embedded software is stored in the microcontroller's memory. All modules are placed in an infrared plastic box with sizes 110x60x30mm.
Termo-6 needs mains to operate.

## Technical parameters

Temperature

| | |
|---|---|
| Sensor temperature range | from -40 to +60 ºC |
| Operational temperature | from -15 to + 50 ºC |
| Temperature sensitivity | 0.1 ºC in region 0 ºC |
| Calibration | ± 1 ºC |
| Sensor's thermal reaction speed | Min 11 sec |
| Hysteresis of the sensor | 0.5 ºC |
| Time between two measurements | Approximately 1 sec |

Electrical

| | |
|---|---|
| Supply | 220V/50Hz |
| Total Consumption | Max 150mA |
| Voltage on detector's line | Max 5V/0.02A |
| Relay contacts | 220V/10A (NO ,NC, GND) |

Communication

| | |
|---|---|
| RS 232 to any serial port | Configuration 9600,8,1,n |

Switching parameters

| | |
|---|---|
| Thermo-6 has one minute switching restriction on the output | This functionality is embedded in the software |
| Thermo-6 has protection for false signals | The software allows switching only if it has 10 stable measurements showing same output for the relay |

Controls

| | |
|---|---|
| Preset temperature (threshold temperature) | Preset temperature is controlled from the user and stored in EEPROM |
| History of the temperature | History of the temperature is automatically saved every 10 min. It can be obtained from the user for upto 10 hours. |

Communication protocols

| | |
|---|---|
| Thermo-6 uses specially designed protocol (24 byte string) | Programmed in the software |

## Control operations and Menus

Thermo-6 has embedded operation menus. The device can be controlled via the two buttons in front of the panel.

## *Normal mode*

In normal mode the device will show the temperature (in ºC) represented on two LEDs. For the sign + (red) and – (green) two diodes (3mm) are situated in front of the LEDs.

The big green diode on the left side of the buttons will light when the normal open contact of the relay is closed.
In this mode the LEDs will flash for every measurement of the device (approximately every 1 sec).
In every 10 minutes for 1 second, a single 'o' (on the LEDs) will appear on the screen indicating that the temperature measurement is saved into the EEPROM of the microcontroller.

In this mode, every second before taking a new measurement, the microcontroller will send the data to the RS232 line.

## *Obtaining programmed preset temperature*

If the preset temperature from the microcontroller's EEPROM is required, then the red button has to be held for approximately 2 sec. and then released immediately after LEDs changes.
The preset temperature will flash three times on the display and the normal mode will be restored.

## *Sending temperature history to rs 232*

The microcontroller has 60 bytes EEPROM memory where the temperature history is saved. Internally the system saves every 10 minutes until the memory is full. After that, an overriding process is performed. The system keeps in RAM memory the position of the current cell to write.

- ✓ How to make it work!

Press the red button in normal mode and keep it until mode 'Obtaining programmed preset temperature' has finished. A small 'o' will be displayed. The red button can be released now.

The system will send the status of the EEPROM via RS 232.

The value of the bytes (cells) will be displayed on the PC (Windows terminal program) in a form of a column starting with the content of the last recorded cell.

ATTENTION! If you intend to use this option, do not switch the device from the supply because the position of the actual cell will be lost! If you restart the device, the position of the first cell will be displayed as the current cell. It is still possible to see the EEPROM cells but they will not be ordered according to the time.

After sending this information, the microcontroller will return automatically in normal mode

## *Inserting new preset temperature*

Preset temperature is the temperature which will activate the output.
For example if you're cooling an object to -20 ºC your preset temperature will be -20. This tells the thermostat to switch the relay if the temperature is higher then -20 degrees.
However, if the temperature is under -20 ºC the relay will be switched off.
It is obvious that this approach can be applied also for heating. You just have to connect the heater to the normal closed terminal of the relay.

