



Ethernet thermometer

TME

a thermometer with Ethernet data transmission

ASCII, HTTP (WEB), SMTP (e-mail)
SNMP, MODBUS and SOAP protocols



Ethernet thermometer TME

Datasheet

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BASIC INFORMATION

Description

TME is a simple temperature sensor with Ethernet interface. It measures temperatures ranging from -55°C to $+125^{\circ}\text{C}$. Measured values can be read in several ways including internal WEB pages.

The communication is realized via various TCP/IP protocols. Thanks to this it is possible to choose a method suitable for particular application. The temperature is sent in a simple ASCII format directly in degrees Celsius; there is no need of any additional conversion. It also enables communication with SNMP protocol (UDP) or sending an e-mail in case any of the pre-set limits is exceeded.

The temperature from TME can be easily inserted in your WEB pages (HTTP GET).

TME is also able to communicate via MODBUS TCP protocol.

The temperature can also be read from XML file or send it via SOAP protocol to be processed by the WEB Service. (A comprehensive overview of the possibilities concerning the temperature acquiring and utilizing can be found on page 5.)

Features

- Measurement of temperatures ranging from -55°C to $+125^{\circ}\text{C}$; resolution $0,1^{\circ}\text{C}$
- Data transfer via TCP/IP protocols (10/100 Ethernet)
- Internal WEB pages
- Data transfer in simple ASCII format (Spinel) needing no conversion
- Easy temperature insertion on the WEB pages
- E-mail sending when preset limits are exceeded
- SNMP protocol
- MODBUS TCP protocol
- SOAP protocol for the WEB Service
- Can be mounted to DIN rail

Software

- An user friendly configuration program is included free of charge
- A demo program, including commented source code, is also free of charge

Overview of innovations

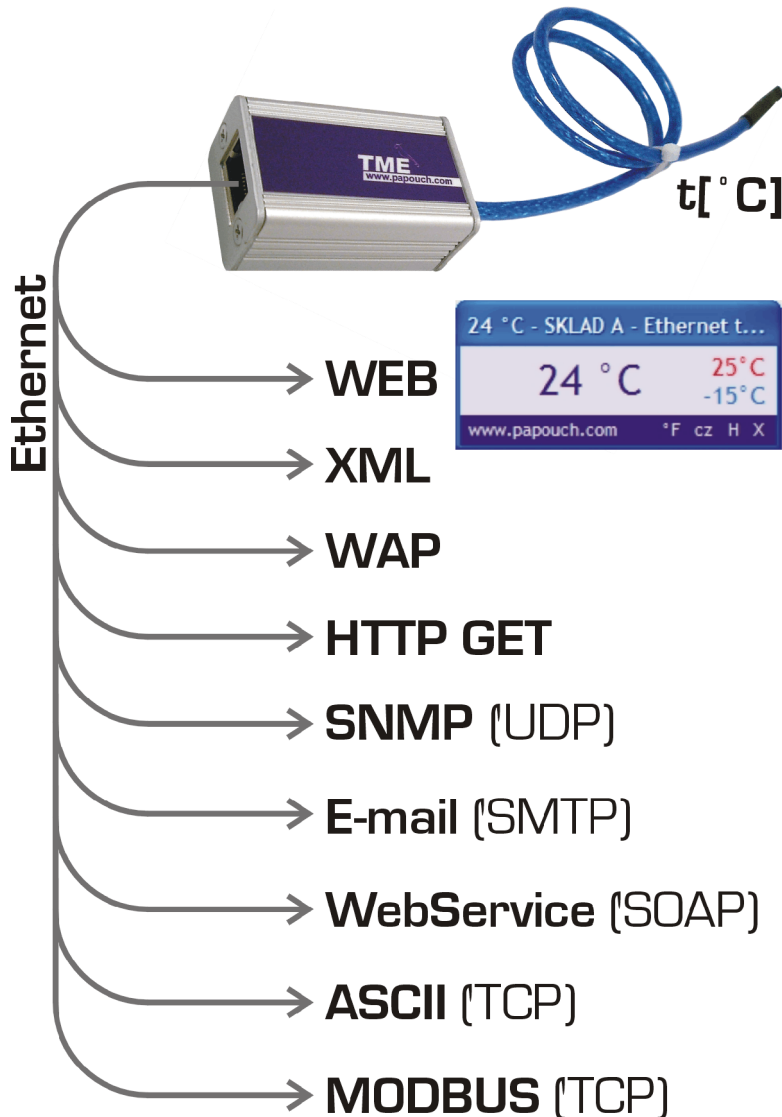
Version 1.7

- MODBUS TCP protocol.

Version 1.6

- Support for sending information to the WEB service via SOAP protocol (XML) – easy processing of values from TME in .NET.
- WAP pages for mobile phones or PDA.
- User-defined XML file sent via SOAP protocol.
- Possibility to change the port number for WEB. This enables to easily access TME behind the firewall, router, etc.
- New variable consisting of 40 characters added to enable clear identification of TME by a user-defined string. If this variable is completed, it is added as a new parameter into HTTP GET and it can also be used as a variable in the file sent via SOAP protocol.
- The maximum length of the title extended to 23 characters.
- The possibility to define the hysteresis of temperature limits. (Prevents frequent sending of notification of limits violation if the temperature oscillates around a preset limit.)
- E-mails notifying of a limit violation can be sent in a preset interval until the temperature returns to the preset range.
- TME can insert a parameter *Host* with the target server URL into the header of HTTP communication (HTTP protocol v. 1.1.) – this holds for HTTP GET as well as sending XML files to the WEB service.
- When communication via TCP, TME can function not only as a server (passively waits for a connection), but also as a client (actively establishes connection to the defined IP address and port).
- In TCP mode the TME connection can be established permanently or disconnected after the temperature is sent.
- XML page (*tme.xml*) coding changed from iso-8859-2 to iso-8859-1.
- The structure of setup via Telnet modified.
- The error of error messages overlaying on the WEB page corrected.

Acquiring temperature values from a TME thermometer



1) Internal website

When the thermometer's IP address is set in an Internet browser,¹ a website is brought up displaying the actual temperature value and the set temperature limits. A Czech or English language version of this website can be chosen within the settings. The temperature value can be shown in degrees Celsius or Fahrenheit. Either a graphical display resembling a mercury thermometer can be selected, or a plain text. (Cf. also page 33.)

2) XML file

At [http://\[IP_address_of_thermometer\]/tme.xml](http://[IP_address_of_thermometer]/tme.xml), the file in XML format contains the actual temperature value, the name of the measurement location, and the temperature limits. (Cf. also page 34.)

3) Inserting the temperature value into a website using a script (HTTP GET)

Thermometer TME enables a periodic call for a script (e.g., PHP or ASP) on a given address – for example, a WEB server. (Cf. also page 36.)

¹ Optimised for Internet Explorer 6.0 or Mozilla Firefox 1.5. The browser's JavaScript support must be enabled.

4) SNMP protocol

According to the settings, TME sends out SNMP traps if the temperature value is outside of the set limits. Regular transmission of a trap with the actual temperature value is also possible. (Cf. also page 41.)

5) E-mail

According to the settings, the thermometer sends E-mails with information if the temperature value goes outside of the set limits. (Cf. also page 43.)

6) TCP protocol

The thermometer behaves as a server and waits for a connection request on the set IP address and port. Upon connecting, it sends the Client temperature data in ASCII format. (Cf. also page 39.)

7) WAP page for PDA or mobile phone

Entering an IP address of the thermometer in the form: *http://[IP_address]/wap* on a mobile phone or PDA with WAP browser opens a simple page with current data from the TME thermometer (current temperature, thermometer name and limits, if they are set).



Fig. 1 – TME WAP

8) Webservice (SOAP protocol)

Information from TME can be regularly sent via SOAP protocol (Simple Object Access Protocol) directly to the WEB service waiting on the server. WEB service receives from TME a XML file in a format, which can be defined to precisely reflect the user's needs. This data can be easily processed e.g. in the .NET environment – there is no need to spend time on programming the communication protocol etc. It is only necessary to process the received XML file. (The service setup can be done via the Configuration Panel – SOAP, as described on page 22 of this document.)

9) Via MODBUS TCP protocol

TME communicates via MODBUS TCP protocol on its own IP address and port 502. It contains a “Temperature Register” No. 30001 of a signed integer type and a “Status Register” No. 30002 of an integer type.

The Temperature register contains the currently measured temperature in degrees Celsius multiplied by ten (the temperature of 12,3°C expressed as 123). If an error occurs, the register shows the value 9999.

The Status Register shows the value 0. If an error occurs (e.g. a temperature sensor error), the register shows the value 1.

Installation options

Mounting:

- Without a holder (*standard*)
- With a DIN rail mount



Length of cable:

- 3 m (*standard*)
- 10 cm to 20 m

Cable temperature resistance:

- -10 to +80 °C (*standard*)

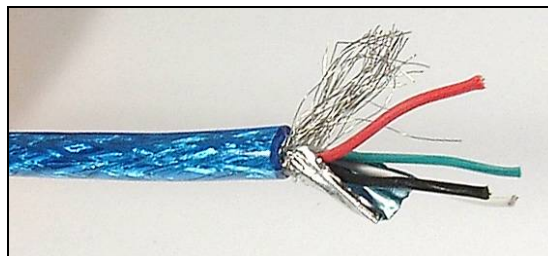


Fig. 4 – standard cable

Sensor designs:

- Sealed in shrinkable coating (*standard*)



Fig. 2 – sensor in shrinkable coating

- In metal housing \varnothing 6 mm, (the metal part is 50 to 70mm long)



Fig. 3 – sensor in metal housing

- -55 to +150 °C



Fig. 5 – ETFE cable

Please do not hesitate to contact us if you have specific requirements for the Ethernet thermometer TME module's workmanship and functionality.

Contents of the package

- TME Thermometer with a 3-m cable (the temperature sensor is sealed in shrink-foil coating).

Accessories

- The power supply unit with cable and the corresponding connector (3.8 × 1.3 mm).
- Power-supply cable, 2 m long, with a 3.8 × 1.3 mm connector. The other end is open, with conductors to be wired into the power source.
- A power-supply cable from a USB 2.0 port.

CONNECTION

The Ethernet interface is connected on the front side into an RJ45 connector. It is connected with a standard (uncrossed) cable to a HUB or Switch.

On the rear side of the module, there is a power-supply connector (cf. the Fig. 7) The power is connected via a coaxial connector with a 3.8×1.3 mm (minus outside; plus inside; Fig. 6).



Fig. 6 – power supply cable

INDICATORS

ON (green) indicator (top LED indicator in the Fig. 7)

TITLE: Indication of the power-supply voltage

TCP/IP connection (yellow) indicator (bottom LED indicator in the Fig. 7)

TITLE: Indicates established TCPIP connection.

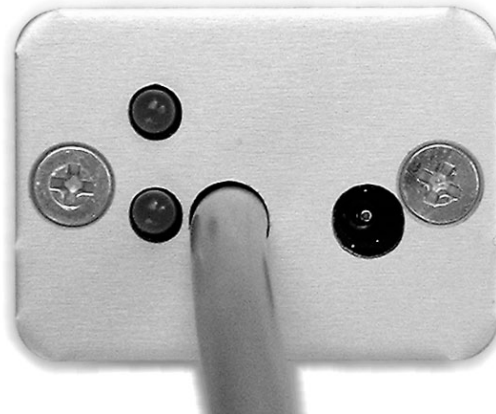


Fig. 7

TECHNICAL PARAMETERS**Temperature sensor**

Measuring range -55 °C to +125 °C

Accuracy $\pm 0,5$ °C within the range -10 °C to +85 °C; otherwise ± 2 °CTemperature drift $\pm 0,2$ °C over 1000 hours at 125 °C**Standard sensor cable**

Working temperature range -10 to +80 °C

Cable diameter 4,5 mm

*(The cable is shown in Fig. 4.)***ETFE sensor cable**Producer Cambridge Technologies ²

Working temperature range -55 to +150 °C

Cable diameter 3 mm

Type Mil-27500

Specification M27500/22TG2T14 ³

Cable coating extruded ETFE (Ethylen TetraFluorEthylen)

*(The cable is shown in Fig. 5.)***Ethernet interface**

Ethernet connection TBase 10/100 RJ45

Other parameters

Power supply 4 to 6 V (230 mA max.)

