METEOROLOGICAL TEMPERATURE PROFILER

MTP-5

version H(HE)

User manual

Contents

1 GENERAL INFORMATION

The MTP-5 Meteorological Temperature Profiler is an instrument for the remote measurement of the air temperature profile from ground level to 600/1000 (H/HE) meters. The instrument is typically used in studies of gas dispersion, atmospheric stability and climatology.

The unique technology that is employed in MTP-5, a completely passive microwave radiometer, has many advantages. The main benefits are that the instrument has a wide operational range (also covering conditions of fog, snow and rain), zero emission of radiation, a high level of quality assurance, automatic calibration and low operational costs while operating continuously.

The MTP-5 is primarily designed for use in air pollution networks, in which it is used to predict pollution levels.

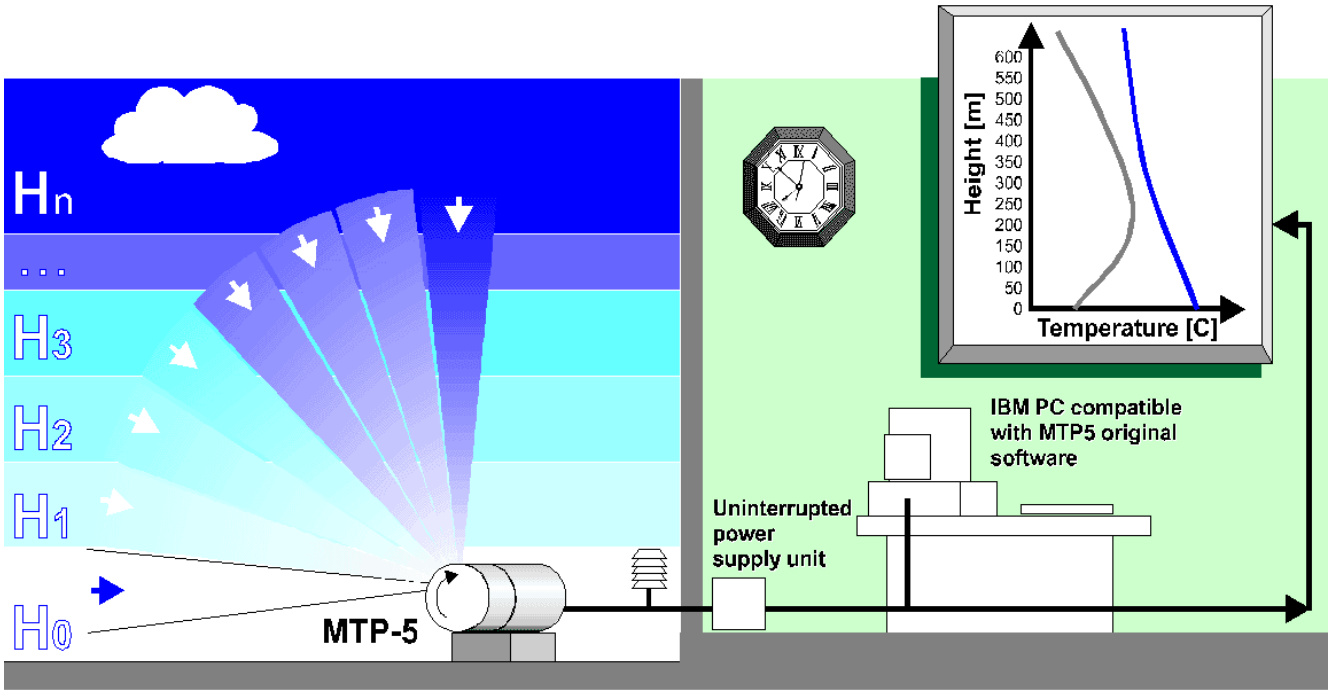


Figure 1. The total system configuration of MTP-5. The determination of the temperature profile is based on thermal radiation measurements at different zenith angles in one azimuth plane. An ambient temperature sensor serves as a reference. Software offers visual information, acquisition and control. The graph shows a typical development of an inversion.

2 SYSTEM DESCRIPTION

2.1 Hardware

The total MTP-5 system consists of 5 major components. “MTP-5 ” is used alternately to indicate the total system and the measurement instrument. The 5 components are:

1. MTP-5 Meteorological Temperature Profiler (receiver with antenna, scanner, microprocessor-controller, meteoprotection)
2. Ambient Air Temperature Sensor
3. Personal Computer (PC)
4. MTP-5 Software
5. Power Supply Unit

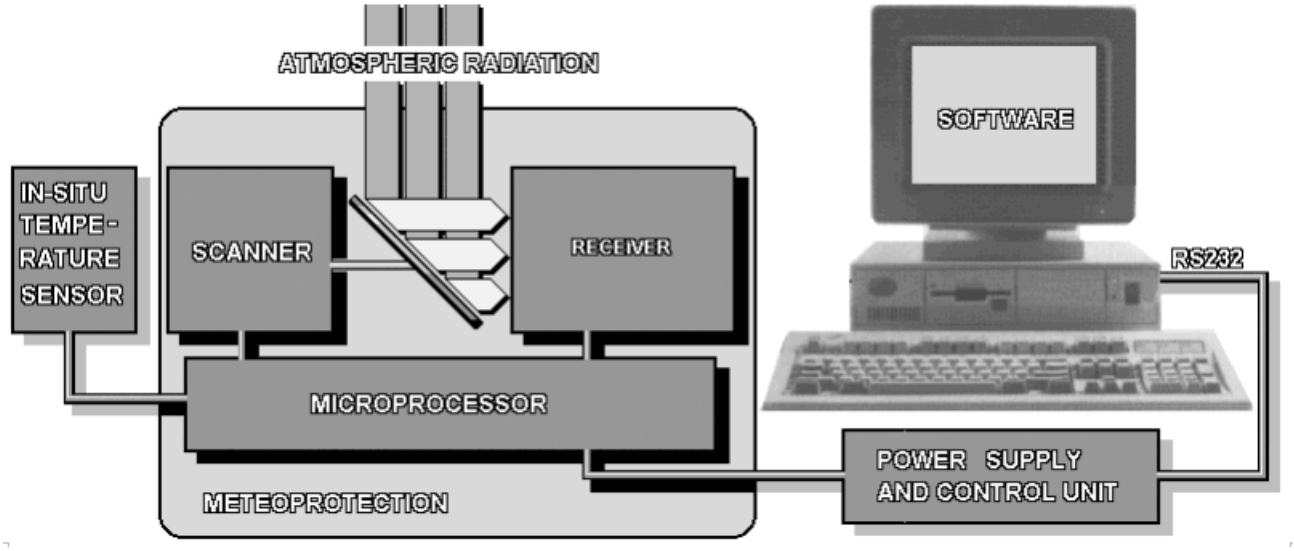


Figure 2. More detailed view of the MTP-5 system, in particular the MTP-5 itself. The scanner, the receiver, the controller and the thermal radiation are specifically shown. The MTP-5 housing protects the radiometer and offers a thermally stable environment for the receiver.

2.2 Measurement principle

The technique that is used in MTP-5 for determination of the air temperature profile is based on measuring the thermal radiation of the atmosphere at the centre of the molecular oxygen absorption line, around 5 mm. The technique can also be referred to as microwave remote sensing. The lowest meters (about 1000 m) of the atmosphere are often called the Planetary Atmospheric Boundary Layer (PABL). The atmosphere is an extremely weak source, so to do the measurement it's require a very sensitive radiometer. The radiometer plus the added antenna, we will call 5 mm wavelength receiver or receiver. It is the core of MTP-5. The brightness temperature measured at the different zenith angles (from 0^o…up to 90^o) allows to retrieve PABL temperature profiles by means of calculation. This calculation is done relative to the last calibration relative to ambient air temperature. The measurements are processed, and the air temperature for altitudes of 0 to 600/1000 (H/HE) m is calculated with a 50 m resolution. The algorithm for this the calculation of the angular temperature distribution to the required profile, is written specifically for the MTP-5. It essentially solves an inverse problem. The reception of radiation from the different zenith angles is achieved by mechanical rotation of a mirror-reflector. This reflector is mounted at 45 degrees relative to the receiver axis. The combination of a stepper motor and the mirror-reflector is called scanner. The mirror is rotated around the receiver axis. Thermal radiation of the atmosphere from different zenith angles is reflected to the input of the receiver. The PC controls the scanner. The mirror-reflector is located in the so-called the rotating part The rotating part is connected with a circular bearing to the rest of the housing, which is mounted on an internal metal frame. The rotating part of MTP-5 is shielded by a teflon foil from the environment. The teflon foil is transparent for the thermal radiation. The rotation has the advantage that rain and snow are automatically removed. The complete housing protects the radiometer and offers a thermally stable environment for the radiometer. The measured signal is amplified and processed in the receiver and then goes to the controller (still inside the MTP-5 but outside the receiver) where the signal is digitised by the Analogue to Digital Converter (ADC). After that it is transmitted through a serial port to the PC.