To insert a new preset temperature from normal operation, press and keep the red and the blue buttons together. After one second the numbers on the LEDs will disappear. Using the blue button you can chose the positive or negative temperature by selecting the proper diode. Then press the red button and you are ready to select the decimal number of the first LED (again with the blue button). After selecting the first digit pres again the red button and

you can select the second digit. After selecting the last digit press the red button to finish the input.
For around a second, the system will save the data and then three times will flash the new preset temperature.

☞ Please note that the preset temperature is saved in EEPROM and can remain there even if you disconnect the device from the mains.

# Transmitting protocols

Thermo-6 has 2 different protocols. One transmitting data every second via RS232 and second which transmits only the EEPROM memory content.

## *Data Transfer Protocols*

This data will be transferred every second in normal operation of the device.
This protocol consists of 24 bytes word (ASC code) as follows:

| Byte number | meaning |
|---|---|
| Byte 1-5 | Processor time related to the measured temperature |
| Byte 6 | Space |
| Byte 7 | Output status represented as:(0)-relay is off and (1) relay is on |
| Byte 8 | Space |
| Byte 9 | Motor restriction (1)-motor cannot be switched on/off. |

| | |
|---|---|
| | (0) motor can be switched on/off (The restriction is 1 min after every triggering) |
| Byte 10 | Space |
| Byte 11 and 12 | Signal statistics (-0 to-9) and (+0 to+9). This shows how many measurements we have for + switch on /- switch off the relay. The relay can be switched on/off only if there are 9 consecutive signals. |
| Byte 13 | Space |
| Byte 14 ,15 and 16 | Preset temperature |
| Byte 17 | Space |
| Byte 18, 19 and 20 | Actual temperature displayed on the LEDs |
| Byte 21 | Space or '#' if the system is writing in EEPROM. |
| Byte 22 and 23 | Minutes counter or when writing in EEPROM is performed shows the EEPROM cell. |
| Byte 24 | New paragraph |

All data can be captured in Windows terminal as every row represents 24 Bytes word from the protocol.

## *Protocol for transfer of EEPROM data*

This protocol represents the EEPROM saved history information of the temperature.
Saving every 10 min the temperature, Thermo-6 will display the value of all 60 cells in reverse mode starting with the most recent data.

The protocol is as follows:

| | |
|---|---|
| Byte 1 | Polarity of the temperature |
| Byte 2,3 | Temperature |
| Byte 4 | Return |

The protocol finishes with two return signals.

# Working with Thermo-6 Windows application

Thermo-6 windows application is especially designed to accelerate the sensitivity of the thermo-6 detector and at the same time to provide better communication using the same protocols from thermo-6.

## *Main functionality*

The main GUI of the software is presented on Figure 1

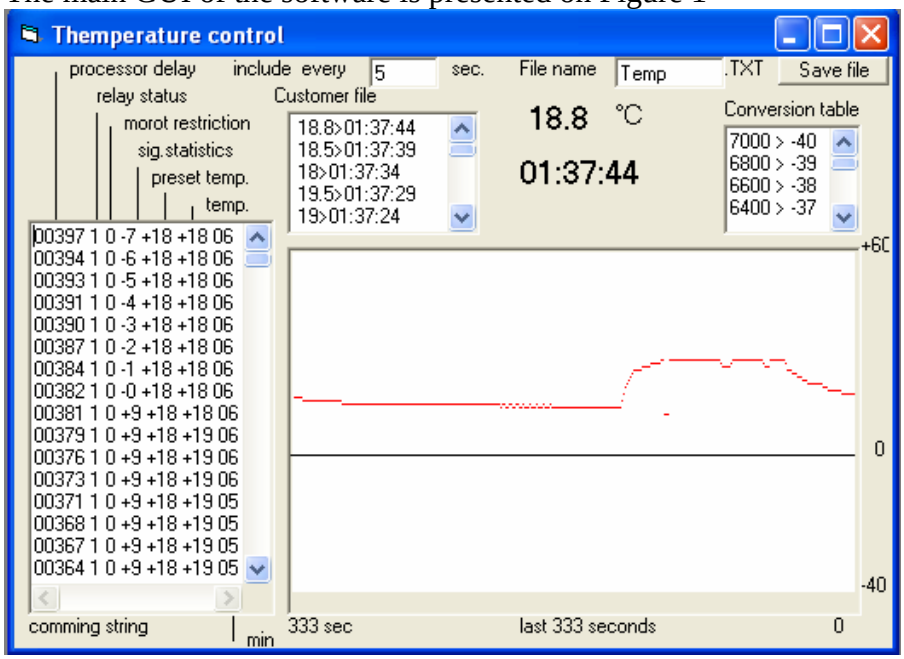


Figure 1 Thermo-6 Windows application

The main functionalities of this system are:

