

# MANUAL

FOM/mts  
and  
TDR/MUX/mpts  
and  
TDR/MUX/mpts/dlog

Ver. 1.41

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## Contents

Introduction .....	6
Device identification and serial numbers .....	6
Software .....	7
Firmware upgrade .....	7
ET USB Communicator window .....	7
Operation of the program with FOM/mts handheld device .....	9
Probe type and probe selection .....	10
Program Log .....	11
Buttons .....	11
Probe length calibration .....	11
Probe full calibration .....	11
Measure salinity .....	12
Measure probe temperature .....	12
Measure moisture .....	12
Measure all .....	13
Graph window .....	14
Menu .....	14
File menu .....	14
Save measurement results .....	14
Export measurement results to MS Excel .....	14
Exit program .....	14
Calibration Menu .....	14
Probe length calibration .....	14
Probe full calibration .....	14
Measurement menu .....	15
Read menu .....	15
Read last measured salinity .....	15
Read last measured probe temperature .....	15
Read last measured moisture .....	15
Read time .....	15
Read date .....	15
Read contrast .....	15
Read supply voltage .....	15
Memory banks menu .....	16
Stored data points .....	16
Read data bank .....	16
Save data bank .....	16
Com ports menu .....	16
COM[No] .....	16
Help menu .....	16
Help 16 .....	16
About command .....	17
How to .....	17
How to connect with the device over USB cable .....	17
How to perform the calibration .....	17
How to read banks memory .....	17
How to perform salinity measurement .....	18
How to perform moisture measurement .....	18

How to perform probe temperature measurement .....	18
Operation of the program with TDR/MUX/mpts device.....	18
Type of probe in a channel .....	19
Testing LP/t and LP/p probes connected to AUX port .....	19
Calibration of FP/mts and LP/ms probes in TDR/MUX/mpts channels .....	20
Testing FP/mts and LP/ms probes .....	20
Data Logger window .....	20
Time period between the measurement series .....	22
Writing and reading of the probes assignment to channels .....	23
Output data format .....	23
Exporting Data Logger configuration to the script file to work with MIDL-2 data logger.....	24
TDR/MUX/mpts.....	24
Front panel description .....	24
Rear panel description .....	25
Operational modes of the TDR/MUX/mpts device .....	25
Features of TDR/MUX/mpts device.....	26
TDR/MUX/mpts/dlog .....	27
Starting the DL100.exe application.....	27
Synchronizing the device with PC computer clock .....	27
Setting up measurement periods .....	28
Configuration of sensors in measurement channels .....	28
Starting and stopping the measurement.....	29
Format of data in the flash memory and output file .....	30
Exporting the measured data to the PC text file .....	31
FOM/mts – handheld meter.....	31
Features of FOM/mts handheld devices .....	32
Maintenance.....	33
FOM/mts operation.....	33
External connections .....	33
Battery supply and battery charging.....	33
Manual operation.....	34
FP/m, FP/mts - Field Probe for moisture, temperature and salinity of soil.....	36
LP/ms - Laboratory miniProbe for soil moisture and salinity.....	38
LP/t - Laboratory Probe for soil temperature .....	39
LP/p - Laboratory miniProbe for soil water capillary pressure.....	40
Appendix 1. Watering of LP/p probes .....	42
Appendix 2. ....	44
Introduction to MIDL-2 GPRS data logger.....	46
Functional description .....	47
Front panel .....	48
Rear panel .....	48
Initial configuration of MIDL-2 data logger .....	48
SIM card installation.....	48
PC computer and MIDL-2 connection.....	49
Operation with Easy Test Configurator application.....	49
Operation with Internet browser .....	51
User data bookmark .....	51
Data bookmark.....	52
Measurements and GPRS communication time schedule .....	54

References .....	57
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## INTRODUCTION

The purpose of this Manual is to present the main features of FOM/mts and TDR/MUX/mpts meters as well as the related probes developed and manufactured in the Institute of Agrophysics Polish Academy of Sciences (IA PAS), Lublin, Poland. Also, it provides the description of the program “ET USB Communicator” that can control the devices from a PC compatible computer connected by USB link.

The FOM/mts and TDR/MUX/mpts are measurement devices for soil moisture (on the base of Time Domain Reflectometry technique), matrix pressure (applies to TDR/MUX/mpts), temperature and electrical conductivity (salinity).

The TDR/MUX/mpts multichannel laboratory or field device is described in page 24 and FOM/mts handheld meter is described in page 31 of this Manual.

## DEVICE IDENTIFICATION AND SERIAL NUMBERS

Each measurement device manufactured in IA PAS is provided by an unique 8 characters serial number (Fig. 1).

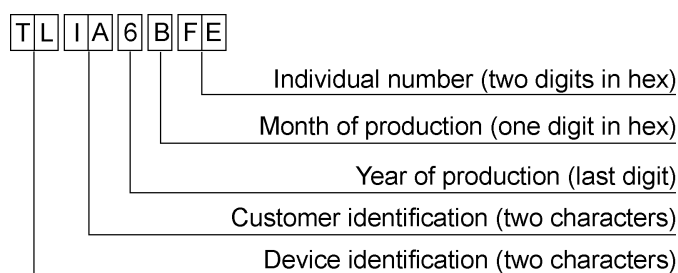


Fig. 1. Serial numbers of the measurement devices from IA PAS, Lublin

The first two characters of the serial number contain the information identifying the device. Table 1 describes identification codes of the implemented devices.