MTP-5 has a separate Power Supply Unit. This unit supplies power at various DC levels to the instrument. The digital signals travel to the PC through a separate cable.

After signal processing, the graphs of the temperature profile (as a function of altitude and time) are immediately displayed on screen.

A unique aspect of the MTP-5 is its calibration. As the central frequency of the receiver is at the centre of a strong absorption line of molecular oxygen (14dB/km on wavelength of 5 mm) if so the brightness temperature at the reception of the atmosphere radiation from a horizontal direction is

practically equal to the atmosphere temperature near by a ground surface. It gives an opportunity to use the atmosphere like a quality microwave target.

2.3 Software and user interface

An important part of the MTP-5 is its software. The MTP-5 software is the primary user interface of the system. Also it performs several essential functions: control of the MTP-5, collection and storage of data and data visualisation. In case of trouble it is a tool for trouble shooting. The software plays a major role in the day-to-day quality assurance of the measurement.

The MTP-5 system configuration is such that it has to be operated by an on-line PC. The software is written in a Windows environment. More information can be found in the section on software in the chapter “Using MTP-5 ”.

3 USING THE MTP-5

Warning: During installation it is suggested to switch off the main power for your own safety. Non-proper grounding may cause damage to the instrument that is not covered by any warranty.

It is strongly recommended to let a first installation and training of the operators be performed by Kipp&Zonen representatives of the production company.

Using the MTP-5 is not difficult, the equipment does not require a lot of maintenance, and has a lot of built-in intelligence. After installation, the device automatically performs its automatic measurement sequence, usually doing a measurement and a subsequent self-test every 10 minutes. More about maintenance can be found in the section on maintenance. Typically every morning the system operator will review the data of the previous night, and will retrieve the information that he needs. More on data review can be found in the sections on software and quality assurance. The paragraph on maintenance contains a recommendation on the maintenance schedule. In case of unexplained behaviour the sections on trouble-shooting can be consulted.

For using MTP-5 it is recommended first to do some indoor (laboratory) testing. Assuming that the outdoor measurement location has been prepared, the next phase is outdoor installation (measurements conducting). The next paragraphs will guide you through this process.

3.1 The minimum necessary requirement

The following table offers a checklist for preparing installation of MTP-5 .

Item	Requirement
Location MTP-5	The MTP-5 scans in one azimuth direction (e.g. north), across some zenith angles from horizon to zenith, the receiver opening angle is 6 degrees. The location must offer a free field of view inside the plane of measurement for about 500m. This implies that the **height of installation is at 15m (fifteen) or higher above ground level. This will typically be on a platform or a building. The field of view at the azimuth angle of measurement should be unobstructed. (see also figure 5).** **Exposure of MTP-5 to solar radiation should be avoided**. One could consider building a shield, or putting the instrument at in a shaded position (e.g. at the north face of a building in northern latitudes). For data transfer and power supply **a maximum distance of 20 m (twenty) to the PC and power supply** are allowed.
Mounting MTP-5	The instrument must be mounted in the **horizontal position**, the mounting platform must be horizontal within 2 degrees. Fine adjustment can be made using the levelling screws that are included in the MTP-5 Support that is part of the delivery. For permanent installation it must be **connected using the belts** that are supplied with the instrument. **The mounting should not vibrate, and be able to carry the MTP-5 weight (20 kg).** Typically **a table or a metal mounting platform is used with a surface area of at least 1 by 0.6 m**. For mounting the belts screws are connected to the belts **and holes must be drilled** in the platform**. The maximum thickness for the mounting platform is 1 cm.** The mounting platform should be **solid**. **Before placing the mounting platform and drilling holes, one should determine the plane of measurement. This is important for the orientation of the mounting platform**. At locations where **snow** can be expected, it is recommended to mount the scanner part of MTP-5 hang over the edge of the table, so that snow will not accumulate.

Location Ambient Air Temperature Sensor	This measurement must be done close to the MTP-5. The Ambient Air Temperature Sensor is housed in a hut (included in the delivery) which must be connected to a **mast or rail** at the **same height as the MTP-5, at a maximum distance of 3.0 m (three m) from MTP-5. The connection that is supplied is suitable for installation on vertical round objects with a diameter from 3 (three) to 5 (five) cm. A shaded and well-ventilated location is preferred.**	
Power Supply	Standard **220/110V, 1A**, **modified on request. Proper grounding must be available. For 100 % reliable operation, it is recommended to use an additional Uninterruptable Power Supply (UPS) to power both the MTP-5 and the PC. The power consumption of the UPS should be 400 W max.** The maximum standard distance between the MTP-5 and mains power is 20 m. Larger distances can be offered on request.	
Data transfer	Data are transferred through RS232. The **maximum standard distance between the MTP-5 and an indoor PC should be 20 m (twenty)**. Larger distances can be offered on request.	
Power Supply Unit Installation	The Power Supply Unit that is part of the instrument, and converts main power to DC voltage **should be installed indoors**. The Power Supply Unit **should be properly grounded**.	
PC	Dedicated PC Processor PentiumII RAM Hard Disk LPT mouse CD ROM Monitor Com port Operational system	 ≥ 300 MHz ≥ 64 Mb Memory on a hard disk: -for arranging up to 50 Mb. -for files of measuring 300 Kb per day. Printers port PS/2 Preferred 24x 15” ≥1024X768 RS232C Com2 Windows’9x, Windows2000 More then 3 Mb free disk space must be available for measuring program and 300 Kb for each day of measurements.