- showing the incoming string from thermo-6
- storing temperature in preset intervals (different then thermo-6)
- saving the accumulated data in file
- using advanced temperature representation (0.1ºC)
- using new, editable conversion table
- represent temperature as graph

## *Extracting temperature using different time intervals*

If you need to extract temperature in different intervals than 10 minutes you can enter the desired interval in seconds and the system will collect data for you using the computer timer. At the end of the measurement you can save the data on a file.
This file will be placed in the working directory of the main program.

## *Recalibration the signal from thermo-6*

You can recalibrate the device by using new calibration table. The calibration curve stored in the device's memory is not very exact. It can calculate within ±1ºC. At the same time the data from the microprocessor allows conversion with ±0.1ºC precision to be performed by using better calibration approximation curve. Data for such curve can be input into the conversion table box and the software will use it to calculate the temperature.

☞ Please note that if you wish to collect the EEPROM information you have to exit the Thermo-6 windows application and use Windows terminal for this task.

## *Graphics*

Graphical representation of the temperature is available using Thermo-6 software application. The graph will represent the temperature for 330 seconds period of time and will update itself continuously if the system receives signals from the detector.
The color of the graph in positive temperatures is red while in negative temperatures is blue.

APPENDIX 1

## *Calibration table for Windows application*

The system uses the following calibration dependency:

| Processor time | Temperature |
|---|---|
| 7000 | -40 |
| 6800 | -39 |
| 6600 | -38 |
| 6400 | -37 |
| 6200 | -36 |
| 6000 | -35 |
| 5800 | -34 |
| 5600 | -33 |
| 5400 | -32 |
| 5200 | -31 |
| 5000 | -30 |
| 4800 | -29 |
| 4600 | -28 |
| 4400 | -27 |
| 4200 | -26 |
| 4000 | -25 |
| 3800 | -24 |
| 3600 | -23 |
| 3400 | -22 |
| 3300 | -21 |
| 3100 | -20 |
| 2900 | -19 |
| 2800 | -18 |
| 2700 | -17 |
| 2600 | -16 |
| 2400 | -15 |
| 2300 | -14 |
| 2100 | -13 |
| 2000 | -12 |
| 1900 | -11 |
| 1800 | -10 |
| 1700 | -9 |
| 1600 | -8 |
| 1500 | -7 |
| 1400 | -6 |
| 1300 | -5 |
| 1200 | -4 |
| 1100 | -3 |
| 1000 | -2 |
| 900 | -1 |
| 860 | 0 |
| 820 | 1 |
| 770 | 2 |
| 750 | 3 |
| 710 | 4 |
| 680 | 5 |
| 650 | 6 |
| 630 | 7 |
| 600 | 8 |
| 570 | 9 |
| 540 | 10 |
| 520 | 11 |
| 500 | 12 |
| 480 | 13 |
| 460 | 14 |
| 440 | 15 |
| 420 | 16 |
| 400 | 17 |
| 380 | 18 |
| 360 | 19 |
| 350 | 20 |
| 320 | 21 |
| 310 | 22 |
| 300 | 23 |
| 290 | 24 |
| 270 | 25 |
| 260 | 26 |
| 255 | 27 |
| 240 | 28 |
| 237 | 29 |

| | | | | | |
|---|---|---|---|---|---|
| 231 | 30 | 182 | 42 | 156 | 54 |
| 225 | 31 | 179 | 43 | 154 | 55 |
| 219 | 32 | 176 | 44 | 152 | 56 |
| 214 | 33 | 174 | 45 | 150 | 57 |
| 209 | 34 | 171 | 46 | 148 | 58 |
| 204 | 35 | 170 | 47 | 146 | 59 |
| 200 | 36 | 168 | 48 | 144 | 60 |
| 197 | 37 | 166 | 49 | 142 | 61 |
| 194 | 38 | 164 | 50 | 140 | 62 |
| 191 | 39 | 162 | 51 | 138 | 63 |
| 188 | 40 | 160 | 52 | | |
| 185 | 41 | 158 | 53 | | |