Table 1. Device identification codes

Device identification	
First character	Second character
H – handheld soil moisture (TDR), temperature and salinity meter	S – standard version or Slave (MIDL)
T – TDR/MUX/mpts 8-channel soil moisture, matrix pressure, temperature and salinity meter	M – Master (MIDL)
M – Multi-Interface Data Logger (MIDL)	G – GPS option
G – GPRS Data Logger (MIDL-2)	F – field version
I – 8-channel high input impedance voltage meter for potentiometric measurements	L – laboratory version
B - battery	1 – Li-Polymer 3.6V/1500 mAh

When contacting with the producer the user is asked to provide the serial number for identification of the individual device.

## **SOFTWARE**

The both TDR/MUX/mpts and FOM/mts handheld measurement devices communicate with PC compatible computer by dedicated program *ET USB Communicator*, which is provided with no charge to the user.

The program allows to:

- perform single measurement on selected probe to test the device and the probe,
- individually calibrate each TDR probe (i.e. fix the electrical length and the “dead time” of a probe as well as account for individual characteristics of the channel) and send this data to the device,
- read the data stored in the internal memory of the device to PC computer (applies to FOM/mts handheld meter),
- control the probes measurement sequence and time period between the measurement sequences (applies to TDR/MUX/mpts meter in the data logger mode of operation),
- generate a script file defining the devices and probes measurement sequence for later importing by the MIDL data logger.

Virtual COM port drivers for USB and installation instructions are provided in the attached CDROM (in the catalogue Drivers\FTDI\Windows\_XP\_&\_2000 and Drivers\FTDI\Windows\_98\_&\_ME) or on our WEB site <http://www.easytest.lublin.pl>.

### **Firmware upgrade**

The firmware of the FOM/mts and TDR/MUX devices is continuously improved to meet the objective of being user friendly. The latest version of firmware is available on request from IA PAS, Lublin, Poland or can be downloaded from the WEB site [www.easytest.lublin.pl](http://www.easytest.lublin.pl). The process of firmware upgrade consists in the execution of appropriate files FOMXXXXX.exe or TDRXXXXX.exe, where XXXXX is the upgrade version. It is requested not to interrupt the execution of the above files.

### **ET USB Communicator window**

After connecting the device to PC compatible computer by USB cable and starting, the program displays the main window of *ET USB Communicator* (Fig. 2).

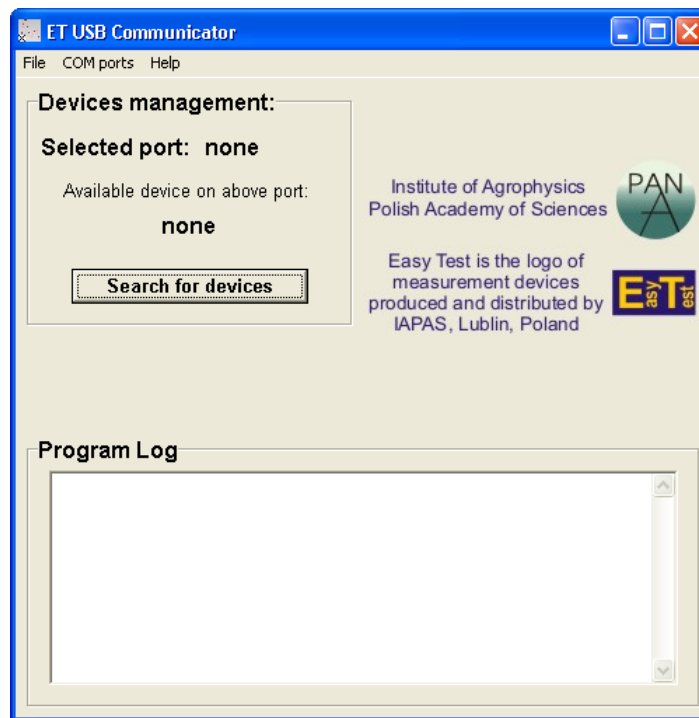


Fig. 2. The ET USB Communicator window

The user should select the COM port appropriate for the selected device. The COM port number can be determined by checking Windows Device Manager. The example presented in Fig. 3 has USB serial port on COM5.