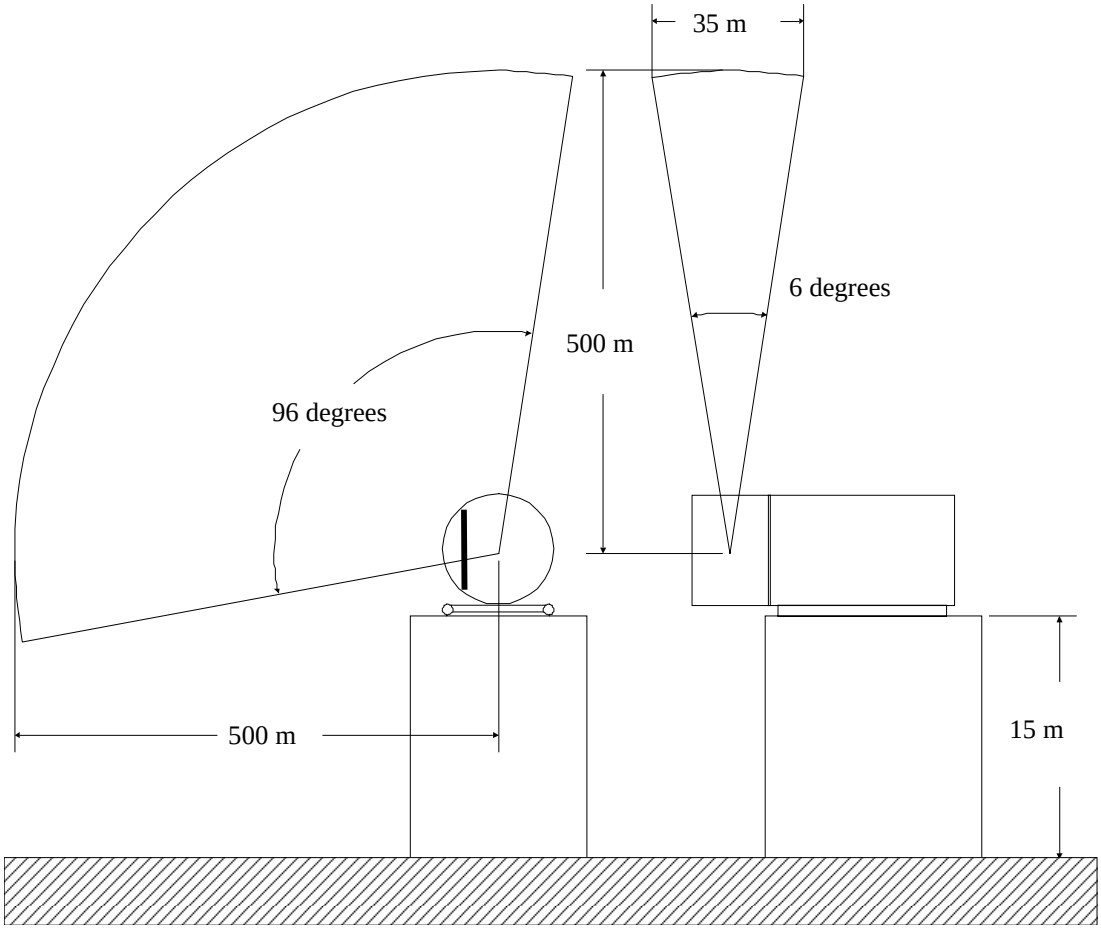


Figure 5. Typical installation of MTP-5 . In case of possible snowfall, the rotating part of the MTP-5 could be mounted over the edge of the mounting platform. The platform should be solid, and should not be exposed to solar radiation.

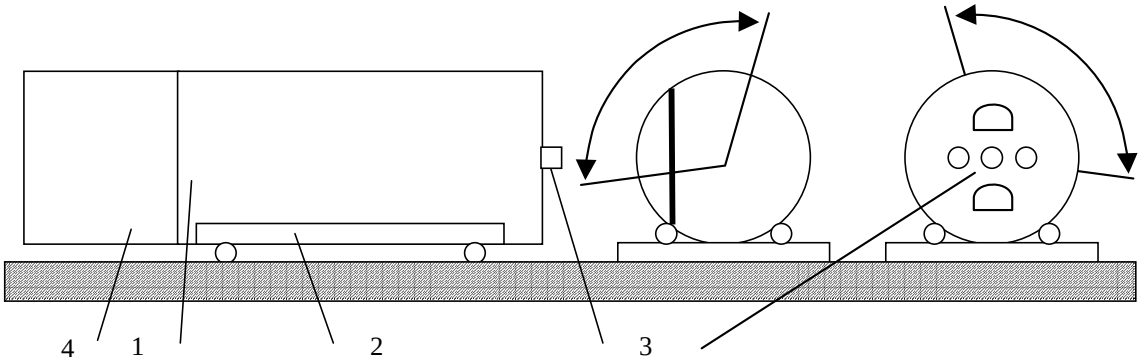
3.2 Getting started.

3.2.1 Checking the delivery

The delivery consists of:

1. MTP-5.
2. Receiver (antenna plus radiometer).
3. Ambient Air Temperature Sensor in housing
4. MTP-5 Software.
5. Power Supply Unit.
6. MTP-5 Support.
7. Connecting cable MTP-5 to Power Supply Unit (20 m).
8. Connecting cable MTP-5 to Ambient Air Temperature Sensor (5 m).
9. Connecting cable MTP-5 to PC (20 m).
10. Belts (2 pcs).

3.2.2 Laboratory Testing



Where: 1 – device; 2 – support; 3 – connecting sockets; 4 – rotation part with mirror.

Figure 6.

1. Install device on support as shown in a Figures 6
2. Connect a cables as shown in a Figures 7…10.

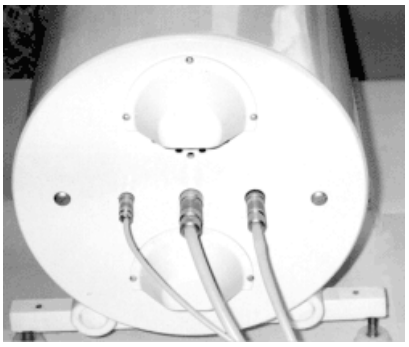


Figure 7. MTP-5 connection.

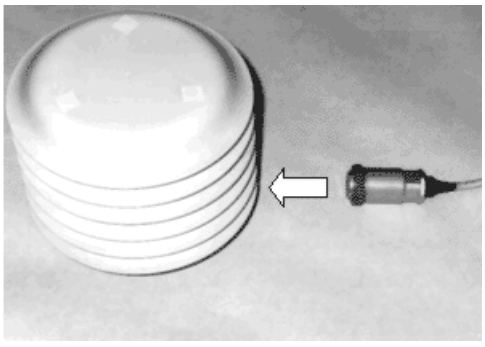


Figure 8. Temperature sensor connection.

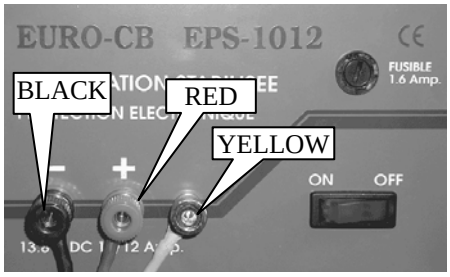


Figure 9. Power Supply Unit.

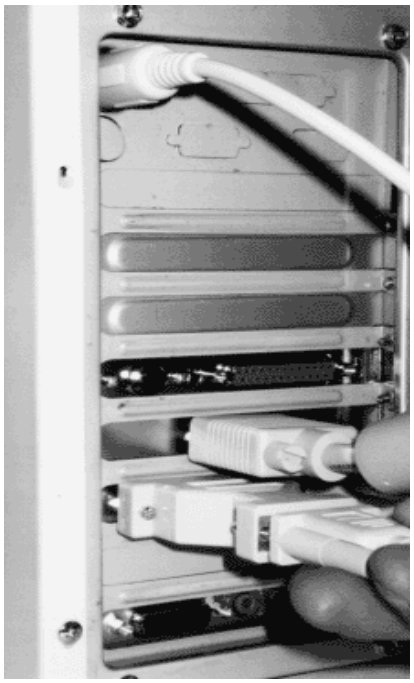
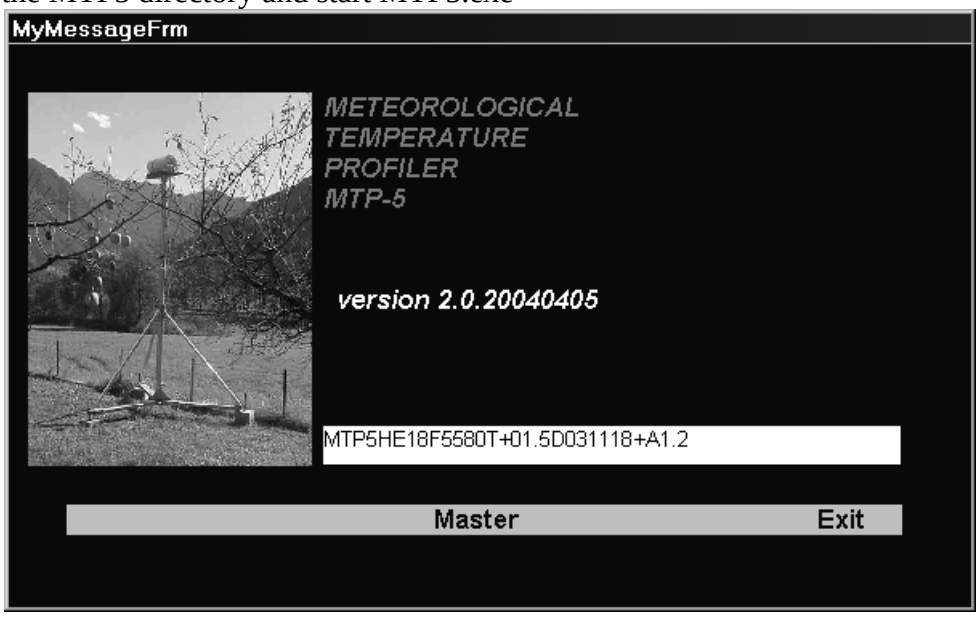
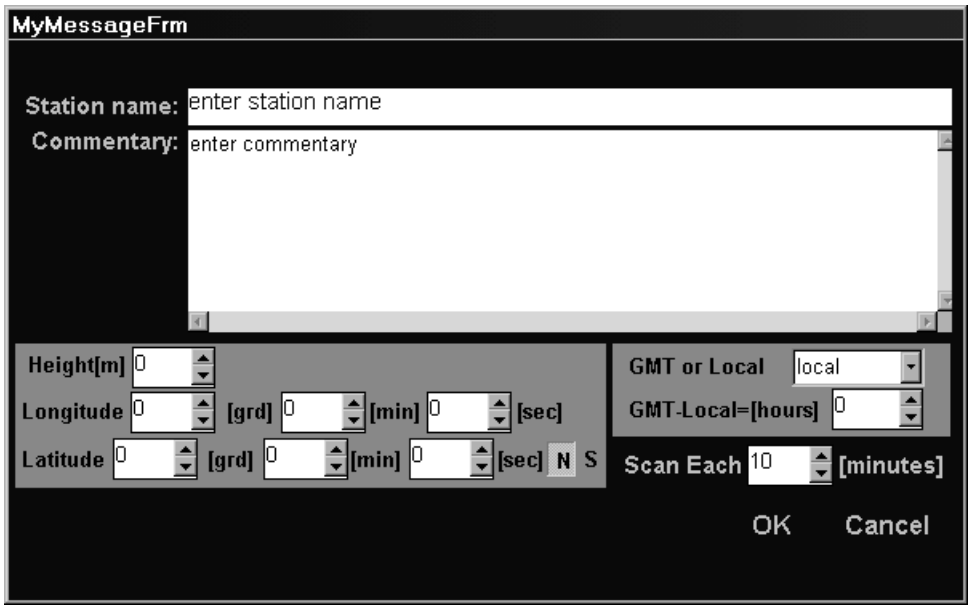