Electronics working temperature range -40 °C to +85 °C

Electronics dimensions 54 x 33 x 24 mm

Weight 135 g (incl. 3 m of standard cable)

ETHERNET DEFAULT SETTINGS

IP address 192.168.1.254

Subnet mask 255.255.255.0 (8 bits; C mask)

Gateway 0.0.0.0

² Producer's homepage: <http://cambridge-tec.com/>³ Cable catalogue list: http://cambridge-tec.com/pdf/Cable_catalog.pdf#page=22

FAQ

What settings are necessary so that the thermometer will work in my network?

The parameters (IP address and subnet mask) of the network connection should be correctly set. The settings are described for Windows operating systems.

- 1) Connect the TME to your network and run the included configuration program.
- 2) Click on "Set up IP". In the dialog box which appears, insert the MAC address written on the label on the thermometer (cf. the Fig. 5).
- 3) The program will try to find the TME according to this address. If succeeded to find, configuration of thermometer will open.
- 4) Change the IP address and subnet mask as necessary, and click on "Set."
- 5) After a while the thermometer will register in the network with the new parameters.

How can I find the thermometer's IP address?

- 1) The default IP address of the thermometer is 192.168.1.254. If you have changed this address, or cannot connect to the thermometer at this address, follow the steps described below.
- 2) Activate the included configuration program and find the TME ("Find by MAC") according to the MAC address written on the label placed on the thermometer's side.
- 3) As soon as the program finds the TME, click on "Network Settings." The thermometer's IP address is the first item.

I do not know the actual IP address and I need to change it

- 1) Run the included configuration program and click on "IP settings." A wizard will lead you through the steps of finding the TME and changing its IP address.
- 2) After setting the IP address, you will be able to set up other TME parameters.

Firefox: This Address is Restricted

"It seems as a security touch to Firefox it is now⁴ blocking non standard HTTP ports." ... "To override this type this in the address bar "about:config" and search for "network.security.ports.banned.override". This may or may not exist, if it doesn't, right click anywhere in the window and select new->string and use "network.security.ports.banned.override" as the name and the port number you need to connect to as the value. You can also select a range of ports by using "1-1024" as such a value or as a CSV style values such as "1024, 8080, 1-1000, 80"... etc"⁵

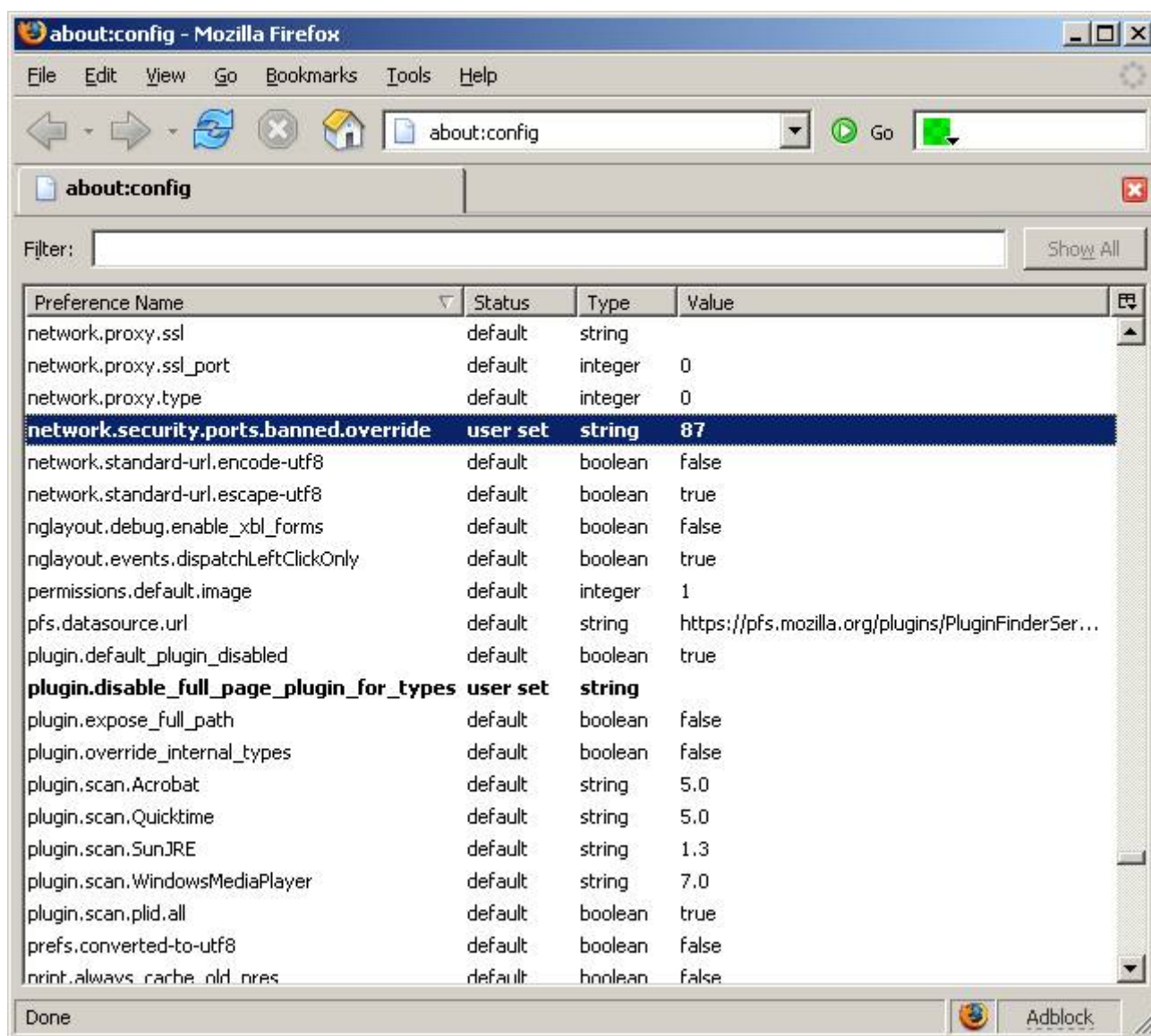


Fig. 8 – Example of Firefox browser with port 87 enabled

⁴ March 24, 2006

⁵ Text originally come from:

[http://www.redbrick.dcu.ie/~d_fens/articles/Firefox: This Address is Restricted](http://www.redbrick.dcu.ie/~d_fens/articles/Firefox:_This_Address_is_Restricted)

SETTINGS

The TME thermometer can be set by:

- Configuration program
- Telnet protocol (cf. page 27)

Configuration program

The configuration program for Windows operating systems can be downloaded for free from www.papouch.com/en/ . It will enable you to set all the necessary parameters of your TME thermometer.

The program can find the TME connected to the network either according to its IP address, or the MAC address, after which you will be able to change its parameters.

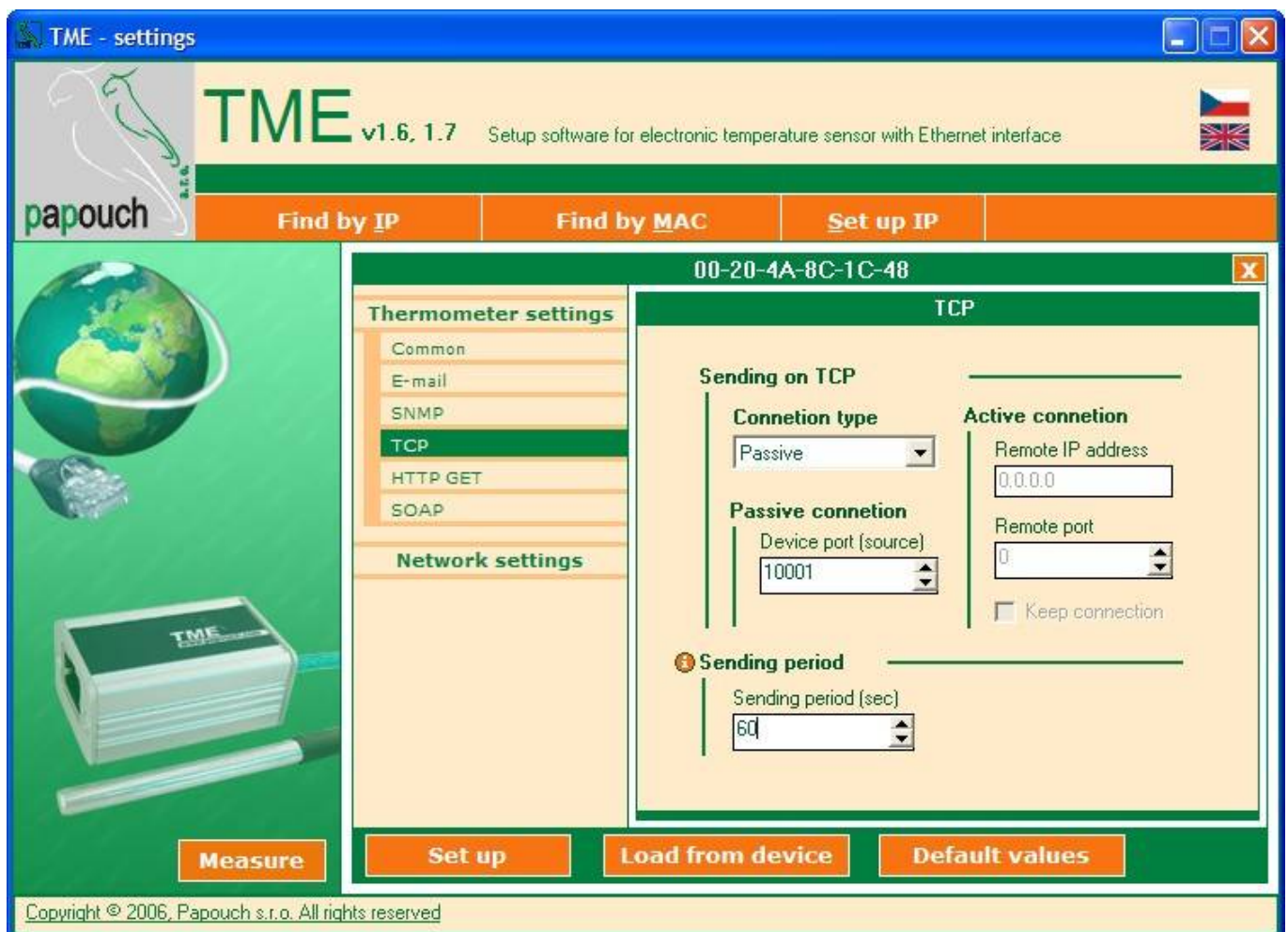


Fig. 9 – the main screen of the configuration program

Search according to IP address

When you click on this button, a dialog box for setting the requested IP address is displayed first (cf. the Fig. 10).



Fig. 10 – entering the requested IP address

The program will then try to find the TME thermometer at the address you have inserted. If you are successful and find the thermometer, the configuration panel will be displayed in the main window of the program.

If the TME thermometer is connected into another network – for example, behind a router – and its IP address is mapped to a different port, check the "Port" field and enter the port value (cf. Fig. 11).



Fig. 11 – entering the IP address and non-standard port to be looked for

Search according to MAC address

When you click on this button, a dialog box for setting the relevant thermometer's MAC address (cf. the Fig. 12) is displayed first (cf. the Figure).⁶

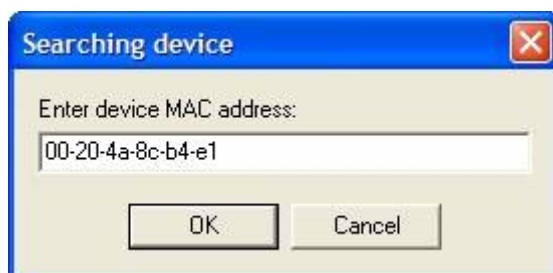


Fig. 12 – entering the requested MAC address

The program will then try to find the TME according to this address. If you are successful and find the thermometer, the configuration panel will be displayed in the main window of the program.

⁶ The MAC address of the TME thermometer is written on its side. It is a 12-character code, e.g. 01-23-45-67-89-AB.

Setting of IP address

After clicking on this button, the thermometer's parameters are to be set in two steps.

In the first step (cf. the Fig. 13), the TME thermometer's MAC address should be entered.



Fig. 13 – changing the IP address of a thermometer with a known MAC address

In the second step, a new IP address, subnet mask and gateway of the TME thermometer are to be set. If you are not sure what values you should set, please contact your network administrator, who will give them to you.