The transformation ‘cycles – temperature’ is presented on Figure 2

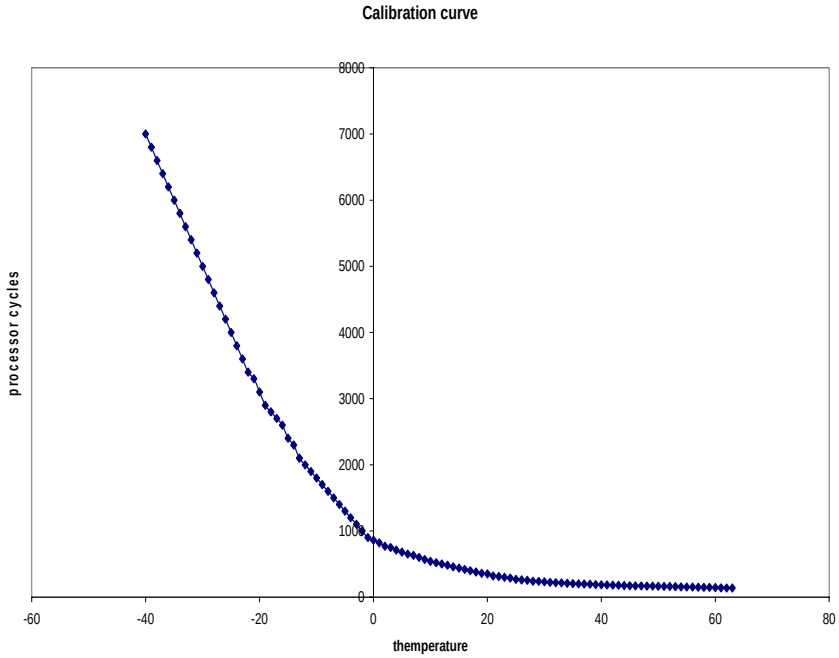

Figure 2 Calibration curve

## *Calibration values for the embedded system*

The embedded system uses approximation to represent the calibration curve. The table for this calibration is shown bellow.

| cycles | temperature |
|---|---|
| 7000 | -40 |
| 6800 | -39 |
| 6600 | -38 |
| 6400 | -37 |
| 6200 | -36 |
| 6000 | -35 |
| 5800 | -34 |
| 5600 | -33 |
| 5400 | -32 |
| 5200 | -31 |
| 5000 | -30 |
| 4800 | -29 |
| 4600 | -28 |
| 4400 | -27 |
| 4200 | -26 |
| 3900 | -25 |
| 3700 | -24 |
| 3300 | -23 |
| 3200 | -22 |
| 3100 | -21 |
| 3000 | -20 |
| 2800 | -19 |
| 2700 | -18 |
| 2600 | -17 |
| 2500 | -16 |
| 2400 | -15 |
| 2300 | -14 |
| 2200 | -13 |
| 2100 | -12 |
| 2000 | -11 |
| 1900 | -10 |
| 1800 | -9 |
| 1700 | -8 |
| 1600 | -7 |
| 1500 | -6 |
| 1400 | -5 |
| 1300 | -4 |
| 1200 | -3 |
| 1100 | -2 |
| 1000 | -1 |
| 900 | 0 |
| 820 | 1 |
| 770 | 2 |
| 750 | 3 |
| 710 | 4 |
| 680 | 5 |
| 650 | 6 |
| 630 | 7 |
| 600 | 8 |
| 570 | 9 |
| 540 | 10 |
| 520 | 11 |
| 500 | 12 |
| 480 | 13 |
| 460 | 14 |
| 440 | 15 |
| 420 | 16 |
| 400 | 17 |
| 380 | 18 |
| 360 | 19 |
| 350 | 20 |
| 320 | 21 |
| 310 | 22 |
| 300 | 23 |
| 290 | 24 |
| 270 | 25 |
| 260 | 26 |
| 255 | 27 |
| 240 | 28 |
| 237 | 29 |
| 231 | 30 |
| 225 | 31 |
| 219 | 32 |
| 214 | 33 |
| 209 | 34 |
| 204 | 35 |
| 200 | 36 |
| 197 | 37 |
| 194 | 38 |
| 191 | 39 |
| 188 | 40 |
| 185 | 41 |
| 182 | 42 |