Figure 10. PC and RS232 COM2 connection.

3. Switch on the power supply unit.
4. Install the distributive CD and start program MTP-5.exe.
5. Please fill the position “Unzip to folder” (point the directory for unpacking). For instance: C:\.
6. After the unzip procedure will be fulfilled successfully, please push the button “Ok” and “Close”.
7. Open the MTP5 directory and start MTP5.exe

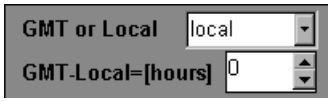


8. Please push “Master” button in the window, which will appear.

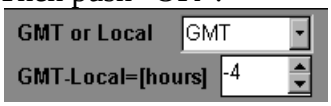


9. Fill the fields
Station name
Height
Long
Latitude
Scan each

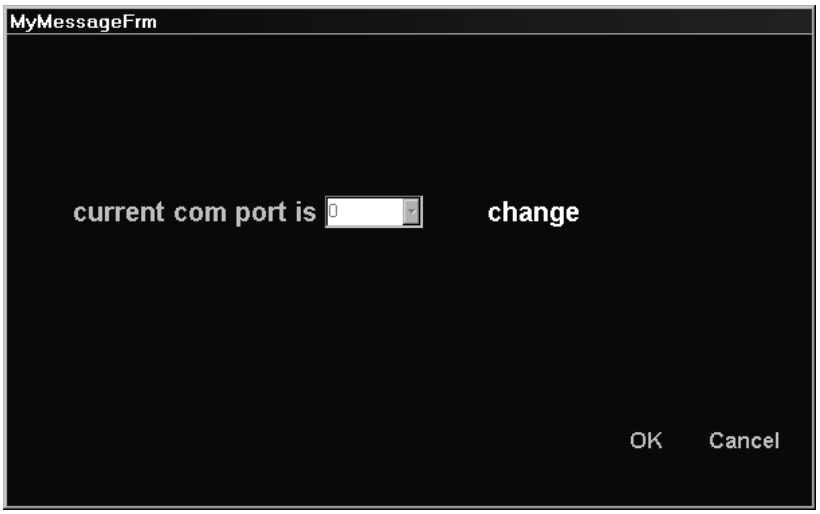
Important: If the time period in "Scan each" field is less then 120 sec, the scanning will be made within the period twice longer than it is pointed in "Scan each" field



10. Make a choice of recorded time of your PC. Local (for domestic time) or GMT (for Greenwich Mean Time). If the time is defined as Local, in the field GMT-Local use to be "0". If your choice was for GMT, in the field GMT-Local you have to introduce the difference between GMT and Local time in hours. Then push "OK".



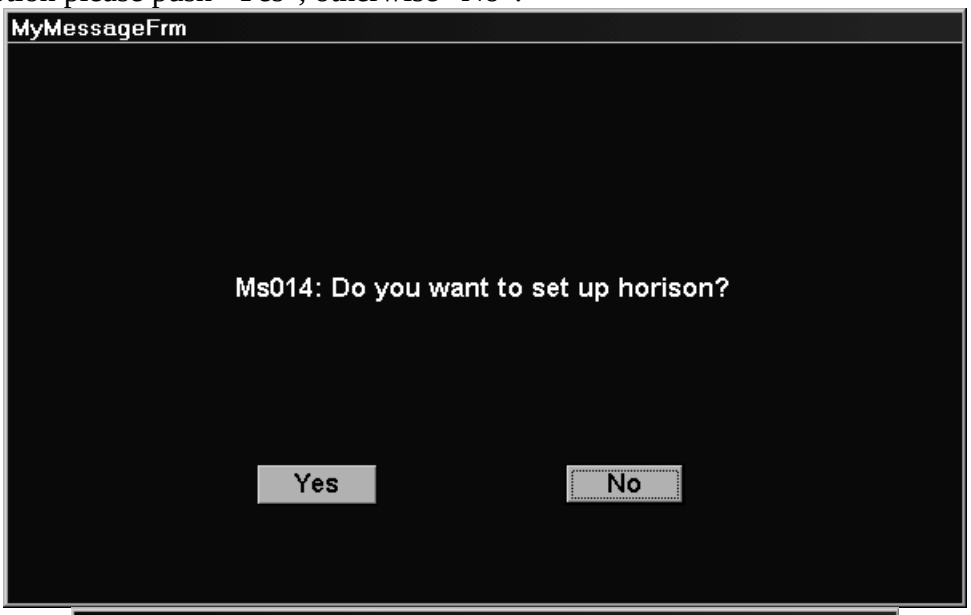
11. Press **"OK"**

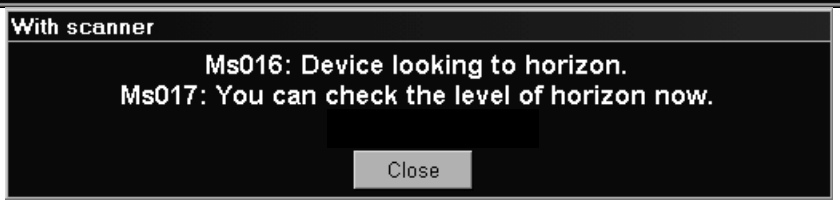


12. The next window will allow you to introduce number of Com port, which is defined as a port for communication between MTP-5 and computer.

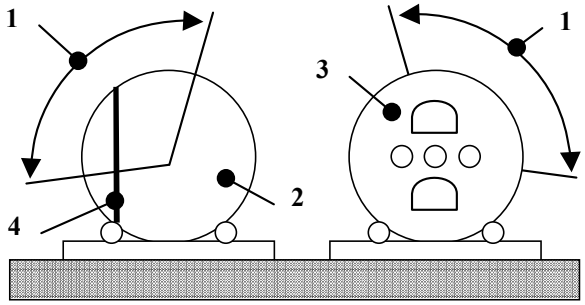
Zero means that the program will find device automatically. In case the Com port number is definitely known, please push “Change”, and then introduce the port number in “current com port is” and push “OK”. If the “Cancel” button will be pushed, the Com port number after previous installation will be in use.