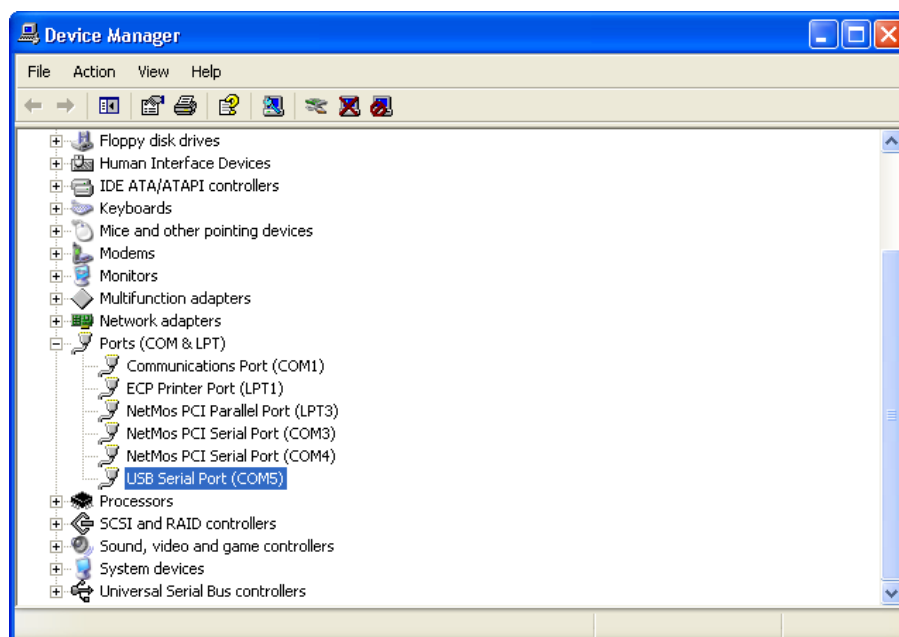


Fig. 3. Determination of the USB COM port number used by the FOM/mts handheld or TDR/MUX/mpts meters

After the COM port selection the user should search the devices on the selected port. Only one type of devices can be connected to the PC computer at the time: either FOM/mts or TDR/MUX/mpts. Only one FOM/mts device can be connected to a PC



computer. The example connections of several TDR/MUX/mpts devices are presented in Fig. 4 and Fig. 5.

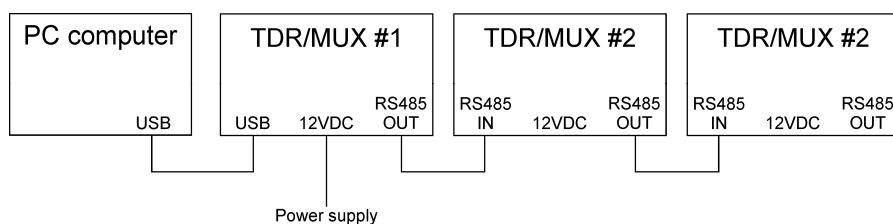


Fig. 4. Example connections of the measurement system consisting in a PC computer and three TDR/MUX devices connected in a chain

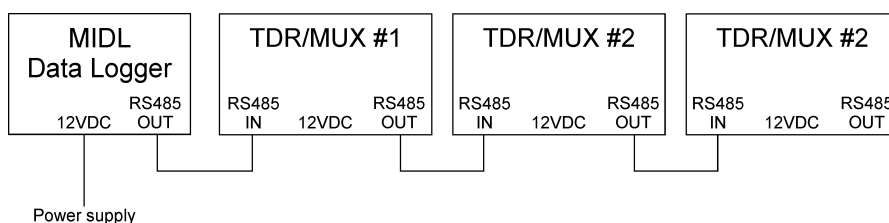


Fig. 5. Example connections of the measurement system consisting in a MIDL Data Logger and three TDR/MUX devices connected in a chain

TDR/MUX/mpts devices connected in a chain are supplied by means of the linking cable RS485. In the example from Fig. 4, the external supply of 12VDC is connected preferably to the first in a chain TDR/MUX/mpts device and the power inputs (marked 12VDC) of other devices are not connected. In the example from Fig. 5 the external power supply of 12VDC is connected to the MIDL Data Logger and the TDR/MUX/mpts devices are supplied by means of the cable connected in a chain.

The response from the connected device is displayed in the Program Log window. The available devices connected to the computer can be selected from the Available devices Combo Box. The operation of the program is different for controlling FOM/mts handheld and a TDR/MUX/ mpts meters.

### Operation of the program with FOM/mts handheld device

Short description of TDR/MUX/mpts devices is presented on page 31.

The *ET USB Communicator* can control only one FOM/mts handheld meter, therefore, the Available devices has only one selection consisting of the serial number of the device connected to the computer.

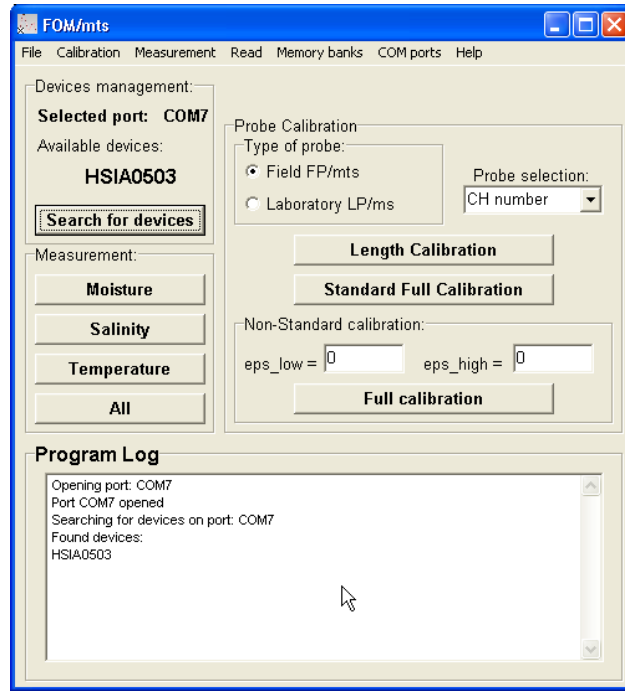


Fig. 6. Calibration, configuration and test measurement window for FOM/mts device

The calibration, configuration and test measurement window for FOM/mts handheld device is presented in (Fig. 6). Using this window the user can perform:

- selection of current measurement probe from the earlier calibrated ones,
- calibration of standard and non-standard field (FP/mts) or laboratory (LP/ms) probes,
- measurement moisture, salinity (electrical conductivity), temperature and displaying the received reflectogram (Fig. 8),
- collection of data stored in the internal memory banks of the device.