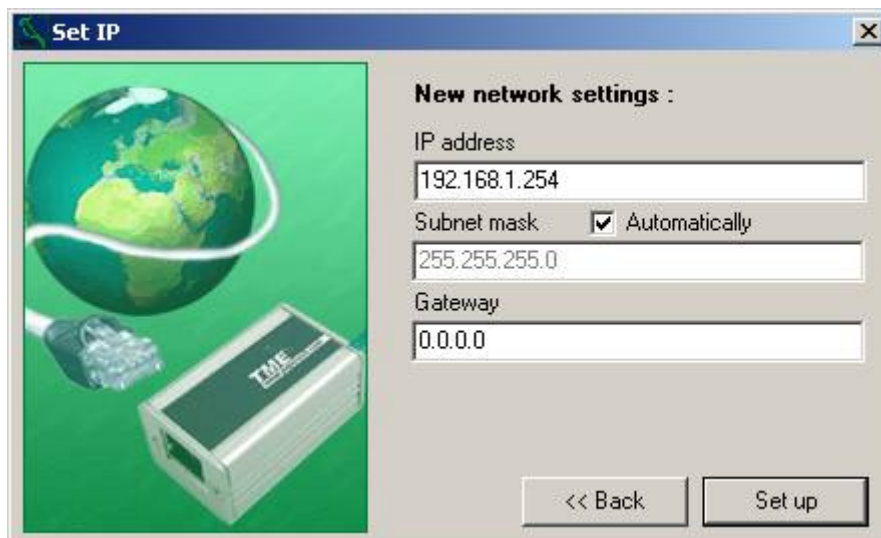


Fig. 14

Configuration Panel – Common

By clicking the “Common” bookmark you access the following setup items.

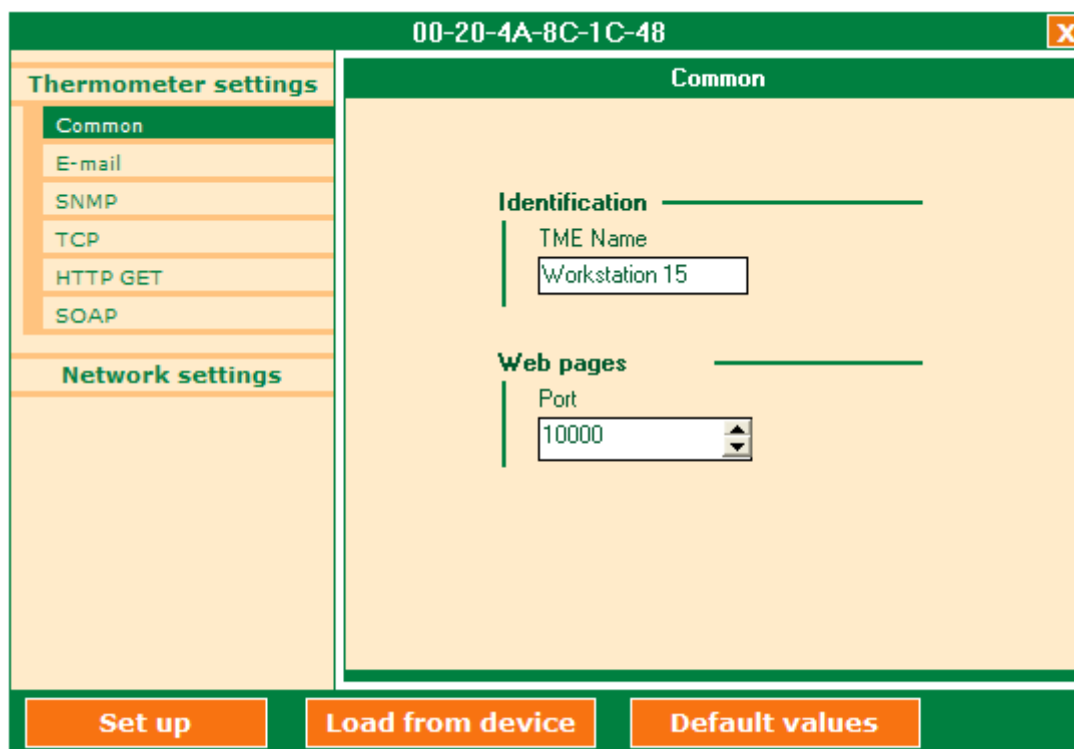


Figure 15 – Configuration Panel – Thermometer settings – Common

Identification

TME Name

Enables easy identification of a particular thermometer among others. (The maximum length of the name is 15 characters.)

Website

Web Port

Here it is possible to change the initial value of the port where the thermometer WEB pages are available. This option is suitable in case TME is placed behind a firewall or a router with a blocked port 80 (standard WEB port). If this is the case, find out which port is available and enter it in this field. You can access the pages from a web browser by entering an address in the following form: *http://[IP-address]:[port]* , i.e. for example *http://192.168.1.254:8080*

Configuration Panel – E-mail

By clicking the “E-mail” bookmark you access the following setup items.

The screenshot shows a web-based configuration interface for an Ethernet thermometer. The main window is titled 'E-mail' and contains the following elements:

- A checkbox labeled "Sending temperature to email (when limits overrun)" which is currently unchecked.
- Fields for "SMTP Server IP" (0.0.0.0) and "Sending period" (0 sec).
- Fields for "Sender's address (From)" and "Recipients's address (To)".
- A section titled "Critical temperature values" with a warning icon, containing:
 - "Minimal value (°C)" set to 21.
 - "Maximal value (°C)" set to 30.
 - "Hysteresis (°C)" set to 0.
- At the bottom, three buttons: "Set up", "Load from device", and "Default values".

Figure 16 – Configuration Panel – Thermometer settings – E-mail

Sending temperature to e-mail (when limits overrun)

By ticking the field you activate a function of sending notification e-mails based on the following setup.

SMTP server IP

IP address of the SMTP server, which will be used for sending the notification e-mails. It must be a server which does not require sender's identity verification. It is also possible to enter a symbolic address into this field and translate it into an IP address by clicking a button with @ symbol to the right of the field. (SMTP server must be accessible at that moment.)

Sender's email address

Thermometer email address. (You will receive an e-mail from this address.)

Recipient's email address

Email to which the information on preset temperature limits overrunning will be sent.

Temperature sending period in case of critical values violation

If the value is set to more than 0, the function is active. If one of the preset limits is overrun the information email will be sent in the given period until the temperature returns below the limit (+ the value of hysteresis, if it is set).

Critical temperature values

[These settings are mutual for sending emails and for SNMP. Changes to these settings will also show in the corresponding SNMP settings.]

Minimum value

An information email will be sent if temperature drops below this value.

Maximum value

An information email will be sent if temperature exceeds this value.

Hysteresis

Hysteresis that will apply to the preset limits.

The value is set in degrees Celsius and applies below the upper temperature limit (or above the lower temperature limit) – see Fig. 17.

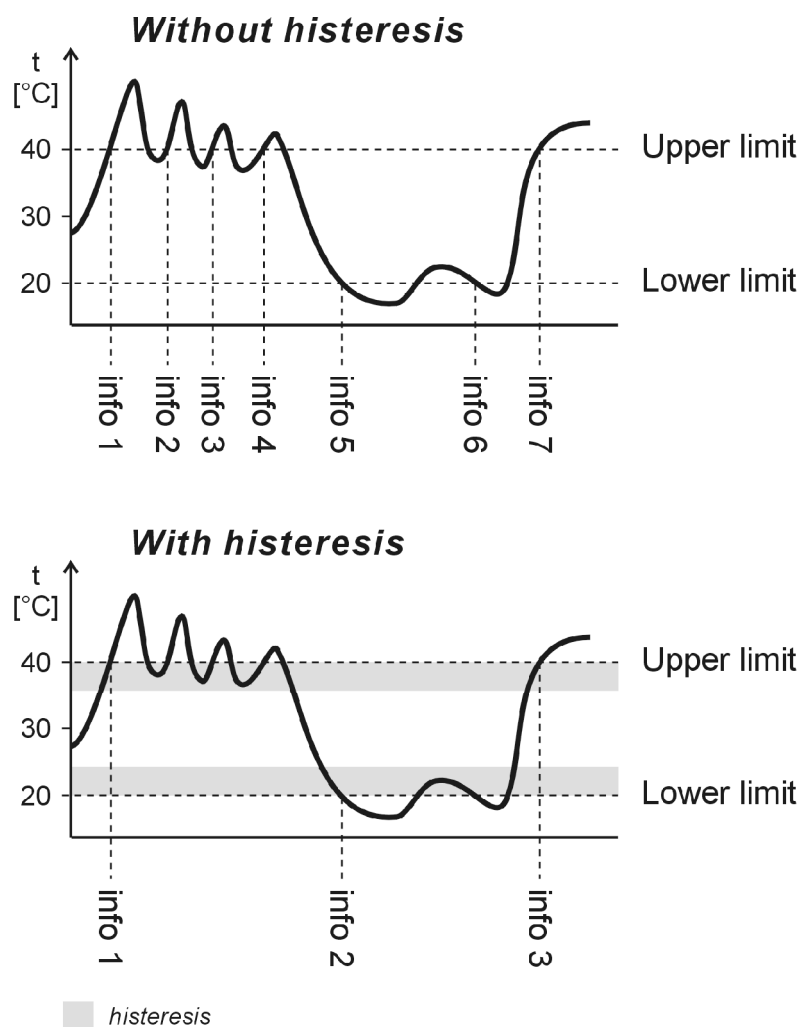


Fig. 17 – Temperature limits hysteresis

Temperatures marked in the figure as “info” show the moment of sending an information email (or SNMP trap – according to the setting) notifying that one of the limits has been overrun.

Configuration Panel – SNMP

By clicking the “SNMP” bookmark you access the following setup items.

Fig. 18 – Configuration Panel – Thermometer settings – SNMP

Sending SNMP traps

By ticking the field you activate a function of sending SNMP traps based on the following setup.

SNMP manager IP

IP address of the PC with SNMP manager, which will be used for sending the SNMP traps. It is also possible to enter a symbolic address into this field and translate it into an IP address by clicking a button with @ symbol to the right of the field. (SNMP manager must be accessible on the network at that moment.)

Read community

SNMP community name for reading.

Write community

SNMP community name for writing.

Keep-alive trap period

It sets an interval in which SNMP trap with measured temperature will be sent. The value should be sent in the format mm:ss. The maximum time span is 60 minutes. If the value 0 (0:00) is entered the function is inactive.

Critical temperature values

These settings are mutual for SNMP and sending e-mails. The setting itself is described on the previous page below the Critical temperature values heading.

Configuration Panel – TCP

By clicking the “TCP” bookmark you access the following setup items.

Fig. 19 – Configuration Panel – Thermometer settings – TCP

Temperature sending via TCP

Connection type

Passive: TME passively waits for a connection to the preset port (“Device port”).

Active: TME actively establishes connection with a remote IP address (“Remote IP address”) and port (“Remote port”). The connection can be kept established permanently (“Keep connection” field is ticked) or disconnected once the temperature is sent (“Keep connection” field is not ticked).

Passive connection

Device port

Number of port on which TME waits for an incoming connection

Active connection

Remote IP address

IP address of a remote device (mostly a server), to which TME connects in the active mode of connection establishing.

Remote port

Port number of a remote device (mostly a server), to which TME connects in the active mode of connection establishing.

Keep connection

Ticked: TME keeps the established connection alive.

Not ticked: TME establishes a connection in the preset interval (“Sending period”), sends the temperature and disconnects.

Sending period

Sending period

Time interval in seconds in which the temperature is regularly sent via the established TCP connection. The setting range of the interval is 2 to 3600 sec. (This interval is mutual for TCP, HTTP GET and SOAP.)

Configuration Panel – HTTP GET

By clicking the “HTTP GET” bookmark you access a setting window for sending data from TME in the form of HTTP GET enquiry to a server on the Internet or Intranet. (*For more information on HTTP GET see page 36.*)

Fig. 20 – Configuration Panel – Thermometers settings – HTTP GET

Sending temperature to HTTP server

By ticking the field you activate a function of sending temperature via HTTP GET to a WEB server.