13. The next window will allow you to make horizon adjustment of the device. If you will need in that option please push “Yes”, otherwise “No”.





This window means that rotation part of the device looking to horizon. Marker of the mirror position must be vertical strongly.



1 - zone and direction of scanning
2 - rotation part of the device
3 - unrotation part of the device
4 - marker of the mirror position

14. The next window will allow you to start the measurements (“Start” button) or to exit from the program (“Stop” button).

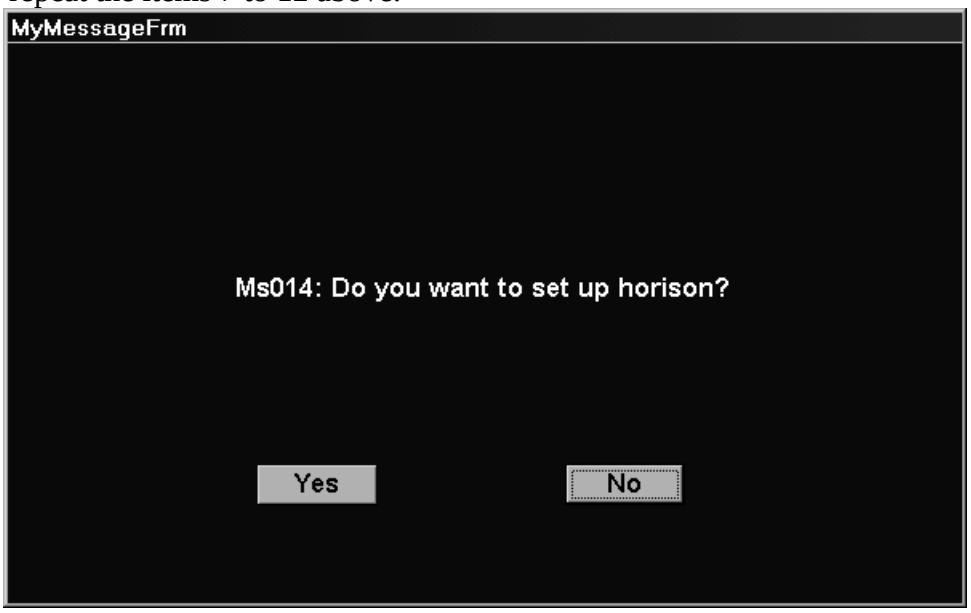
After the “Start” button will be pushed, the circle with yellow/brown sectors will appear in the right bottom corner of the PC screen.

The rotating part of the MTP5 housing will start. You have to wait for two complete round cycles. As far as the sectors remain yellow/brown all the time while rotation was done, the laboratory check is decided passed successfully. If **“!”** sign will appear instead of yellow/brown sectors, please check the Error list. This list will be available when you click by the mouse on **“!”** sign. To stop the program please move the mouse marker to the circular section and push right button on the mouse. On the window, which will appear, please take **“close”** and click on the left mouse button.

15. Switch off power supply.
16. Disconnect all the cables.
17. Such an option is used for auto running of the program after restart PC. Create the shortcut icon of the MTP5.exe in Start Up folder with parameter of /start. For example**:**
    C:\MTP5\MTP5.exe /start

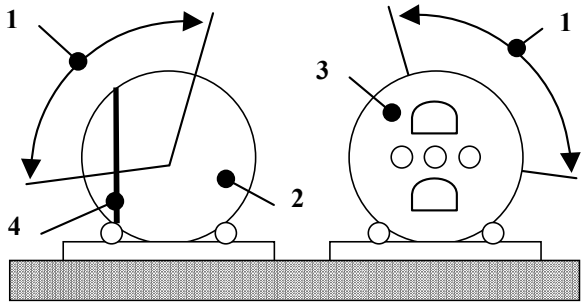
3.2.3 Measurements conducting

1. Install the device at the permanent position in full accordance with the recommendations of the Manual.
2. Connect the cables.
3. Switch on the power supply unit.
4. Please repeat the items 7 to 12 above.



5. The window will allow you to make horizon adjustment of the device. If you will need in that option please push “Yes”, otherwise “No”.

6. This window means that rotation part of the device looking to horizon. Marker of the mirror position must be strongly vertical.



1 - zone and direction of scanning
2 - rotation part of the device
3 - nonrotation part of the device
4 - marker of the mirror position

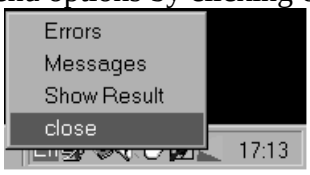
7. The next window will allow you to start the measurements (“Start” button) or to exit from the program (“Stop” button).

After the “Start” button will be pushed, the circle with yellow/brown sectors will appear in the right bottom corner of the PC screen.

Attention! **It is necessary 30 to 60 minutes (depending on environment temperature) to let the device warm up and be ready for measurements.**
When the device is ready for measurements, the icon will change the color to green.

If auto running option is applicable, the start of measurements will be done automatically within a time as was specified during the laboratory testing. You may start the measurements immediately by pushing “GO” button.

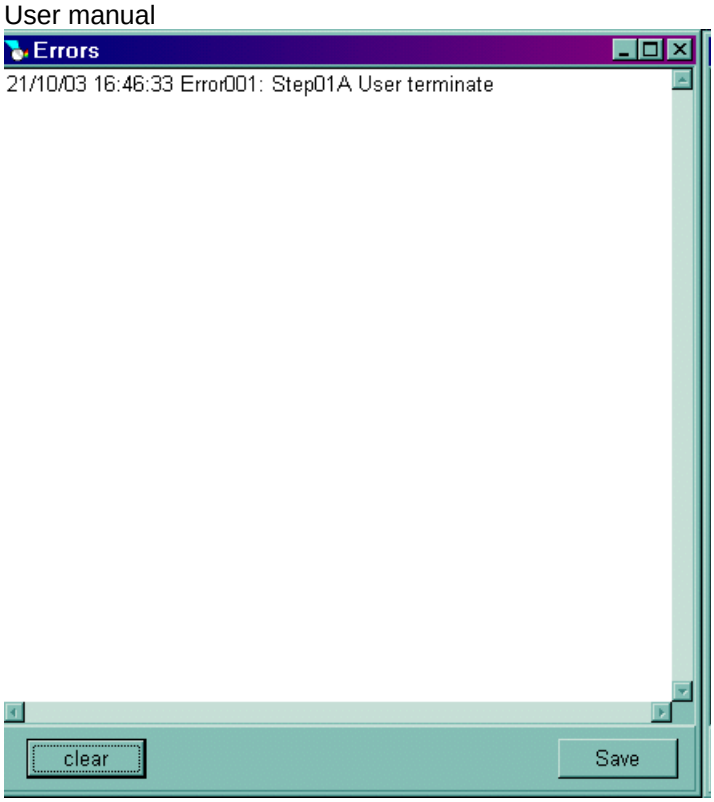
Along with the measurements conducting, you have an option to get more info about the system within the time when scanning is not activated. To do this, you have to point mouse marker on the circle icon and push right button on the mouse. The Menu window will appear. You may use any of the next Menu options by clicking of left mouse button.