The length of parallel waveguide rods in non-standard probes differ from the standard ones (10 cm for FP/mts and 5.2 cm for LP/ms).

Temperature and electrical conductivity measurements with standard FP/mts and LP/ms probes are factory calibrated.

Calibration of standard and non-standard FP/mts and LP/ms probes for TDR soil moisture measurements consists of the determination of three elements:

- probe length defining the coaxial cable length between the device and the TDR sensor and fixing in time the beginning of the TDR sensor on the cable (i.e. the first negative reflection presented in Fig. 8),
- length of the sensor rods,
- “dead time”, i.e. the time the TDR pulse travels the double length from the first negative marker and the beginning of the probe rods.

These values are calculated by the device on the base measurements of a FP/mts and LP/ms probes in two media of various dielectric permittivity.

### ***Probe type and probe selection***

Although the FOM/mts handheld meter can measure only one probe at a time, the user can change probes manually and use up to eight earlier calibrated probes: standard FP/mts and LP/ms probes (having the length of parallel rod waveguide 10 cm and 5.2 cm, respectively) or non-standard FP/mts and LP/ms probes of other length. This is done by Probe selection Combo Box and Type

of probe radio switches. The calibration parameters of earlier calibrated probes (defined by appropriate Probe selection number) are stored in the device for further application.

### ***Program Log***

Program Log is a text field used to present results of measurements, information about the program and about communication with the device. It is located at the bottom of the main window. It can be used like any text editor – for example it is possible to copy its content to the clipboard and paste it elsewhere.

### ***Buttons***

Using the buttons is the fastest way to perform exact actions with the connected device. The Search for devices button located on the left from the centre of the main window enables the user to connect with the device on the selected COM port. When connection is established, the image on the right from the Search for devices button disappears and reveals calibration and measurement buttons. These buttons represent the same actions as Calibration and Measurement Menus, respectively.

### ***Probe length calibration***

Performs the probe length calibration necessary for TDR soil moisture measurements, i.e. calculates the length of cable between the coax connector at the device and the time marker in the FP/mts or LP/ms probes. The user is asked to fulfil all actions asked for in the message windows. Probe length calibration is the same for standard and non-standard probes.

### ***Probe full calibration***

Performs the full probe calibration necessary for TDR soil moisture measurements. During the process the user is asked not to disconnect the USB cable from the handheld device. The user is asked to fulfil all actions asked for in the message windows.

There is a distinction for standard and non-standard probes full calibration. The introduction of non-standard probe results from the user demands for different length of the probe parallel waveguide. In case of short probes the calibration medium of low dielectric constant value should not be air because of troubles in distinction the pulse reflected from the rods end (the reflections from the rods beginning and end overlap). Even in case of a standard laboratory probe LP/ms the calibration medium of low dielectric constant is ertacetal ( $\varepsilon = 3.8$ ) to ensure distinct reflections. The calibration media for standard TDR probes are presented in Table 2.

Table 2. Calibration media for standard field (FP/mts or FP/ms) and laboratory (LP/ms) probes

Type of probe	Medium of low value of dielectric constant	Medium of high value of dielectric constant
FP/mts	Air ( $\varepsilon = 1$ )	Water ( $\varepsilon = 81$ , water temperature = 18°C)
LP/ms	Ertacetal (3.8)	Water ( $\varepsilon = 81$ , water temperature = 18°C)

For non-standard probes the user can chose the calibration media by himself using data from Table 3. He should be aware that the measured values

of dielectric constant should be between the low and high values of calibration media dielectric constants (to minimise the measurement error).

Table 3. Calibration media for non-standard field (FP/mts) and laboratory (LP/ms) probes. Dielectric constant values and the temperature dependencies are taken from Handbook of Chemistry and Physics, CRC, 2002

Medium	Dielectric constant, $\epsilon$	Temperature dependence
Water	80.1 (T=293.2 K)	$\epsilon = 0.24921E3 - 0.79069 * T + 0.72997E-3 * T^2$ (273 < T (K) < 373)
Benzene	2.28 (T = 293.2 K)	$\epsilon = 0.26706E1 - 0.91648E-3 * T - 0.14257E-5 * T^2$ (293 < T (K) < 513)
Acetone	21.01 (T=293.2 K)	$\epsilon = 0.88157E2 - 0.343 * T + 0.38925E-3 * T^2$ (273 < T (K) < 323)
Metanol	33 (T=293.2K)	$\epsilon = 0.19341E3 - 0.92211 * T + 0.12839E-2 * T^2$ (177 < T (K) < 293)
Ethanol	25.3 (T=293.2K)	$\epsilon = 0.15145E3 - 0.87020E1 * T + 0.19570E-2 * T^2$ (177 < T (K) < 293)
Teflon	2.5	-
Ertacetal	3.8	-

### ***Measure salinity***

The handheld device is asked to perform the salinity measurement. It takes about 1 second to complete the measurement. During the process the user is asked not to disconnect the USB cable from the handheld device. It is most advised not to remove the probe from the measured sample in order to receive reliable results. After this time the result is received and displayed in the Program Log in the program main window.