URL path

It sets a script which will be regularly called and to which data from TME will be sent as GET parameters. This URL is entered into the header as the parameter *Host:* (*For more information on the URL part format see page 36.*)

Server IP address

SMTP server IP address. If a valid address is filled in the “URL path” field and it is currently accessible, it is possible to enter the server IP address automatically by clicking the @ symbol to the right of the “URL path” field.

Parameters

Sending period

Time interval in seconds in which the temperature is regularly sent. The setting range of the interval is 2 to 3600 sec. (This interval is mutual for TCP, HTTP GET and SOAP.)

GUID

A string of up to 40 characters. This variable serves for e.g. saving a unique ID within the measuring system. If this field is filled in, another variable is added into the HTTP GET calling in the form “*guid=[string_GUID]*”. (This variable is mutual for HTTP GET and SOAP.)

Configuration Panel – SOAP

By clicking the “SOAP” bookmark you access the setting for sending data to the WEB service via SOAP protocol.

The screenshot shows a web browser window titled "00-20-4A-8C-1C-48". On the left, there is a sidebar with "Thermometer settings" and "Network settings". Under "Thermometer settings", "SOAP" is selected. The main content area is titled "SOAP" and contains a checked checkbox "Sending temperature by SOAP". Below this, there are three input fields: "URL path" with the value "http://example.com/sensors.php", "Server IP address" with the value "123.456.789.11", and "SOAP document" with the value "448 B". To the right of the "SOAP document" field is a "Settings" button and a trash icon. Below these fields is a section titled "Parameters" with an information icon. It contains two input fields: "Sending period (sec)" with a value of "60" and "GUID" with the value "94E358FB-8142-42BB-88". At the bottom of the window, there are three buttons: "Set up", "Load from device", and "Default values".

Fig. 21 – Configuration panel – Thermometer settings – SOAP

Sending temperature via SOAP

By ticking the field you activate a function of sending temperature to the WEB service via SOAP protocol.

URL path

URL address of the WEB service. The entered URL is inserted into the header instead of the “Host:” parameter in a document selected on the following screen. (If the “Host:” parameter is already set in the file, it is overwritten.)

Server IP address

IP address of a server with the WEB service. If a valid address is filled in the “URL path” field and it is currently accessible, it is possible to enter the server IP address automatically by clicking the @ symbol to the right of the “URL path” field.

SOAP document

In this section it is possible to insert a document, which will be sent to the WEB service. By clicking the SOAP document “Settings” button it is possible to choose a document a header that is to be sent as a header and POST parameters via SOAP protocol. The document selection is described below in chapter: “Configuration panel – SOAP – Document selection”.

The number displayed next to the button shows the length of the document, or “Empty document” text is displayed instead.

Parameters

Sending period

Time interval in seconds in which the temperature and other information is regularly sent via the SOAP protocol. The setting range of the interval is 2 to 3600 sec. (This interval is mutual for TCP, HTTP GET and SOAP.)

GUID

A string of up to 40 characters. This variable serves for e.g. saving a unique ID within the measuring system. This string is inserted into the document sent via SOAP to the spot in the text marked with the tag: <%guid%>. (This variable is mutual for HTTP GET and SOAP.)

Configuration panel – SOAP – Document selection

By clicking the “SOAP” bookmark followed by the Document “Settings” button it is possible to choose a desired document to be sent to the WEB service via SOAP.

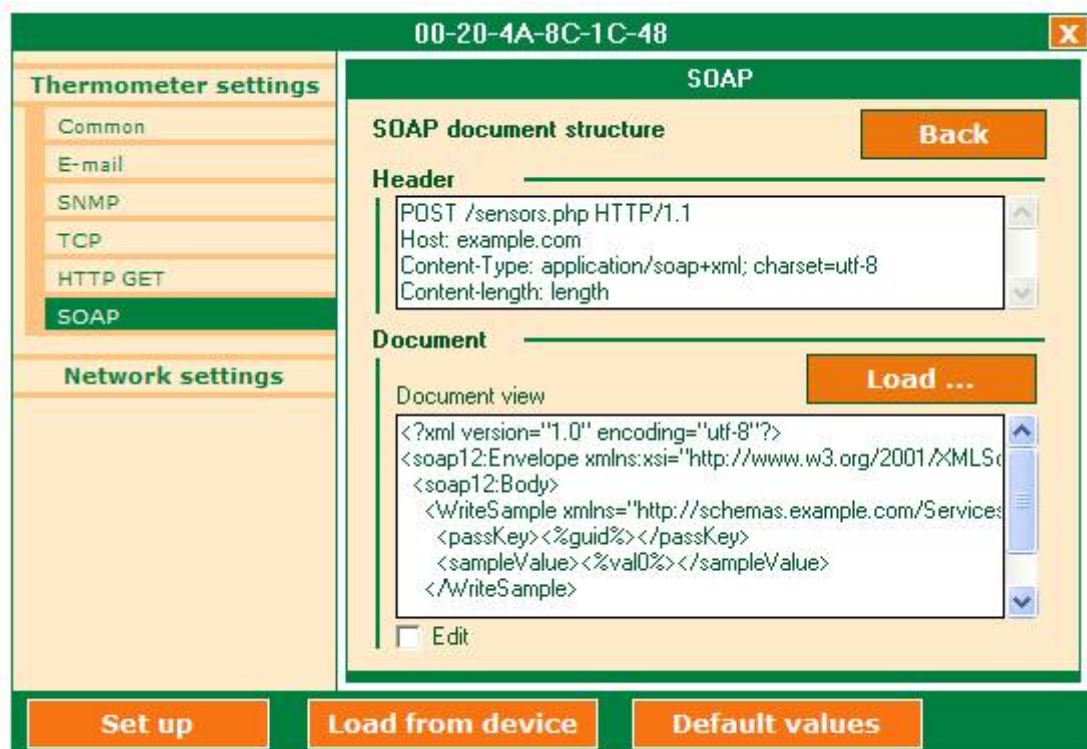


Fig. 22 – Configuration panel – Thermometer settings – SOAP – Document settings

You can enter the document manually or chose an existing file by clicking the “Load” button. In the standard dialog for file selection it is possible to insert a XML file, a file incl. a header⁷ or another file.

If a “Host:” parameter is specified in the header, its value is automatically used for the “URL path” field in the previous window. (The “URL path” field is filled with the value from the file only if the “URL path” field is empty.) By manual overwriting the “Host:” parameter in the “Header” field the value in the “URL path” field is overwritten as well.

The header and the file body displayed in the Document part of the window must not exceed 65 500 bytes. The file and well as the header can be defined based on the format required by the server. **The following values will be inserted by TME into designated places in the document:**

Measured temperature: The just-measured temperature in degrees Celsius is inserted into the place marked as `<%val0%>`. The temperature is sent as a decimal number with the accuracy to decimal places. A sign (plus or minus) is included in front of the number. A temperature of 23.6 °C is defined as a string: +23.6. If a sensor error occurs (sensor cable disconnection etc.) the string “Err” is inserted.

Upper temperature limit: The preset upper temperature limit in degrees Celsius is inserted into the place marked as `<%hit0%>`. The temperature is sent as a decimal number with the accuracy to decimal places. A sign (plus or minus) is included in front of the number. A temperature of 23.6 °C is defined as a string: +23.6. If no upper temperature limit is preset, a temperature of +999.9 is inserted.

Lower temperature limit: The preset lower temperature limit in degrees Celsius is inserted into the place marked as `<%lot0%>`. The temperature is sent as a decimal number with the accuracy to decimal places. A sign (plus or minus) is included in front of the number. A temperature of 23.6 °C is defined as a string: +23.6. If no lower temperature limit is preset, a temperature of -999.9 is inserted.

Name: TME name will be inserted into the place marked as `<%name%>`. (It is set in the “Common” section.)

GUID: A string defined on the previous page below the GUID heading will be inserted into the place marked as `<%guid%>`.

The above mentioned variables can appear several times in both the header as well as the document body. Not all the variables must be used.

⁷ File including a header is a text document, where the header is separated from the document body by an empty line. The part above the first empty line is used as a header, the part below the empty line as the document body.

Example of SOAP document:

Example of a document including a header as it is defined during setting:

```
POST /sensors.asmx HTTP/1.1
Host: thermometer.papouch.com
Content-Type: application/soap+xml; charset=utf-8
Content-Length: length

<?xml version="1.0" encoding="utf-8"?>
<soap12:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:soap12="http://www.w3.org/2003/05/soap-envelope">
  <soap12:Body>
    <WriteSample xmlns="http://schemas.papouch.com/WebServ/TME">
      <guid><%guid%></guid>
      <val0><%val0%></val0>
      <name><%name%></name>
      <hit0><%hit0%></hit0>
      <lot0><%lot0%></lot0>
    </WriteSample>
  </soap12:Body>
</soap12:Envelope>
```

A document including a header as it is sent from TME to a server:

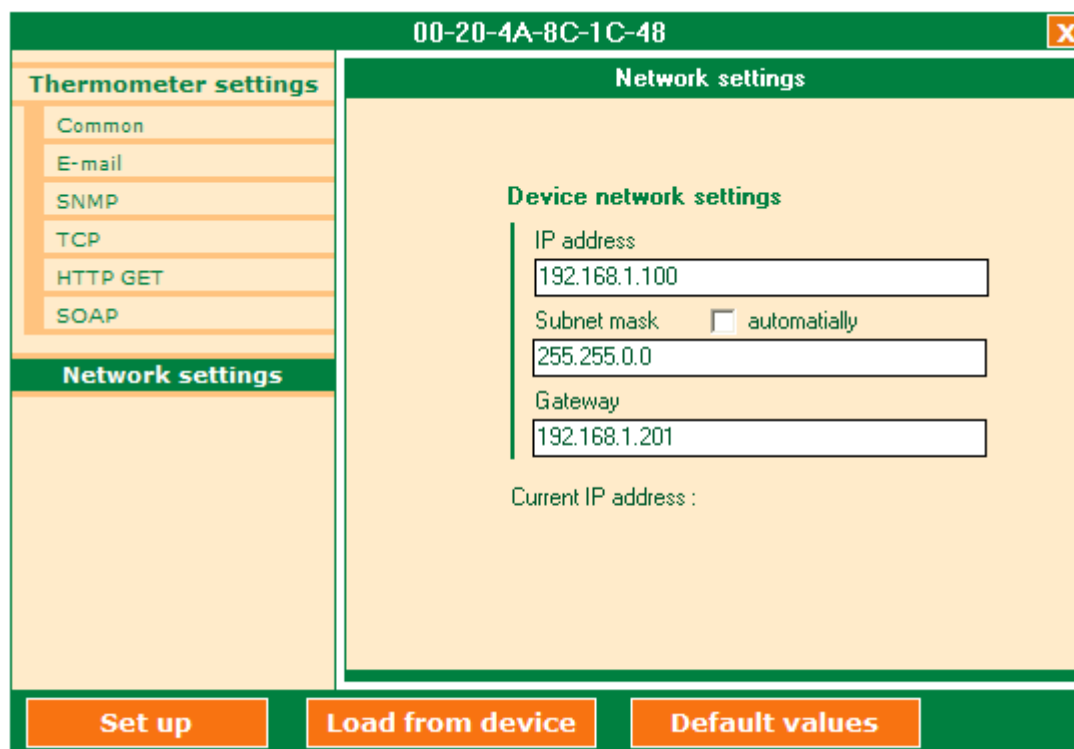
```
POST /sensors.asmx HTTP/1.1
Host: thermometer.papouch.com
Content-Type: application/soap+xml; charset=utf-8
Content-Length: [real length of the document]

<?xml version="1.0" encoding="utf-8"?>
<soap12:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:soap12="http://www.w3.org/2003/05/soap-envelope">
  <soap12:Body>
    <WriteSample xmlns="http://schemas.papouch.com/WebServ/TME">
      <guid>98E3D8FB</guid>
      <val0>+23.6</val0>
      <name>Workstation 15</name>
      <hit0>+56.5</hit0>
      <lot0>-999.9</lot0>
    </WriteSample>
  </soap12:Body>
</soap12:Envelope>
```

The defined strings in the example file were replaced with real values from TME. The value -999.9 in the lower temperature limit (lot0) means that this limit has not been set.

Configuration panel – Network settings

By clicking this bookmark you access basic network setting of TME.