- Check the Error list (“Errors”);
- Check the current program operational messages (“Messages”);
- Demonstrate the measurements result on the screen (“Show result”). In this case, the program for result representation “Mtpnews” is activated. The operation with “Mtpnews” program is described in the correspondent Instruction and is supported by build in “Help” option or see chapter 4.
- Cancel the program operation (“close”)

3.2.4 Programs messages

If any error occur you will see this in the window:



The list of messages are as follows:

Error006: Port is not open	Mistake at work with port RS232. Try to connect to other COM port and repeat the procedure ones more
Error007: Value out of range	**One of system sensors works not correctly. URGENTLY CONTACT TO THE DEVELOPER**
Error008: error in answer with:	**One of system sensors works not correctly. URGENTLY CONTACT TO THE DEVELOPER**
Error009: Unknown device:	Mistake in configuration files. Close the program and repeat installation again. If it will be the same problem then **CONTACT TO THE DEVELOPER**
Error010: There is no answer...	The communication with the device is interrupted. Press **clear.** If the mistake has repeated: - check if the device has been **ON;** - is there no breakage of connection. If it would be the same then **CONTACT TO THE DEVELOPER**
Er001: Error with file:	Mistake of the file system. Close the program and repeat installation again. If it would be the same then **CONTACT TO THE DEVELOPER**
Er010: StepMotor Error	Mistake in work of scanning system. Press **clear.** If the mistake has repeated: -send to the **DEVELOPER** a file **errors.log,** from a directory of the measuring program
Er021: Unknown stepper motor. Step per Grad	Mistake in work of scanning system. Repeat installation again. If it would be the same then **CONTACT TO THE DEVELOPER**

4 SOFTWARE/USER-INTERFACE DESCRIPTION

4.1 Microwave Temperature Profiler MTP5 data presentation program MtpNews

4.1.1 On start program

MtpNews program was developed for visualization of the microwave temperature profiler (MTP5) data sets. After you start the application (MtpNews.exe) from for example Windows explorer you will see the next window:

IMPORTANT NOTICE: *for the first time you start the program please specify the path for the data directory by clicking on the* ***Set New Path*** *button*

Application works in regimes:

- Viewing data archive - **OPEN** button
- Real time operation - **START** button

Every regime allows to view results of measurements as:

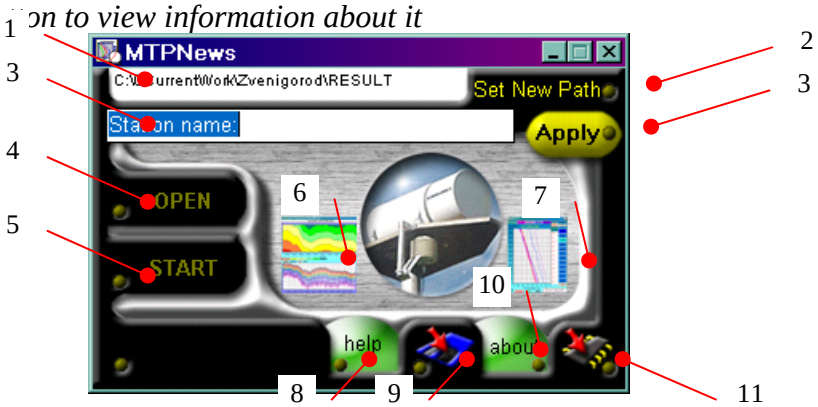
- Graphics
  - *Temperature as function of time*
  - *Temperature inversion as function of time*
  - *Temperature as function of height*
- Fields
  - *Temperature values field*

Additional capabilities:

- Results can be saved as pictures in JPEG (*.jpg) format files.

  Just click on  *button to view information about it*
- Result graphs can be saved to the system clipboard and then will be available from every **MS WINDOWS** application by means of using *Paste* command.

  Just click on  *button to view information about it*



1) directory with ASCII data - Here you can see the path to the data directory.

***IMPORTANT**: if there is no path specified (for example if it is the first time you start the program) or if you want to change this path click on **Set New Path** button*

2) select NEW directory with ASCII data - Use Set New Path button if it is necessary to specify new path to the MTP5 data directory. The path to the selected directory will be displayed in directory with ASCII data window.

3) Station name - Description of the processing data can be written in this field.

Enter your comments and then click on Apply button.
Text will appear in the comment field of Temperature[time] window

4) open current directory with ASCII files - Start the Viewing data archive regime.

5) real time mode - Start the Real time operation regime.

6) Temperature[time] - Used to display temperature as function of time graph.

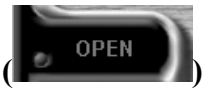
7) Temperature[height] - Used to display temperature as function of height graph.

8) help - Displays Help topics for the MTP5 data presentation program.

9) save data as *.jpg file - Allows to save content of Temperature[time] window in JPEG format files (*.jpg).

10) about - Displays the software version information and the information about software authors. Use athors e-mail adresses if you have any questions about program.

11) copy to clipboard - Allows to save content of Temperature[time] window to system clipboard. This information will be available from every MS WINDOWS application by means of using Paste command.

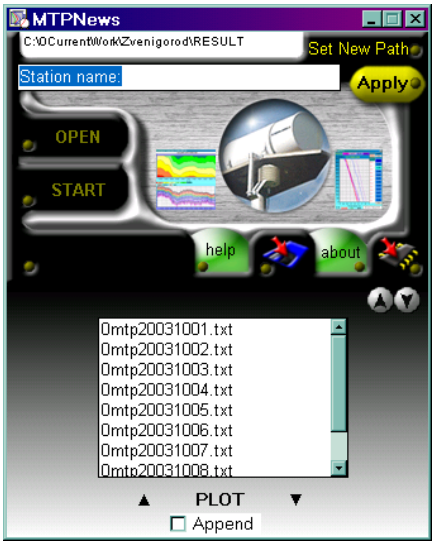
4.1.2 Viewing data archive (

)

Capabilities: Use this regime to view results of measurements by way of *Temperature fields, Dynamics of temperature variations for different heights and characteristics of inversions* in Temperature fields window. Moreover temperature profiles for different time intervals can be shown in Temperature profiles window.

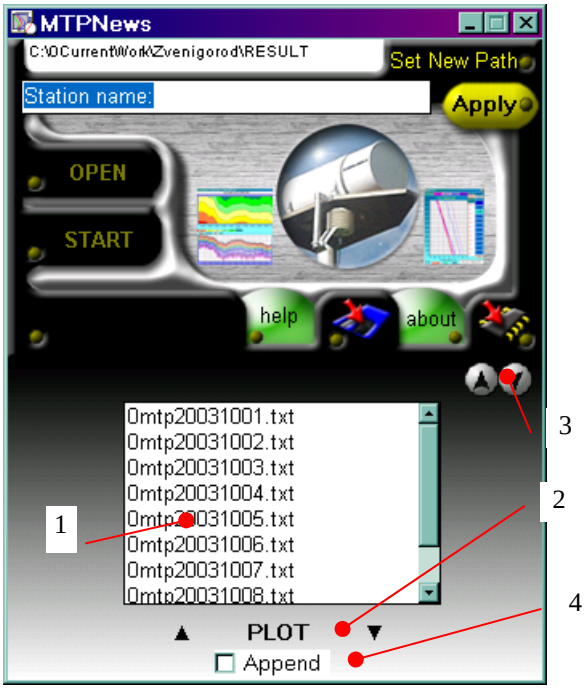
Quick start:

- Use **Set New Path** button if it is necessary to specify *new* path to the MTP5 data directory. This path will be shown in directory with ASCII data
- click **OPEN** button



- choose file from the list of files
- click **PLOT** button
- use navigation tools for data navigation at Temperature fields and Temperature profiles

windows.



1) list of files - file list of the selected data directory. Use **Set New Path** button to specify path to the data directory

2) plot data on graph - the data from selected file will be used to plot Temperature fields and Temperature profiles graphs.

3) hide or show list of files - just hides or shows file list

4) adding files to diagram - This option used to display the set of data files. Switch this option on and the next file you choose from the file list will be added to the previous ones.