### ***Measure probe temperature***

The handheld device is asked to perform the probe temperature measurement. It takes about 5 seconds to complete the measurement. The temperature sensor is located in the epoxy resin at the beginning of the parallel rods waveguide. During the process the user is asked not to disconnect the USB cable from the handheld device. It is most advised not to remove the probe from the measured sample in order to receive reliable results. After this time the result of the probe temperature measurement is received and displayed in the Program Log in the program main window.

### ***Measure moisture***

The handheld device is asked to perform the moisture measurement. It takes about 1 second to complete the measurement. During the process the user is asked not to disconnect the USB cable from the handheld device. It is most advised not to move the probe in the measured sample in order to receive reliable results. After this time the result is received and displayed in the Program Log field in the program main window. The reflectograms used to calculate the moisture value for LP/ms and FP/mts probes are displayed in new windows (Fig. 8 and Fig. 8, respectively).

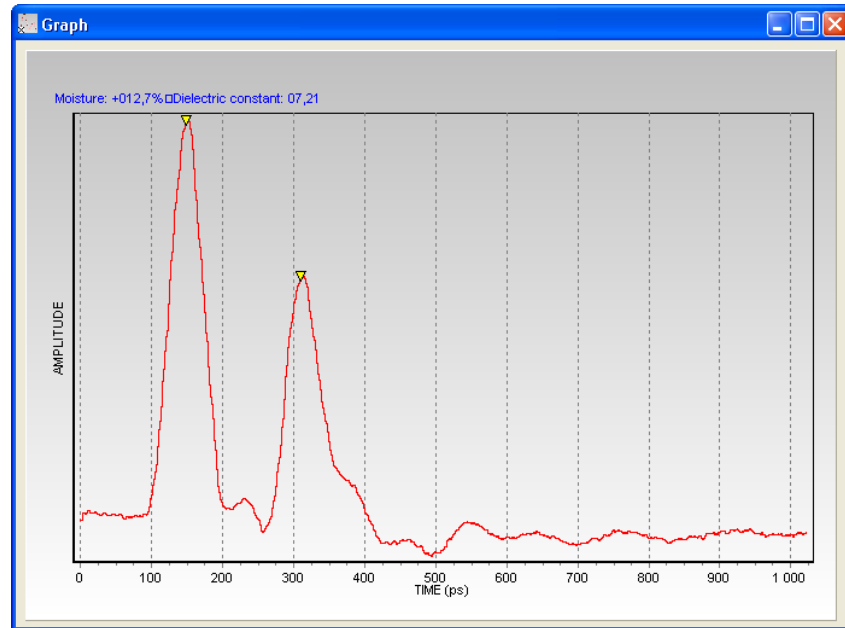


Fig. 7. TDR reflectogram from LP/ms probe connected to FOM/mts device controlled by “ET USB Communicator”

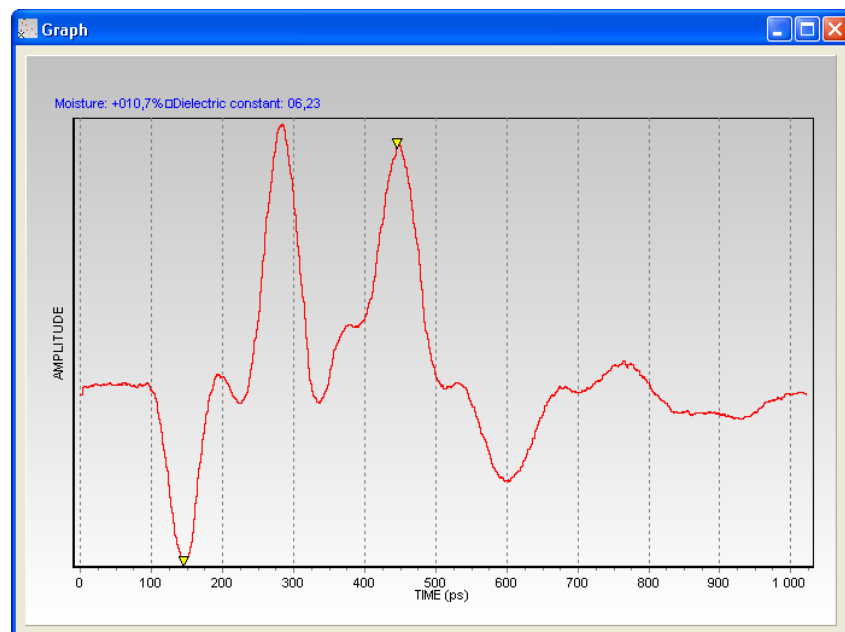


Fig. 8. TDR reflectogram from FP/mts probe connected to FOM/mts device controlled by *ET USB Communicator*

The marked points on the reflectogram represent the time distance, which is the base for the calculation of the soil water content. The first marked point the reflectograms represent the reflections from time markers located in time about 150 ps before the beginning of the parallel rods waveguide. The time marker reflection for LP/ms probe is positive while for FP/mts probe – negative.

### ***Measure all***

The handheld device is asked to perform all three measurements described above. It takes about 7 seconds to complete the measurement. During this process the user is asked not to disconnect the USB cable from the handheld

device. It is most advised not to remove the probe from the measured sample in order to receive reliable results.

The received data are displayed in the **Program Log** field in the FOM/mts window in the following order: probe temperature, salinity, and moisture. The reflectogram graph used to calculate the moisture value during the TDR method is also displayed in a new window. The marked points on the reflectogram graph represent the time distance, which is the base for the calculation of the soil water content (Fig. 8).