The screenshot shows a web-based configuration interface for a TME thermometer. The window title is "00-20-4A-8C-1C-48". On the left, there is a sidebar menu with "Thermometer settings" and "Network settings" (which is selected). Under "Thermometer settings", there are options for Common, E-mail, SNMP, TCP, HTTP GET, and SOAP. The main area is titled "Network settings" and contains "Device network settings". These settings include: IP address (192.168.1.100), Subnet mask (255.255.0.0) with an unchecked "automatically" checkbox, and Gateway (192.168.1.201). Below these fields is a label "Current IP address :". At the bottom of the configuration panel, there are three buttons: "Set up", "Load from device", and "Default values".

Fig. 23 – Configuration panel – Network settings

Device network settings

IP address

Thermometer IP address. In case you are not sure if the address is correct, consult your network administrator.

Net mask

A mask of the network TME thermometer is connected into.

Gateway

Network gateway address.

Telnet protocol

Logging into the setting mode

You can log into the setting mode via Telnet using the following procedure. The procedure is described for Windows operating systems.

- 1) Type "cmd" in the command line (Start/Run...) and push Enter (cf. Fig. 24).



Fig. 24 – Run...

- 2) Run Telnet. (Type "Telnet" in the newly opened window and push Enter – cf. the Fig. 25.

```
C:\>telnet_
```

Fig. 25 – Run...

- 3) Now you can connect to the thermometer. Its IP address setting from the manufacturer is 192.168.1.254. (Type "open 192.168.1.254" in the window and push Enter.) (cf. Fig. 26)

```
Microsoft (R) Windows 2000 (TM) Version 5.00 (Build 2195)
Welcome to Microsoft Telnet Client
Telnet Client Build 5.00.99206.1

Escape Character is 'CTRL+Q'

Microsoft Telnet> open 192.168.1.254 9999_
```

Fig. 26 – Connection to the thermometer

- 4) You have to confirm the option by pushing Enter immediately after loading. The setting menu is now displayed (cf. Fig. 27).

```
Menu:
[ 0 ] Network settings
[ 1 ] Thermometer settings
[ 7 ] Set to default values
[ 8 ] Exit without save
[ 9 ] Save and exit

Your choice: ? _
```

Fig. 27 – Main setting menu

Server configuration

Items of this menu can be configured after selecting the menu by entering "0" and pushing Enter.

```
Menu:
[ 0 ] Network settings
[ 1 ] Thermometer settings
[ 7 ] Set to default values
[ 8 ] Exit without save
[ 9 ] Save and exit                Your choice: ? 0

IP Address : <192> .<168> .<001> .<123>
Set Gateway IP Address <N> ?
Netmask: Number of Bits for Host Part <0=default> <16>
Change telnet config password <N> ?
```

obr. 28 – „Server configuration“ menu

IP Address

The IP address of the module. Type each of the four numbers in the IP address separately, and confirm it by pushing Enter.

Initial value: 192.168.1.254

Set Gateway IP Address

Gateway IP addr

For the "Set Gateway IP Address" item, set "Y" to change its value. You will be prompted to enter the new value. Type each of the four numbers in the IP address separately, and confirm it by pushing Enter.

Netmask

Here you can set how many bits of the IP address is the net part.

The subnet mask is given as the number of bits which determine the range of the local subnet. For example, if the value is 2, mask 255.255.255.252 is used. The value determines the number of the bits taken from the right-hand side. The maximum value is 32.

Sometimes mask types A, B, and C are referred to. They signify values of 24, 16, and 8 bits, respectively.

Initial value: 8 (type "C" mask)

Example:

Mask 255.255.255.0 (binary 11111111 11111111 11111111 00000000) signifies 8.

Mask 255.255.255.252 (binary 11111111 11111111 11111111 11111100) signifies 2.

Change Telnet config password

Enter new Password

This item sets the password which is required for configuration via Telnet.

For the "Change Telnet config password" item, set "Y" to change its value. You will be prompted to enter the new password.

Note: If the password is lost, it cannot be recovered on the user level, and the thermometer must be sent to the manufacturer for a service intervention.

Thermometer settings

You can configure items in this menu after selecting the menu by entering 1 and pressing the Enter button.

```

Menu:
[ 0 ] Network settings
[ 1 ] Thermometer settings
[ 7 ] Set to default values
[ 8 ] Exit without save
[ 9 ] Save and exit
Your choice: ? 1

***** Thermometer settings *****
TME Name : <U kancelari>
> > Change this parameter Y/N ? <N> ?

----- TCP -----
Connection type - Active TCP<Y> or Passive TCP<N>: <N> ?
Device port <source> : <10001>
Remote port : <00000>
Remote IP address : <000> .<000> .<000> .<000>

----- Temperature -----
Sending period <TCP, HTTP GET, SOAP>: <00010> s
Maximum value : <+999.9 C>
Minimum value : <-999.9 C>
Hysteresis : <+000.0 C>

----- SNMP -----
Read community : <aaa>
Write community : <private>
Enabled Trap<Y> or <N> <N> ?

----- SMTP (e-mail) -----
Enabled Email<Y> or <N> <Y> ?
Sending period : <0010>s
SMTP Server IP : <192> .<168> .<001> .<001>
Sender's address <From> : <tme@papouch.com>
> > Change this parameter Y/N ? <N> ?
Recipient's address : <test@papouch.com>
> > Change this parameter Y/N ? <N> ?

----- HTTP and SOAP settings -----
GUID : <98ED78B>
> > Change this parameter Y/N ? <N> ?
URL path <HTTP GET> : <0.0.0.0>
> > Change this parameter Y/N ? <N> ?
HTTP Port <for internal WEB pages> : <00080>
Remote HTTP port : <00080>
Remote HTTP Server IP : <000> .<000> .<000> .<000>
Script address : <>
> > Change this parameter Y/N ? <N> ?
Remote SOAP server port : <00080>
Remote SOAP server IP : <081> .<000> .<246> .<142>

Enabled send HTTP GET<Y> or <N> <Y> ?
Enabled send SOAP<Y> or <N> <Y> ?

```

Fig. 29 – menu „Thermometer settings“

TME Name

Enables you to set a name for the thermometer.

Connection type – Active TCP or Passive TCP

Sets the TCP connection mode: active or passive. **Active** means that TME will actively establish connection with a remote address and port and will send data in the preset interval (TME as a client). **Passive** means TME will expect a connection to be established on a defined port (TME as a server).

Device Port

Sets a local port on which the thermometer will expect a TCP connection to be established in the Passive mode.

Default value: 10001

Remote Port

Sets a remote port to which TME will connect when establishing a TCP connection in the Active mode.

Remote IP address

Sets a remote IP address to which TME will connect when establishing a TCP connection in the Active mode.

Sending period

Sets a common interval in which the current temperature will be sent via the established TCP connection, when sending a temperature script to a HTTP server (HTTP GET) or when sending a document via SOAP protocol. The setting range of the time interval is 2 to 3600 seconds.

Default value: 10

Maximum value

Sets a temperature limit. When this limit is exceeded a notification email or SNMP trap is sent. The setting is made in degrees Celsius.

Default value: +999,9

Minimum value

The setting is similar to the one of Maximum value. When temperature drops below this limit a notification email or SNMP trap is sent. The setting is made in degrees Celsius.

Default value: -999,9

Hysteresis

Sets the hysteresis of temperature limits. The setting is made in degrees Celsius. The hysteresis applies to temperatures below the upper limit or above the lower limit. (The purpose of hysteresis is clearly illustrated in Fig. 17.)

Default value: 0

Read community

Name of SNMP community for reading.

Write community

Name of SNMP community for writing.

Enabled trap

This feature can enable or disable the system to send traps. If sending traps is enabled the following can be set: *SNMP manager IP* and *Keep-alive trap period*.

SNMP Manager IP

Here you set the IP address of the device (mostly PC with SNMP manager) traps are going to be sent to. Enter the IP address numbers individually and separate them with Enter.

Keep-alive trap period

Here you set a frequency of sending the just-measured temperature as a trap for SNMP manager. Set the period in seconds–3600 is the maximum. If the 0 value is entered, no temperature traps will be sent.

Enabled Email

Use this feature to enable (Y) or disable (N) the system to send emails. If sending emails is enabled it will be possible to change parameters of the following items.

Sending period

Here you can set a frequency of sending the temperature when limit violation occurs. Set the period in seconds—3600 is the maximum. If the 0 value is entered, only one email is sent at the moment of limit violation.

SMTP Server IP

IP address of the SMTP server used for sending emails notifying of temperature limits violations.

Sender's address

TME email address.

Recipient's address

An address the email is going to be sent to.

GUID

Optional identification of the thermometer of up to 40 characters. It is possible to insert this parameter into a documents sent via SOAP protocol. If GUID is specified, it is added as a new parameter into HTTP GET.

URL path (HTTP GET)

URL address of the server HTTP GET is sent to. Either URL or IP can be entered.

HTTP port

Number of the port where the TME internal WEB pages are accessible.

Default value: 80

Remote HTTP port

Number of the HTTP server GET is sent to. Standard port for HTTP is 80.

Remote HTTP Server IP

IP address of the HTTP server GET is sent to.

Script address

Path to the script on the HTTP server. Enter only the local path from the server root. For the address of www.papouch.com/temperature.php enter only: `temperature.php` . *(For more info see page 36.)*

Remote SOAP server port

Number of the port on the server to which documents are sent via SOAP protocol. Standard port for HTTP is 80.

Remote SOAP Server IP

IP address of the HTTP server which GET is sent to.

Enabled send HTTP GET

Here you can set if the script to which the measured temperature will be sent via GET parameter shall be called regularly.

Enabled send SOAP

Here you can set if the stored document shall be sent regularly to the desired server via SOAP protocol.

Set to default values

If you select this item, the thermometer's default values will be reset. After completion, the Telnet connection will be terminated (option number 7).

Exit without save

Termination without saving the changed parameters (option number 8).

Save and exit

This option will save the changes you have made. If you have changed any setting, the thermometer will be restarted. Then you will have to reconnect to it – if you have changed its port and IP address, you will have to modify the connection parameters correspondingly (option number 9).

HOW TO CONNECT TO TME

A brief overview of methods for obtaining temperature values from the TME thermometer is on page 5.

WEB interface

After setting the thermometer's IP address in the Internet browser,⁸ you will see the page from Fig. 30.⁹ On the page, there is the actual temperature value, the name of the sensor (if it has been specified), and the temperature limits. If the temperature value gets beyond a limit, the text showing that limit will be flashing.