IMPORTANT: *selected files should be seriated by date*

4.1.3 Real time operation mode (

)

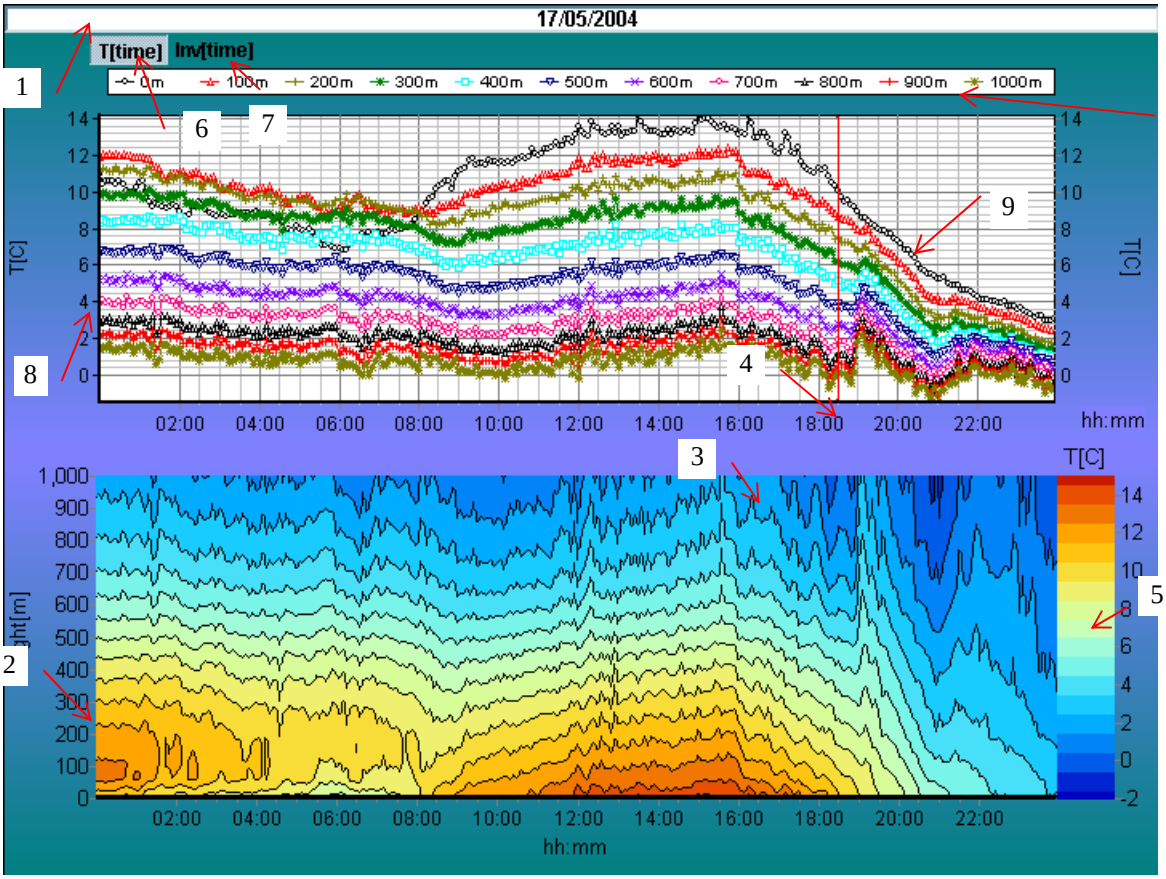
Use this regime to view results of measurements by way of *Temperature fields, Dynamics of temperature variations for different heights and characteristics of inversions* in Temperature fields window in real time mode. Moreover temperature profiles for different time intervals can be shown in Temperature profiles window.

Every time new profile data from MTP5 device is stored to the file all graphs refreshes automatically according to the new information.

Quick start:

- Use **Set New Path** button if it is necessary to specify *new* path to the MTP5 data directory. This path will be shown in directory with ASCII data
- click **START** button
- use navigation tools for data navigation at Temperature fields and Temperature profiles windows.

4.1.4 Temperature fields ( )



1) comment - specified in main window. Use **Apply** button in the Main window to refresh comment string.

2) height scale

3) temperature fields - Displays temperature or temperature gradients fields in the color palette scale Temperature range [C]

4) time scale

5) Temperature range [C] - Temperature ranges of the color scale

6) temperature as function of time - Measured temperature values will be shown on the graph for the heigths from 0 up to 600 meters with 50 meters step.

7) inversion as function of time - changing of the temperature inversion depth **MaxIn** (on the left scale) and the inversion heigth **H[m]** (on the right scale) will be shown on the graph.

8) temperature scale

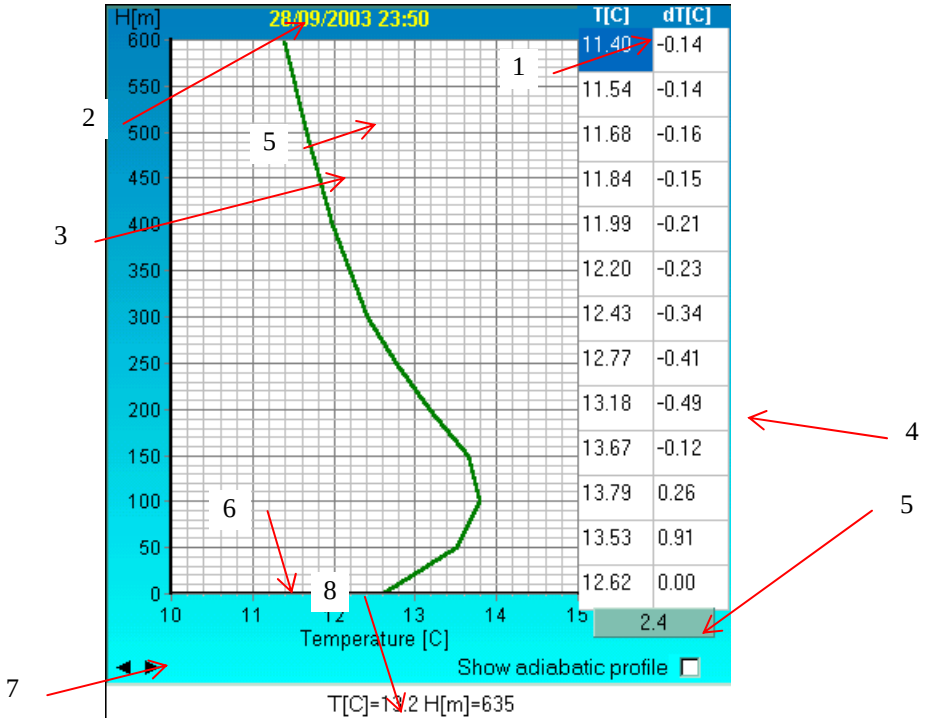
9) graph field

- press left mouse button to see cursor coordinates
- click on the field to choose new temperature profile
- press left mouse button and specify the region from up left side to down right side that you want to zoom in.
- press left mouse button and specify the region from down right side to up left side that you want to zoom out

10) legend

- click right mouse button if you want to change style of graphs for the temperature series of values
- click left mouse button to hide any of the temperature series at different heigths.
- click T[time] or Inv[time] to restore the series for the appropriate regime.

4.1.5 Temperature profiles ( )



1) table of T[C] - table of temperature values for the heigths from 0 up to 600 meters with 50 meters step.
2) profile time
3) field of graph
4) temperature gradients for every 50 meters
5) temperature gradient - abs(Tmax-Tmin) =>

- for adiabatic process - the value of the bias in degrees
- for inversion - its depth.

6) temperature scale - click on the scale for automatic correction of gauge.
7) profiles navigation - use buttons for consequent review of the temperature profiles. You can use cursor control buttons to navigate by the sets of profiles using keyboard.
8) values of T[C] and H[m] - cursor coordinates in the graph window

5 QUALITY ASSURANCE OF THE MEASUREMENT

The quality of the measurement is assured in several ways.

The condition of the instrument is checked by self-tests that are typically performed every 10 minutes. These tests take place without the interference of the user. If anything is wrong, an error message will appear.

The calibration of the instrument is checked every night against the measurement of ambient air temperature. If it's possible, these results are reviewed every morning as a precaution. The usual situation is that the calibration is stable. If something unusual has happened, or the instrument does not function, this will show from the calibration results. Action is defined in the paragraphs on the user interface and on trouble shooting.

The measurement is fairly well under control during conditions of high humidity, rain and snow. The heater systems make sure that water will quickly evaporate, and in any case not condense on the instrument. The measurement accuracy in principle does not suffer from precipitation unless it is very intense rain showers.

Finally, if simultaneous results of temperature profile measurement from some other in situ or remote sensing sensors are accessible, MTP-5 software gives the possibility to compare the results of these measurements to the MTP-5 data .

6 MAINTENANCE OF THE MTP-5.

MTP-5 has a limited need for maintenance. The recommended maintenance schedule, as usual with meteorological equipment, depends strongly on the local conditions.
A recommendation for the maintenance schedule is shown below.