### ***Graph window***

Graph window opens after the moisture measurement is complete (Fig. 8). It contains the reflectogram graph used to calculate the moisture value. The marked points on the reflectogram graph represent the time distance, which is the base for the calculation of the soil water content.

### ***Menu***

The menu bar represents all the functions of the program. The menu bar contains following menus: File, Calibration, Measurement, Read, Memory Banks, Com Ports and Help.

### ***File menu***

#### ***Save measurement results***

After performing all measurements user is enabled to save the measurement results to a text file. The first line consists of values of respectively moisture, salinity and probe temperature. The following 1024 lines contain the data values of the reflectogram.

#### ***Export measurement results to MS Excel***

After performing all measurements user is enabled to export the measurement results to MS Excel sheet. It is advised not to close or edit the sheet while the data is being exported. When operation has finished the sheet looks the same as the text file described above.

#### ***Exit program***

Selecting this command closes the application. Remember to save your measurement results before exiting.

### ***Calibration Menu***

#### ***Probe length calibration***

Performs the cable length calibration. During the process the user is asked not to disconnect the USB cable from the handheld device. The user is asked to fulfil all actions asked for in the message windows.

#### ***Probe full calibration***

Performs the full probe calibration. During the process the user is asked not to disconnect the USB cable from the handheld device. The user is asked to fulfil all actions asked for in the message windows.

### ***Measurement menu***

Commands used to execute certain or all measurement processes on the sample. Their execution corresponds to the respective Command Buttons. The commands include:

- measure salinity,
- measure probe temperature,
- measure moisture,
- measure all.

### ***Read menu***

Commands used to read some settings values and previous measurement results stored in the handheld device.

#### ***Read last measured salinity***

Shows last measured salinity value stored on the handheld device in the log field in the program main window. During the process the user is asked not to disconnect the USB cable from the handheld device.

#### ***Read last measured probe temperature***

Shows last measured probe temperature value stored on the handheld device in the log field in the program main window. During the process the user is asked not to disconnect the USB cable from the handheld device.

#### ***Read last measured moisture***

Shows last measured moisture value stored on the handheld device in the log field in the program main window. During the process the user is asked not to disconnect the USB cable from the handheld device.

#### ***Read time***

Shows the current time set on the handheld device in the log field in the program main window. During the process the user is asked not to disconnect the USB cable from the handheld device.

#### ***Read date***

Shows the date set on the handheld device in the log field in the program main window. During the process the user is asked not to disconnect the USB cable from the handheld device.

#### ***Read contrast***

Shows the contrast set on the handheld device in the log field in the program main window. During the process the user is asked not to disconnect the USB cable from the handheld device.

#### ***Read supply voltage***

Shows the voltage supply on the handheld device in the log field in the program main window. During the process the user is asked not to disconnect the USB cable from the handheld device.

### ***Memory banks menu***

Commands used to read data stored in the data banks in the handheld device. The data consists of a set of previous performed measurements saved by the user in handheld devices memory banks.

#### ***Stored data points***

Displays the amount of measurement results stored in each data bank in the log field in the program main window. It is possible to store up to 300 measurement results in each of three data banks. During the process the user is asked not to disconnect the USB cable from the handheld device.

#### ***Read data bank***

Displays the data stored in the selected data bank in the log field in the program main window. During the process the user is asked not to disconnect the USB cable from the handheld device.

#### ***Save data bank***

Saves the data stored in the selected data bank in the text file. The user is asked to choose the name of the file the data is to be written to. The first line of the text file tells the user which data bank has been written to this file. During the process the user is asked not to disconnect the USB cable from the handheld device.

### ***Com ports menu***

#### ***COM[No]***

Selects a COM port to look for attached devices. Selected COM port is marked with “√” sign. To select another COM port the user has to deselect the previous one with clicking on it again.

### ***Help menu***

#### ***Help***

The command opens the program help file.



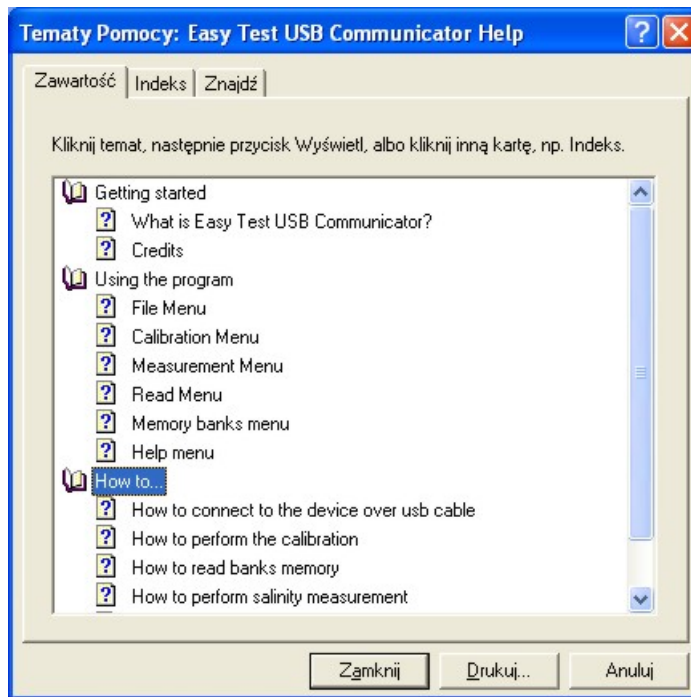


Fig. 9. Help Window of the “ET USB Communicator”

#### *About command*

Displays general program information.