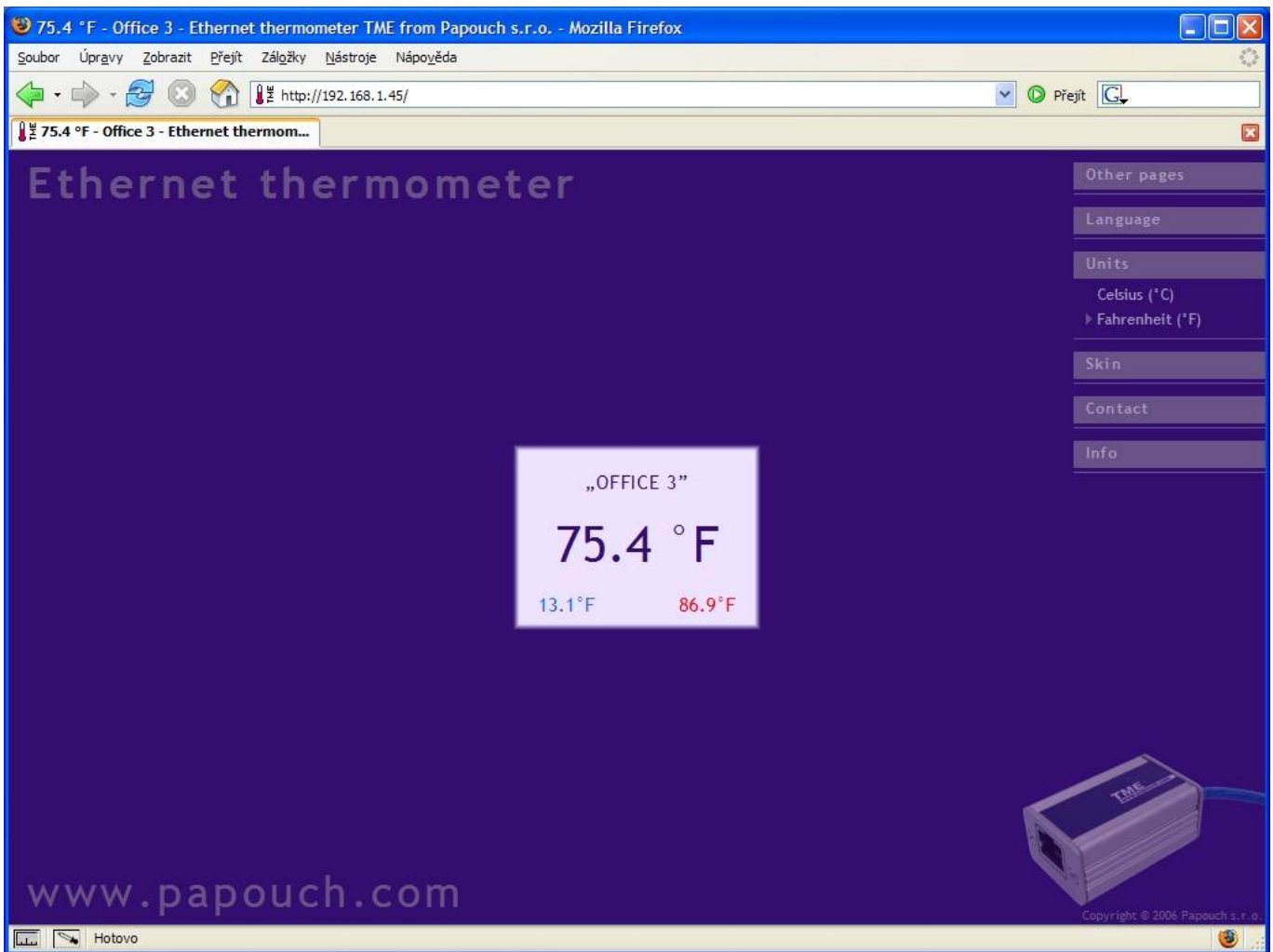


Fig. 30 – appearance: digital thermometer; language: English; units: °F

On the site, you can select language (Czech / English) appearance (mercury / digital) and units (°C / °F).

The settings for language, appearance and units are stored in the PC.¹⁰ When you run it again on the same PC, you will not have to set these parameters.

⁸ The page is optimized for Internet Explorer 6.0 or Mozilla Firefox 1.5. The browser's JavaScript support must be enabled. Set the address in the form *http://[IP_address_of_TME]/* For example, <http://192.168.1.254/> if the default configuration of the TME has been preserved.

⁹ The module's pages can be graphically adapted to your requirements.

¹⁰ Cookies with one-month expiration. The setting will only be stored if cookies are enabled on the PC.

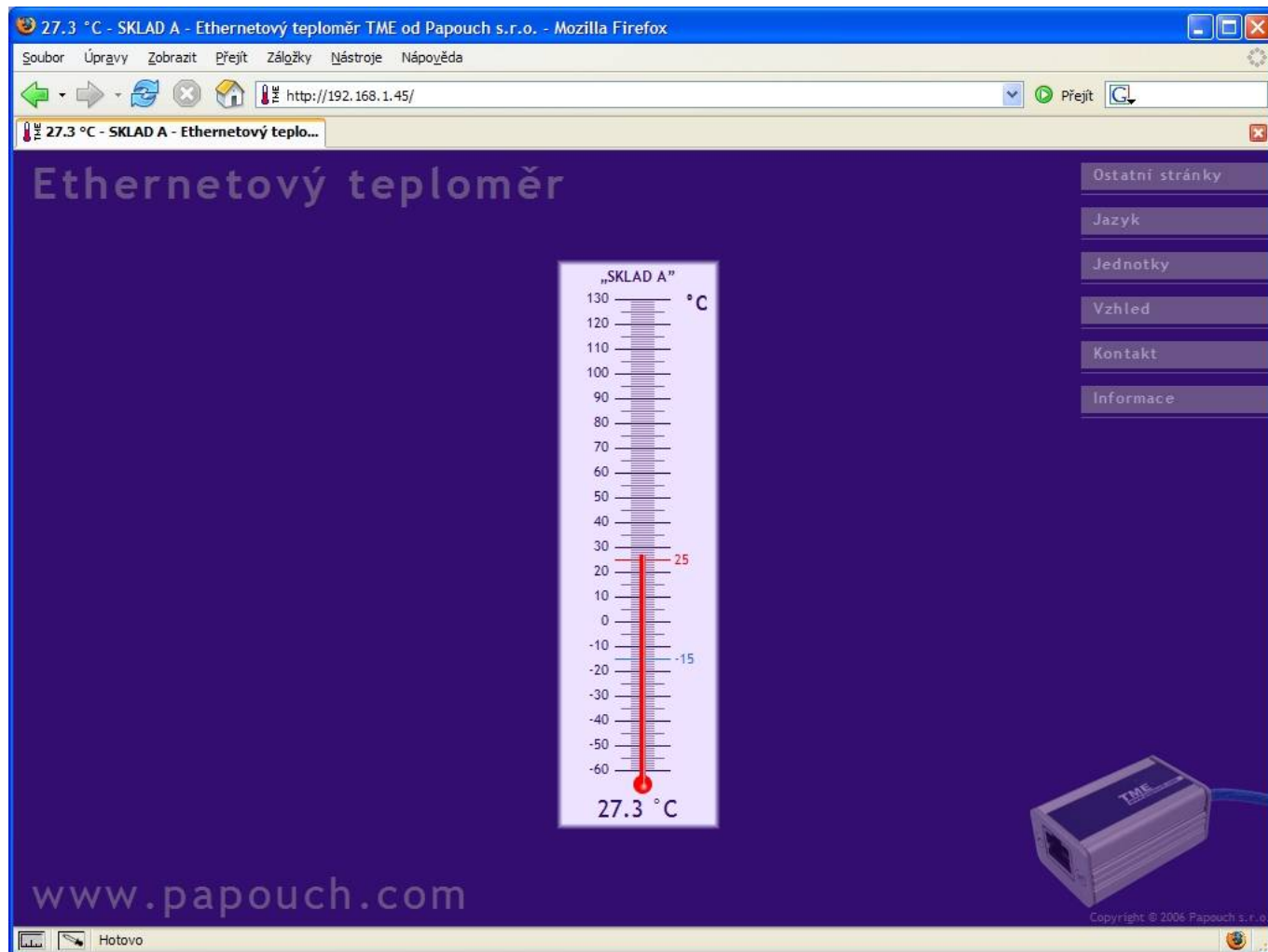


Fig. 31 – appearance: mercury thermometer; language: Czech; units: °C

Clicking on "Other pages > TME mini WEB" a small version of the website will be brought up.¹¹ See an example in Fig. 32.



Fig. 32 – TME mini WEB

A balloon tip for a text in the bottom section of the website will be displayed when the cursor goes over it. (The example in the figure is concerned with switching to degrees Fahrenheit, Czech (to display error messages in this language), returning to the main site and closing the window).

WAP

By clicking to "Other pages > Version for WAP / PDA" you open simple pages suitable for viewing from mobile phone or PDA. These pages are available on the address [http://\[IP_adresa_tme\]/wap](http://[IP_adresa_tme]/wap) . (See the picture)

¹¹ This option is only available in Internet Explorer (it is an HTA application).

XML file

From the TME thermometer, you can get the currently measured temperature value, the temperature limits and the thermometer's name in a text file in XML format. The file is at [http://\[IP_address_of_thermometer\]/tme.xml](http://[IP_address_of_thermometer]/tme.xml) – for example, <http://192.168.1.254/tme.xml> for the default settings of the thermometer.

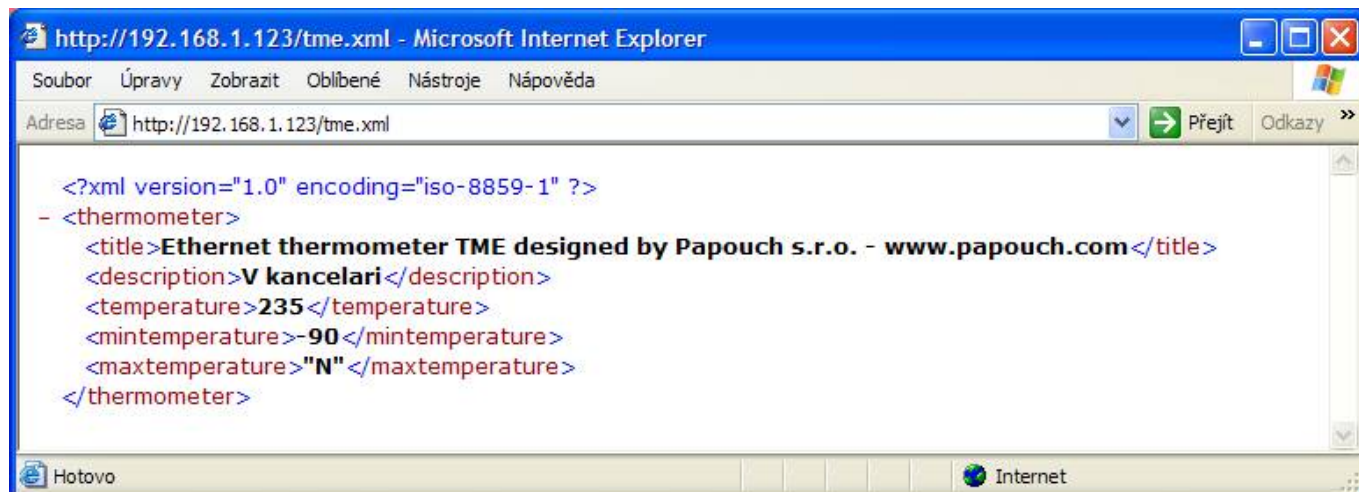


Fig. 33 – view of an XML text

There are the following tags:

title

The page's title.

description

The name of the thermometer entered by the user. (The tag is empty if no name has been entered.)

temperature

The current temperature value in degrees Celsius multiplied by ten. The number 225 in the figure means 22.5 °C. If the temperature value has not been read yet, or there is a sensor error, this tag's value will be 9999.

mintemperature, maxtemperature

The lower and upper temperature limits set by the user. Their format is the same as in the "temperature" tag. If a limit has not been defined, the respective tag's value will be: "N"

Inserting the temperature value into a website using a script

The temperature value from the TME can be inserted into a website using a scripting language (such as PHP or ASP), which processes the value from the thermometer as an HTTP parameter of the GET request. The thermometer periodically calls the script on an Internet (or intranet) server with the actually measured temperature value in the GET parameter. On the server, this value can be stored as a variable and further processed – for example, stored in a log, displayed on the website, etc.

The TME settings contain the script path and the script calling period. If a measurement error occurs (the temperature value cannot be read from the temperature sensor on the cable), the TME will stop calling the temperature-processing script. The temperature will be sent again when it is successfully measured.

If the GUID parameter is filled-in in the thermometer setting, this ID is sent to the HTTP server as a further parameter.

Path to the script – Setting using a configuration program

The path can be defined in several formats:

“URL path“ item	Complete URL of the called script. ¹² (Example: temperature of 25,6°C)
http://192.168.1.254/scr/temperature.asp	http://192.168.1.254/scr/temperature.asp?temp=25,6
http://192.168.1.254/scr/temperature.asp?temperature =	http://192.168.1.254/scr/temperature.asp?temperature=25,6
http://192.168.1.254/scr/temperature.asp?rtd=56	http://192.168.1.254/scr/temperature.asp?rtd=56&temp=25,6
http://192.168.1.254/scr/temperature.asp?wrt=ok&tk=	http://192.168.1.254/scr/temperature.asp?wrt=ok&tk=25,6

Enter preferably the direct IP address of the server. It is also possible to enter an IP address including a port. If no port is specified, port 80 will be used.

If you enter a domain name instead on an IP address you must click on the @ symbol on the right to translate the domain name into an IP address. For this function the server must be accessible on-line.

Example 1:

Task:

A script *temperature.asp* is prepared on the server waiting for data from TME. The complete address of the script on the server is *http://www.example.com/temperature.asp*

The script expects a temperature in the *temp* parameter.

Solution:

The string which is required to be entered to the URL path item:

http://www.example.com/temperature.asp

Next, it is necessary to enter the IP address of this server into the “Server IP address” field. This address can be easily entered automatically by clicking on the @ symbol to the right of the “URL path” field) (the server must be on-line at that moment).