Daily	If it's possible, review of the results of the automatic calibration. If it's possible, visual inspection of the condition of MTP-5 and the Ambient Air Temperature Sensor If it's possible, check the PROTOCOL

	ACTIVITY of the DEVICE
Monthly	Inspection of cables condition
Yearly	Cleaning of Ambient Air Temperature Sensor interior.
Two-yearly	Recalibration of the Ambient Air Temperature Sensor

7 THEORY.

7.1 Comparison to conventional techniques for measuring temperature profiles

There are several possible methods for measurement of the PABL temperature profiles. However none of the conventional or direct measurements are capable of providing a continuous monitoring of a temperature profile above an arbitrary site. Examples of profiling techniques are radiosondes and sensors mounted on a meteorological tower, and remote sensing measurements with a Radar Acoustic Sounding System (RASS). A radiosonde can measure a temperature profile at about 50 m height resolution from about 50 m to 30 km. This requires the launching of radiosondes and does not give the possibility of the continuous measurements. Tethered balloons and meteorological towers can provide fast response turbulence measurements in the lower 1 km (balloon) or 10-300 m (tower) altitude range, however, there are strong location restrictions. A Radio Acoustic Sounding System can provide continuous profiling of the temperature from 100 m to about 1 km, however the technique uses a powerful sound source, which creates a noise nuisance. Also the lower levels are not measurable, and this system will give false readings in conditions with water droplets (rain, mist), and with strong wind. Meteorological satellites can provide temperature profile measurements on a global scale, but can not measure the lower 3 km with sufficient accuracy. A ground based passive meteorological temperature profiler, like MTP offers many features that are not available with the other techniques. The main benefits are that the instrument has a wide operational range (also covering conditions of fog, snow and rain), zero emission of radiation, a high level of quality assurance, automatic calibration and low operational costs. For experiments the added features of being portable and having a low weight are important.

7.2 Radiometry theory

The technique that is used for meteorological remote sensing of PABL temperature profile is based on measuring the thermal radiation of the atmosphere in the centre of the molecular oxygen absorption band where the effective thickness of the radiating layer is about 300…400 m. By definition the effective thickness is equal to the height H_b where optical depth:

$$\tau(H_b) = \frac{1}{\cos Q}\int_0^{Hb} k_f(h)dh = 1 \qquad (1)$$

For the PABL the absorption can be approximated by $k_f(h)=const=k_f(0)$ and $H_b(h)=cosQ/k_f(0)\approx cosQ\times 300m$, where Q is the zenith angle. Remote sensing of the PABL temperature profiles is conducted by measurements of the radiobrightness temperature at different zenith angles from $Q=0^o$ up to $Q=90^{o\cdot}$. In this case the optical depth of the contributing radiation layer ranges from 0 to 300 m.

The expression for the radiobrightness temperature T_b has the form:

$$T_b(Q) = \frac{1}{\cos Q}\int_0^H T(h)k_f(h,T)\exp[-\frac{1}{\cos Q}\int_0^h k_f(h',T)dh']dh = \int_0^H T(h)k(h,Q)dh \qquad (2)$$

where k is the kernel; H≈2 km – the upper limit of integration. The layers of the atmosphere higher than 2 km, do not influence T_b. As the working frequency is chosen in the centre of the molecular oxygen absorption band, where the attenuation is very high, fog, changes in water vapour density, clouds and weak rain do not influence the measurements.

Equation (2) is the type 1 Fredholm equation. For solving (2) for MTP-5H it is possible to use Tikhonov method in form of a generalised variation or an iteration method with a dedicated algorithm permitting retrieval of the temperature profiles in real time. The accuracy of the temperature profile retrieval at the altitude range 0-1000 m is $0,2^0$C for usual lineal profiles and $0,5^0$C for profiles with an inversion.

7.3 MTP-5 calibration

The core of the MTP-5H is a single channel solid state Dicke-type super heterodyne receiver. As the central frequency of the receiver is at the centre of a strong absorption line of molecular oxygen (14dB/km on wavelength of 5 mm) if so the brightness temperature at the reception of the atmosphere radiation from a horizontal direction is practically equal to the atmosphere temperature near by a ground surface. It gives an opportunity to use the atmosphere like a quality microwave target. Using the natural difference of the atmosphere temperature near a ground surface during several hours it is possibly to define the slope of calibration line of the radiometer (dependence of the radiometer output code to the atmosphere temperature). In the special cases for definition of the slope of calibration line of the radiometer can be used internal noise generator with high stability (0.1^0C) simulates the temperature difference that also can be used to define the slope of calibration line of the radiometer.. For the absolute radiation measurements at least one additional point must be known. This reference is provided by an ambient air temperature measurement. An Ambient Air Temperature Sensor that is delivered as part of the system serves as a source for continuous calibration.

The usual situation is that an automatic calibration is performed during the night. Usually the ambient temperature will go down.

Equation for the radiometer calibration can be written as:

$t_i = k_{rd} \cdot k_i + b$ (3)

where:

t_i – temperature of the atmosphere,

k_{rd} – radiometer constant; $k_{rd} < 0$;

k_i – measured code;

b – constant.

When accepting the results of the automatic calibration, the consents of equation (3) are automatically updated.

8 MTP-5H(HE) SPECIFICATIONS

8.1 Instrument specification.

Options	**MTP-5H**	**MTP-5HE**
Altitude range	600 m	1000 m
Altitude resolution	50 m – 100 m	0-100 m, 50 m resolution/100-400 m, 70 m resolution/400-600 m, 80 m resolution/600-1000 m, 120 m resolution
Duration of a measurement	120 sec	120 sec
Accuracy of temperature profile (depends on type of profile)	0,2 ^{0}C (adiabatic) 0,5 ^{0}C (with inversion)	0 to 500 m, 0.3 °C/500 to 1,000 m, 0.4 °C (adiabatic) 0 to 500 m, 0.8 °C / 500 to 1,000 m, 1.2 °C(with inversion)
Weight	20 kg	20 kg
Power requirements	~220 VAC, 1 A, 50-60 Hz (on request : ~110 VAC)	~220 VAC, 1 A, 50-60 Hz (on request : ~110 VAC)
Power consumption	max 120 W (see also Power Supply Unit) average 60 W	max 120 W (see also Power Supply Unit) average 60 W
Ambient temperature range	-40 °C - +40 °C	- 40 °C to + 40 °C
Number of measurement angles	11	11

Options	MTP-5H	MTP-5HE
Calibration	self calibrating relative to ambient air temperature	self calibrating relative to ambient air temperature

8.2 Ambient Air Temperature Sensor specification.

Range of measurements	$-40^0 \ldots +50^0$C
Accuracy	$\pm 0{,}5^0$C
Power dissipation	3 mW
Supply voltage	+12V

8.3 Power Supply Unit specification. (EURO-CB EPS-7/9 compatible)

Supply voltage	~ 220 VAC ±10% 50-60 Hz (on request : ~110 VAC)
Output voltage	+12V $^{+5V}$ I≤5A
Power Consumption	not more than 120 W

9 TROUBLE SHOOTING

EFFECT	CAUSE	SOLUTION
There is no light on the button of the power supply unit	1. There is no ~ 220 VAC 2. Fuse broken 3. Lamp broken	1. Check ~ 220 VAC 2. Change fuse on power supply unit
The mirror does not rotate	1. There is no connection 2. Power supply unit broken 3. Scanner broken	1. Check cables connection 2. Exit from the measuring program, switch off power supply unit and contact with manufacture 3. Exit from the measuring program, switch off power supply unit and contact with manufacture

EFFECT	CAUSE	SOLUTION
The receiver not switch on	1. There is no connection 2. Receiver broken	1. Check cables connection 2. Exit from the measuring program, switch off power supply unit and contact with manufacture
The mirror keeps rotating	1. Sensor of the position broken	1. Exit from the measuring program, switch off power supply unit and contact with manufacture

10 SPARE PARTS.

Please ask for our spare parts list.

11 WARRANTY AND REPAIR POLICY

There is a one-year warranty on the equipment if this concerns faults in manufacturing.
Damage that is the result of electrical damage, by the environment or by the user, is not covered by this warranty. All specifications and design of the device are subject to change without prior notice.

12 DICTIONARY