#### *How to...*

##### *How to connect with the device over USB cable*

1. Connect the USB cable to both the device and the terminal;
2. Choose the correct com port from the com ports menu;
3. Click the “Search for devices” button;
4. Select proper device from the list above the button.

Connection is now established. You can perform any task from the menu or buttons in the programs main window.

##### *How to perform the calibration*

1. Connect the device with the terminal;
2. Choose the „Calibration” menu and click the calibration method you want to execute: “Cable length calibration” or “Full probe calibration”;
3. Follow the guides that will be displayed in message windows.  
The probes are now ready for performing any requested measurement.

##### *How to read banks memory*

1. Connect the device with the terminal;
2. Choose the “Memory banks” menu;
3. After clicking the “Stored data points” button the amount of data stored in each memory bank will be displayed in the program log; it is not necessary to check it before reading the memory banks;
4. After clicking “Read” and then selecting appropriate data bank number the data from the chosen bank will be transmitted to the

terminal and displayed in the program log in the same order in which you saved it in the handheld device's memory from the oldest to the youngest.

*How to perform salinity measurement*

1. Connect the device with the terminal;
2. Choose the "Measurement" menu;
3. Click the "Measure salinity" button.

The measurement results should now be seen in the program log.

*How to perform moisture measurement*

1. Connect the device with the terminal;
2. Choose the "Measurement" menu;
3. Click the "Measure moisture" button.

The measurement results should now be seen in the program log.

*How to perform probe temperature measurement*

1. Connect the device with the terminal;
2. Choose the "Measurement" menu;
3. Click the "Measure probe temperature" button.

The measurement results should now be seen in the program log.

## **Operation of the program with TDR/MUX/mpts device**

Short description of TDR/MUX/mpts devices is presented on page 24.

Up to 16 devices can be controlled by the *ET USB Communicator*.

When only TDR/MUX devices are connected to the computer, the execution of the command Search for devices in the ET USB Communicator window opens the TDR/MUX window (Fig. 10) and the user can choose the current device for testing, calibration and configuration. This can be done by selection a serial number from the Select device Combo Box.

The TDR/MUX/mpts device can measure the following probes:

- FP/mts - field probe for the measurement of soil moisture (by TDR technique), temperature and electrical conductivity (using 8-channel coaxial port),
- LP/ms - laboratory probe for the measurement of soil moisture and electrical conductivity (using 8-channel coaxial port),
- LP/t – laboratory probe for the measurement of temperature (using AUX port),
- LP/p – laboratory probe for the measurement of soil matrix pressure (using AUX port).

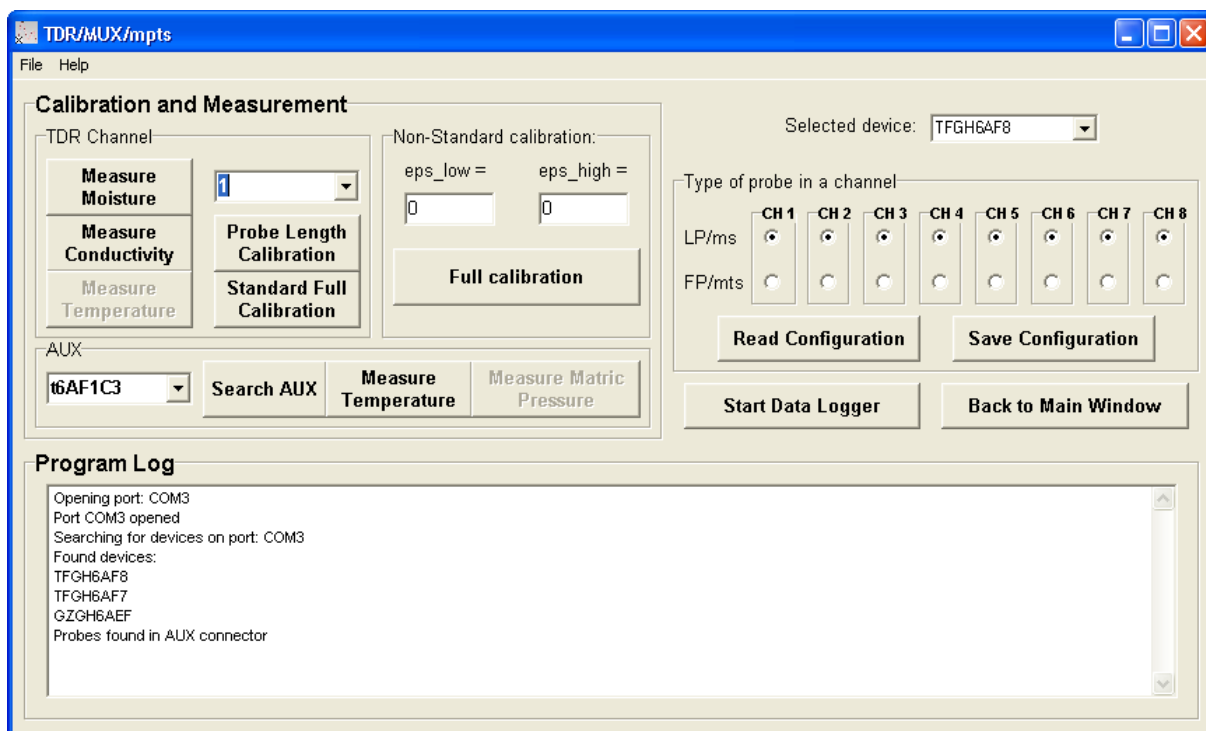


Fig. 10. Calibration, configuration and test measurement window for TDR/MUX/mpts device