¹² If GUID is specified in the settings, another parameter will be added to the end of URL in the following form:
id=[GUID]

Resulting URL called for the temperature of 25,6°C:

<http://www.example.com/temperature.asp?temp=25,6>

Example 2:

Task:

A script *execute.php* is prepared on the server waiting for data from TME. The complete address of the script on the server is <http://www.example.com/execute.php>

The script is prepared for a temperature in the *tr5* parameter.

The script also expects an *id* variable with thermometer identification which is stored in the *GUID* setting item (string *98ED78B* is set).

The server also expect a fixed variable *status=ok*.

Solution:

The string which is required to be entered to the URL path item:

<http://www.example.com/execute.php?status=ok&tr5=>

Next, it is necessary to enter the IP address of this server into the “Server IP address” field. This address can be easily entered automatically by clicking on the @ symbol to the right of the “URL path” field) (the server must be on-line at that moment).

Resulting URL called for the temperature of -2,7°C:

<http://www.example.com/execute.php?status=ok&tr5=-2,7&id=98ED78B>

Path to the script – Setting using Telnet

The path can be defined in several formats:

Via Telnet protocol: “Path” ¹³ item setup	Complete URL of the called script. ¹⁴ (Example: temperature of 25,6°C)
scr/temperature.asp	http://192.168.1.254/scr/temperature.asp?temp=25,6
scr/temperature.asp?temperature =	http://192.168.1.254/scr/temperature.asp?temperature =25,6
scr/temperature.asp?rtd=56	http://192.168.1.254/scr/temperature.asp?rtd=56&temp=25,6
scr/temperature.asp?wrt=ok&tk=	http://192.168.1.254/scr/temperature.asp?wrt=ok&tk=25,6

Calling period

Calling period is set in seconds ranging from 2 to 3600 sec (i.e. 1 hour max).

¹³ Server IP address and port are entered separately. IP address in the “Remote IP HTTP server” item. Port in the “Remote port HTTP server” item. If you do not change the port, standard port 80 will be used.

¹⁴ If GUID is specified in the settings, another parameter will be added to the end of URL in the following form:
id=[GUID]

Demo program

At www.papouch.com/en/ a demo program can be downloaded free of charge, showing how the temperature measurement works. You can also download free of charge its complete commented source code for Delphi 7.

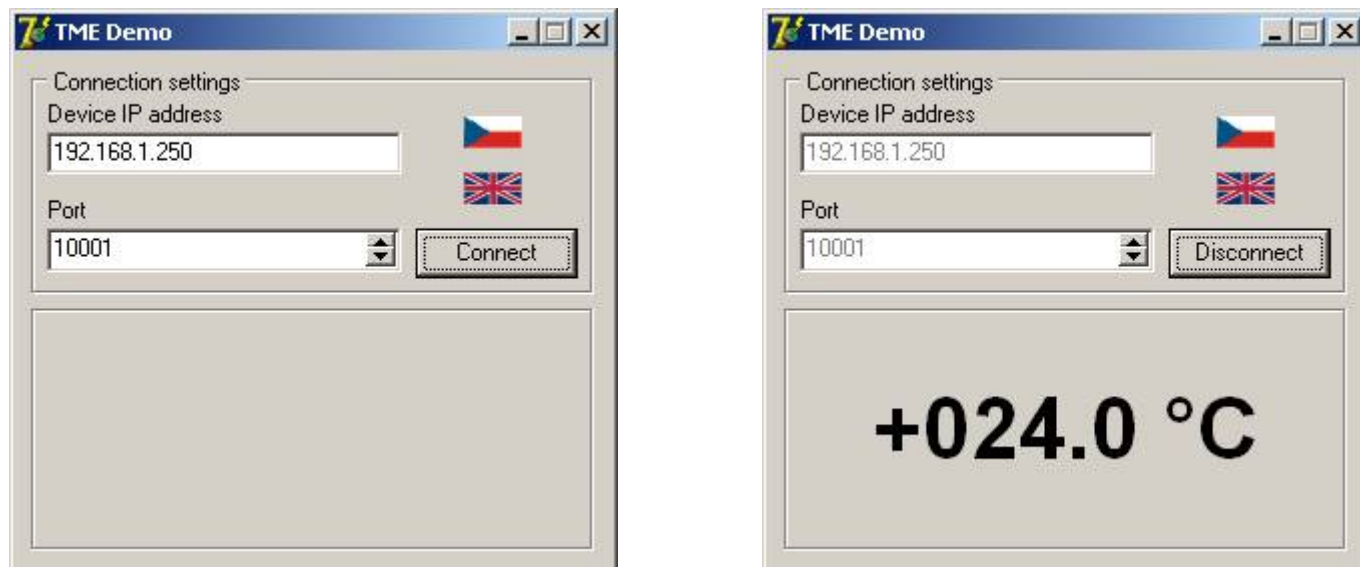


Fig. 34 – demo program

After opening the program, you can fill in the IP address and communication port of the thermometer and push the "Connect" button. If the connection to the thermometer has been successful, the measured temperature value is displayed in the bottom part of the window.

TCP connection

TME thermometer enables active and passive modes of communication via TCP protocol.

Passive mode means that the thermometer waits for a connection on a defined port. This mode can also be called a Server Mode. **Active mode** means that the thermometer actively connects to a remote IP address and a port and sends the temperature. It is possible to define whether the thermometer shall connect only once and keep the connection alive or to connect in regular intervals, send the temperature and disconnect. This mode can also be called a Client Mode.

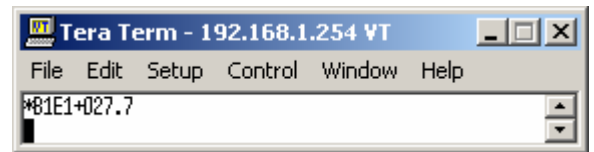


Fig. 35 – thermometer values in the TCP/IP terminal

Passive mode (Server)

This mode is suitable in case a remote system requires a measured temperature from TME and connects to TME actively.

The thermometer acts as a server and waits for a connection request on its own IP address and port. When a connection is established it sends the client temperature data in ASCII format compatible with Spinel protocol.

The process of setting these items can be found in chapter starting on page 13.

Example of a connection via terminal program

(This example illustrates a connection using Tera Term¹⁵ program.)

Establish a new connection (File/New connection...). A dialog shown in the picture is displayed. Here you can select TCP/IP and enter the thermometer IP address and defined port. The picture shows default values for the thermometer.

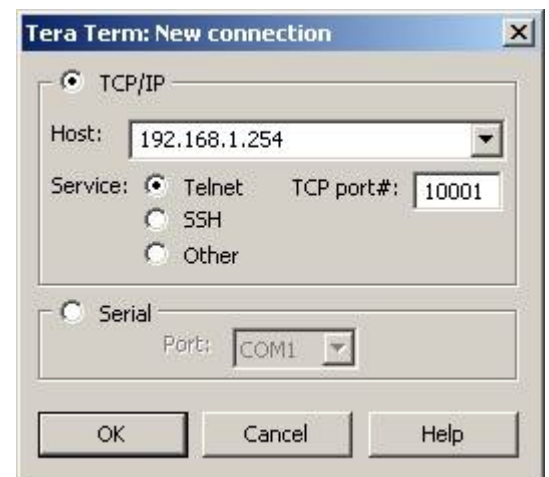


Fig. 36 – New connection

Confirm the dialog. When a successful connection is established a window shown in the picture appears. It displays temperatures which are regularly sends by TME in the preset interval.

Active mode (Client)

This mode is suitable in case one server expects temperatures to be sent from several thermometers or in case TME has not a fixed IP address or is placed behind a firewall or router.

TME connects to a defined IP address and port. These items can be found under the "TCP" bookmark in the configuration program. The description of this setting can be found in chapter Configuration Panel – TCP on page 20.

¹⁵ Tera Term terminal can be downloaded from: <http://www.ayera.com/teraterm/>

Message format

The **temperature-value** message is sent in the following format:

```
*B1E1[sign][degrees].[tenths][enter]
```

[sign] 1 Byte; "+" or "-" sign

[degrees] 3 Byte; temperature in degrees Centigrade (Celsius); always a three-digit number; filled with zeros from the left as necessary

. 1 Byte; decimal point

[tenths] 1 Byte; tenths of degree

[enter] 1 Byte; terminating character "Enter" (DEC: 13; HEX: 0x0D)

All characters are sent in ASCII format. An example is shown in the Fig. 35.

On Error sending TME this string:

```
*B1E1Err[enter]
```

[enter] 1 Byte; terminating character "Enter" (DEC: 13; HEX: 0x0D)

All characters are sent in ASCII format.

Error can be sensor's internal error or broken sensor cable.

SNMP

General

SNMP (Simple Network Management Protocol) is a standard protocol for management of various devices in an Ethernet network. It is built on UDP protocol and ensures quick delivery of control codes and responses between devices on which SNMP applications run.

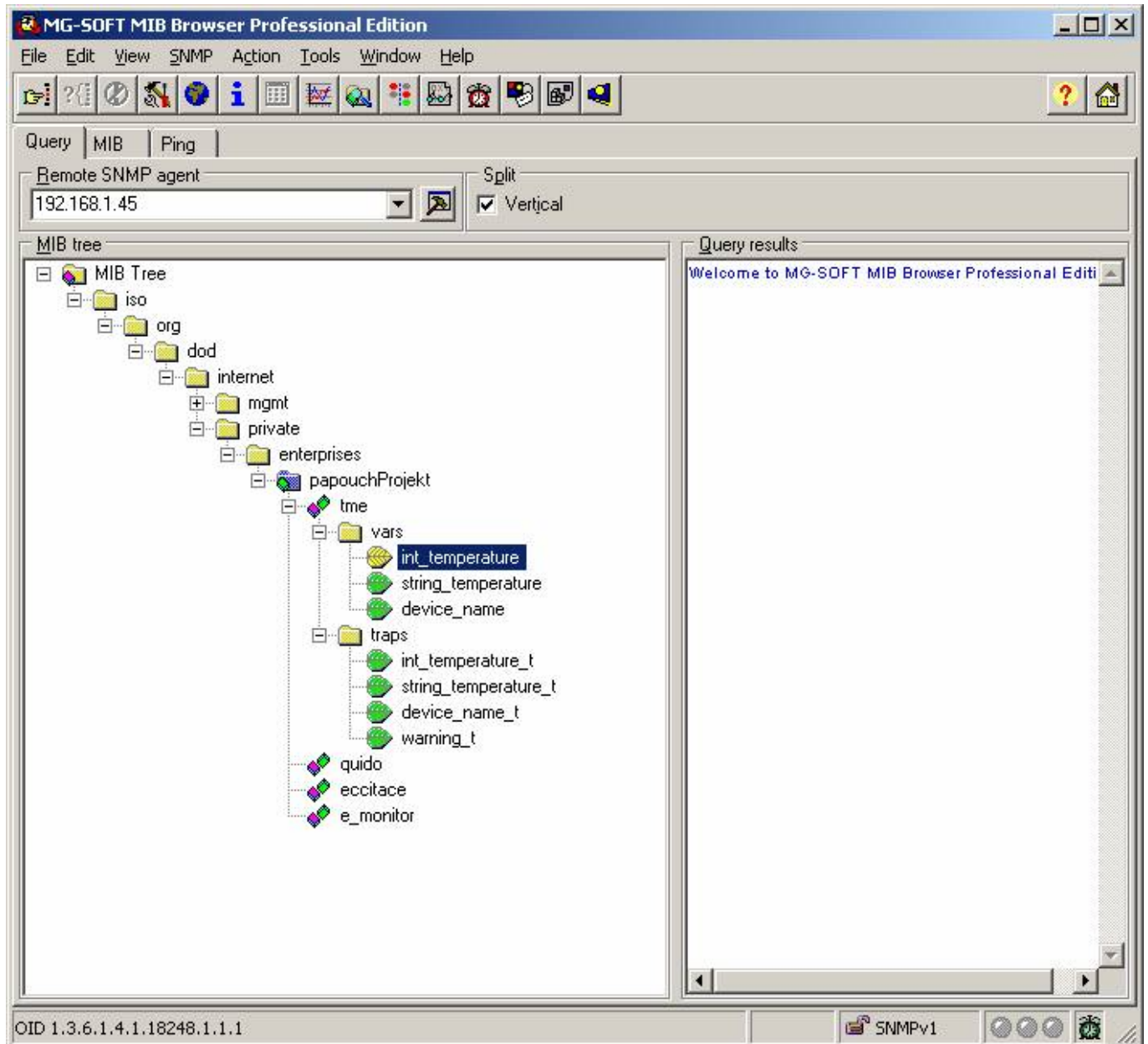


Fig. 37 – MIB tree

SNMP ensures that requests are delivered to and responses from such applications. It works independently of specific features in lower- or higher-level application. This protocol is based on three entities: administrator (which generates commands and receives messages), agent (which responds to commands and creates messages), and proxy (which transfers network traffic).