| | |
|---|---|
| 179 | 43 |
| 176 | 44 |
| 174 | 45 |
| 171 | 46 |
| 170 | 47 |
| 168 | 48 |
| 166 | 49 |
| 164 | 50 |

| | |
|---|---|
| 162 | 51 |
| 160 | 52 |
| 158 | 53 |
| 156 | 54 |
| 154 | 55 |
| 152 | 56 |
| 150 | 57 |
| 148 | 58 |

| | |
|---|---|
| 146 | 59 |
| 144 | 60 |
| 142 | 61 |
| 140 | 62 |
| 138 | 63 |

The graphical presentation of this calibration is shown on Figure 3

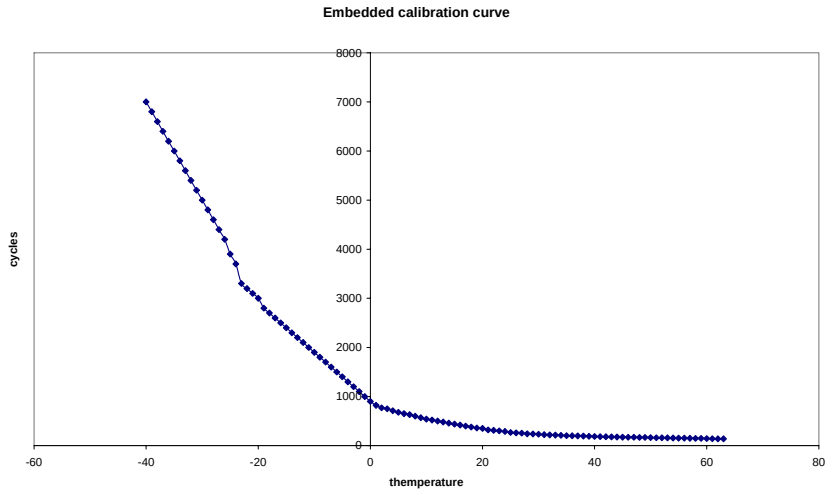


Figure 3 Embedded software calibration curves

## Important Notes

☞Do not expose this device to extreme temperature changes. (You should expose ONLY the detector).

☞Please be sure the device is disconnected from the mains when you open the lid. Also be sure that the other ends of the cable, you intend to connect to the relay, are disconnected from the mains!

☞If you need to replace the detector please use NTC 15K/0.250A thermistor.

☞Do not overcharge the relay. It is designed to operate at maximum 10A load.

☞Do not transfer the EEPROM when the device is operating with the thermo-6 software. This can be done only in Windows terminal program.

☞Do not shortcut the detector by exposing it in water or other liquids. If you have to measure temperature of liquids, make sure that the detector is isolated appropriately before immersing it.

☞Do not leave the detector to freeze in water. This can cause the detector to be physically damaged. For example place it in a glass or plastic tube prior to use.

## Troubleshooting

**The main unit is showing 'E' for Error or '00':** this means you have a problem with the detector's cable. Please check connections and possible places were the cable can be damaged.

**My computer does not receive data properly or does not receive data at all**. Please check the cable for RS 232. Be sure you are using configuration '9600bps, 8, 1, n' and the serial port is free (it is not used from other windows application).

☞If you have any specific needs and/or you are not sure about this information please contact us on: office@selectec-consultants.co.uk