The SNMP administrator sends requests to the agent's UDP port 161 and receives non-requested messages (traps) from agents on UDP port 162.

TME is an SNMP agent. It receives commands from a UDP port 161. The administrator asks about data stored in the local MIB database (Management Information Base, one of the Internet

standards), which consists of a hierarchic tree structure with the administered data. The module does not contain the standard complex database but only a sub-tree with data necessary for processing the TME thermometer data.

Descriptions of the MIB table tree and of SMI (Structure of Management Information) are attached in Papouch-SMI.mib and TMESNMP.mib text files. The programmer should include these two descriptions into the SNMP administrator structure (SNMP version 2.0).

Data in the MIB tree can be accessed through the name of the object, expressed as a series of positive integers separated with dots and describing the path to the object in the MIB tree structure.

TME as an SNMP agent enables the sending of automatic traps to the administrator via UDP port 162.

Using SNMP

Include in your SNMP manager the description of the MIB table from the Papouch-SMI.mib and TMESNMP.mib files ¹⁶.

Then you should set the "Rad community" option to "public".

MIB table

Temperature as number

Name: int_temperature

Object ID: 1.3.6.1.4.1.18248.1.1.1

GET address: 1.3.6.1.4.1.18248.1.1.1.0

Description: The measured temperature value in degrees Celsius as an integer – the measured value multiplied by ten. (For example, 56.9 °C is expressed as 569.)

Temperature as string

Name: string_temperature

Object ID: 1.3.6.1.4.1.18248.1.1.2

GET address: 1.3.6.1.4.1.18248.1.1.2.0

Description: The measured value as a text string. (For example, "+22,4".)

Device name

Name: device_name

Object ID: 1.3.6.1.4.1.18248.1.1.3

GET address: 1.3.6.1.4.1.18248.1.1.3.0

¹⁶ You can download these files from www.papouch.com/en/.

Automatic traps

The TME enables sending out automatic traps. There are two settings for the traps: enable/disable sending, and the receiver's IP address (SNMP manager).

Depending on the settings, the traps are sent when the temperature goes out of the preset temperature limits, and a trap with the measured temperature value is sent out regularly.

Trap 1 – Temperature outside of limits

The trap contains the temperature value in degrees Celsius (expressed as an integer) – the measured temperature value multiplied by ten, as a text string, the thermometer's name and a specification beyond which temperature the limit occurs.

This trap is only sent out if the temperature goes beyond the preset limits. The trap can only be delivered if the SNMP manager's IP address is set correctly.

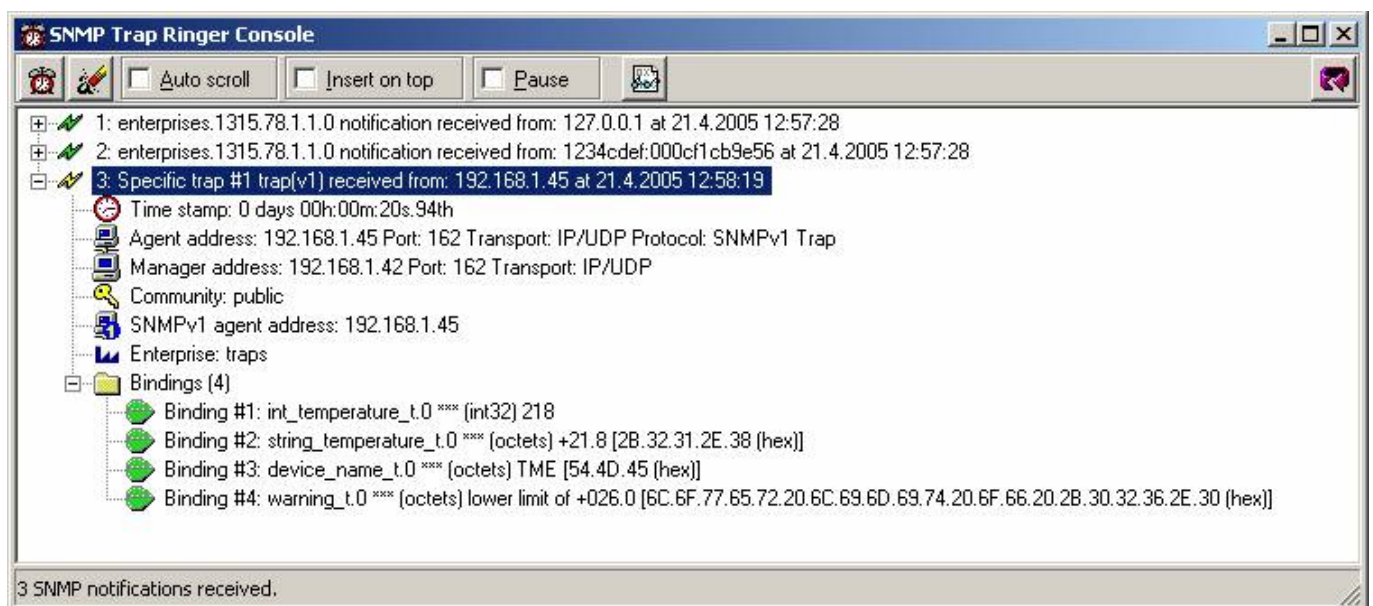


Fig. 38 – Trap 1 – the temperature value occurs below the lower limit

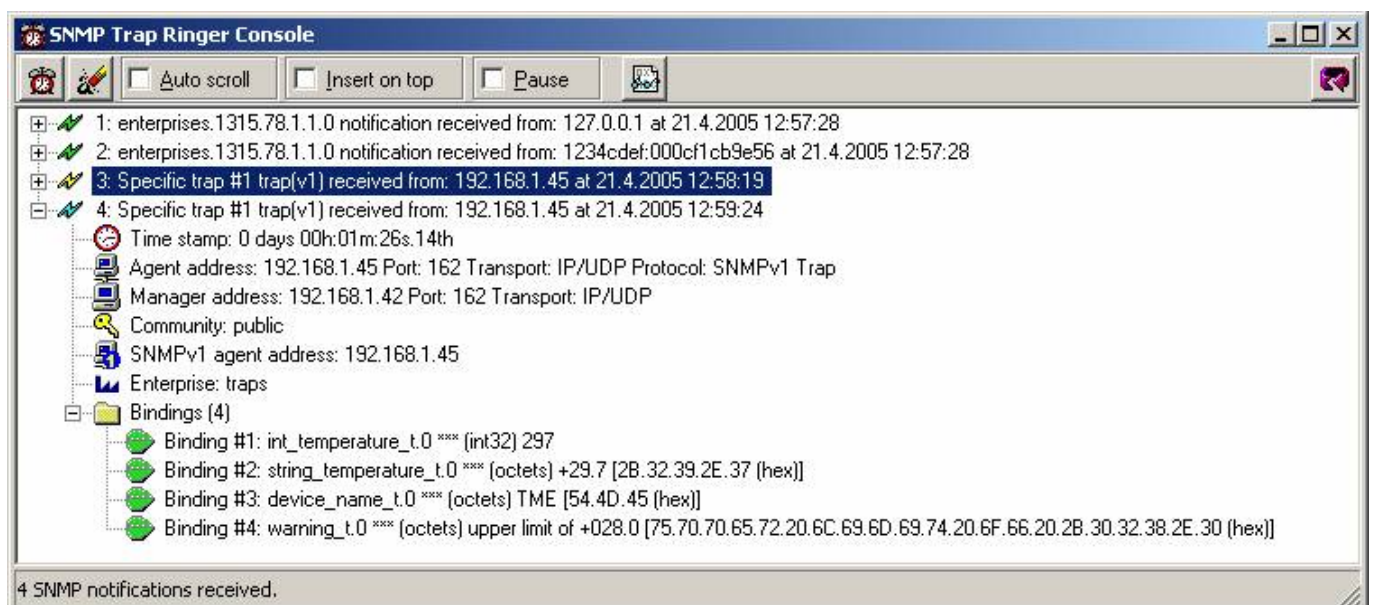


Fig. 39 – Trap 1 – the temperature value occurs above the upper limit

Trap 2 – Measured temperature value

This trap sends the temperature value in degrees Celsius expressed as an integer – multiplied by ten,¹⁷ and the measured temperature value as a text string. The thermometer's name is sent as a text string.

The trap is only sent if a non-zero period is set ("Temperature trap period" for Telnet; "Keep-alive trap interval" for the configuration program).

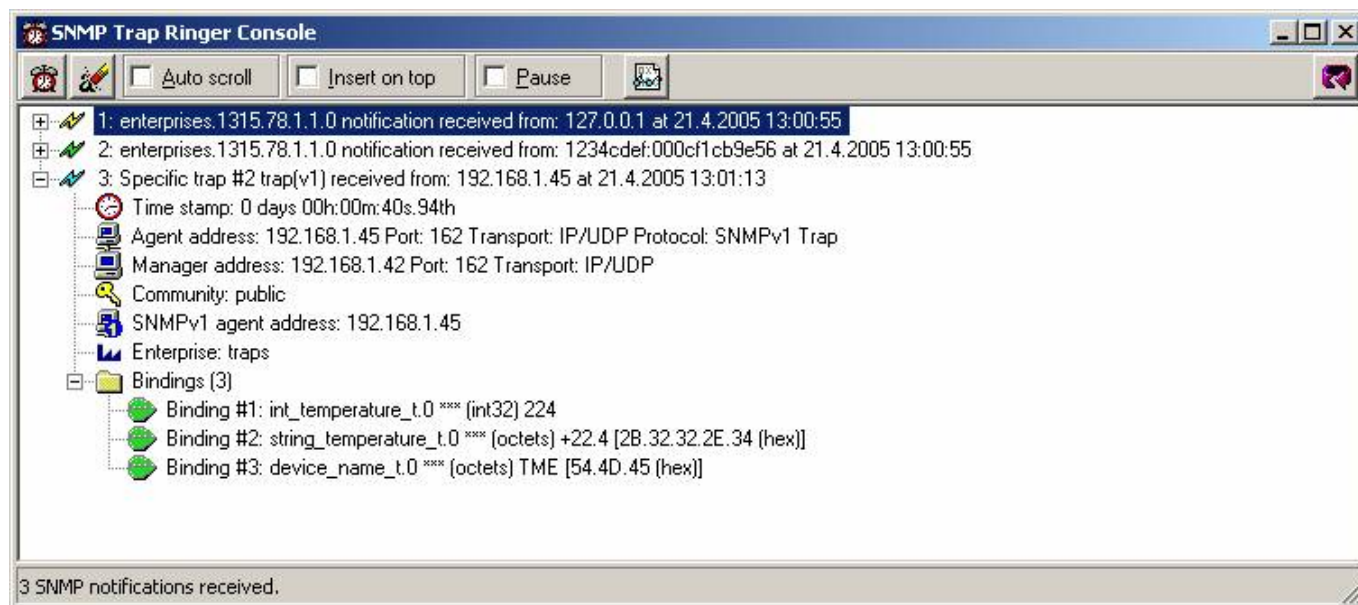


Fig. 40 – Trap 2 – Regular transmission of the measured temperature value as a trap

¹⁷ In the example in Fig. 40, the value "224" means a temperature of 22.4 °C.

Sending e-mails

The TME thermometer can send e-mail alerts if the temperature value goes outside of the preset limits. These limits are the same as those for SNMP traps, and are set in Item "Configuration Panel – E-mail" and the following ones on page 17. (The delivery of e-mail alerts requires the IP addresses of the SNMP server and of the sender and addressee to be correctly set.)

The prompt is only sent when the temperature first goes outside of the limits. After that, the system waits until the temperature goes back within the limits. Another E-mail prompt is sent when another instance of going beyond the limits occurs.

Papouch s.r.o.

Data transmission in industry, line and protocol conversions, RS232/485/422/USB/Ethernet/GPRS/WiFi, measurement modules, intelligent temperature sensors, I/O modules, and custom-made electronic applications.

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