The LP/t and LP/p probes are connected in parallel to the AUX port using the standard 1-Wire protocol (DS18B20 Data Sheet, <http://www.maxim-ic.com>). Each of these probes is identified by a unique serial number. If the AUX probes are connected to the TDR/MUX device when the window from Fig. 10 opens, the program automatically identifies all their serial numbers and they are available by the user.

### ***Type of probe in a channel***

When opening the TDR/MUX/mpts window the program reads the type of probe selected to individual channels (i.e. either LP/ms option for Laboratory Probes or FP/mts option for Field Probes). In case of other configuration of TDR probes than marked, the user should manually select the type of TDR probe by choosing appropriate toggle switch under the selected channel number (CH1, CH2, ... or CH8). Then, this configuration should be saved in the device for storing in the non-volatile memory by pushing the Save Configuration Command Button. The Read Configuration Command Button is for back reading of the recently written data and verification of the chosen selection.

### ***Testing LP/t and LP/p probes connected to AUX port***

Currently two types of probes can be applied for connection AUX port: LP/t – laboratory probe for temperature measurement (see page 39) and LP/p – laboratory probe for soil matrix pressure (see page 40).

When opening the TDR/MUX/mpts window the program searches for 1-Wire link probes connected to the AUX port of the selected device. Each probe has an attached label for identification purpose. The serial number on this label contains six alphanumeric characters preceded by a letter t – for temperature probes and a letter p – for soil matrix pressure transducer, ex. t45BE1D or pEAC016.

To test a sensor connected to the AUX port it is necessary to select its serial number in the Combo Box under the Search AUX Command Button and push the appropriate Command Button in the AUX Section, i.e. Measure temperature or Measure matrix pressure. When the user changes the configuration of 1-Wire sensors connected to the tested device, he should update the current configuration by pushing the Search AUX Command Button. The result of the measurement of the selected 1-Wire sensor is displayed on the Program Log window.

#### ***Calibration of FP/mts and LP/ms probes in TDR/MUX/mpts channels***

Due to long term and temperature drifts as well as the different geometries of various FP and LP probes the system can store individual parameters of each probe in a channel. These parameters are not accessible to the user but they are taken into account in calculation of soil apparent dielectric permittivity and moisture.

Calibration of FP probes is done with two media: air and water. Calibration of LP/ms probes is done with a provided calibrator (a cylinder from ertacetal,  $\varepsilon=3.8$ , with two narrow holes for inserting the needles of the LP/ms probe – for low dielectric constant values) and water.

Calibration in water requires information about its temperature. This information is easily available for FP/mts probes with inherent temperature sensor. The user must provide water temperature for LP/ms sensors by:

- measuring it with a thermometer and filling in the Water Temp. (°C) Text Box (when no AUX probe is selected), or
- measuring it with a selected 1-Wire temperature probes from the AUX port (the selected LP/t AUX probe should be inserted together with the calibrated probe into water).

During calibration procedure the user should follow the instructions given in the information windows.

There is also possibility for non-standard calibration like for FOM/mts device. The details for this type of calibration are the same (go to page 11)

#### ***Testing FP/mts and LP/ms probes***

To test FP/mts or LP/ms probes connected to chosen channels it is necessary to:

- check the type of probe (in the Type of probe in a channel frame) connected in the selected channel and in case of changes - save the current configuration of probe type in channels,
- push the appropriate Command Button, ie. Measure moisture or Measure conductivity

The measurement results will be displayed on the Program log window.

After calibration and testing of all probes connected to the selected device the user can select another device using Select device Combo Box and repeat the same procedures. Then he can start data Logger mode of the program by pushing the Start Data Logger Command Button.

#### ***Data Logger window***

Data Logger window is presented in **Fig. 11**. It is intended to plan the experiment, i.e. determine the sequence of probes measurement in connected

devices and time period between the beginnings of consecutive measurement series.

Channel No.	Probe type		Measured value from LP/ms or FP/mts				Measured AUX probe	
	LP/ms	FP/mts	$\epsilon$	$\theta$	$\sigma$	$T$		
1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	H45BE1D	pEAC016
2	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	no probe	no probe
3	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	no probe	no probe
4	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	no probe	no probe
5	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	no probe	no probe
6	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	no probe	no probe
7	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	no probe	no probe
8	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	no probe	no probe

**Fig. 11.** Data Logger window TDR/MUX/mpts device

Opening the Data Logger window is associated with the execution the following operations by the program:

- reading the serial numbers of TDR/MUX/mpts devices connected in the measurement system and updating the Select device Combo Box,
- importing the assignment of probe types (FP/mts or LP/ms) in the individual channels of each device and updating the Probe type selection (it is inactive in this window),
- searching for 1-Wire probes connected to AUX port for further selection by the user.

After selecting the current device in the Select device Combo Box, the user determines which values will be measured in the channels associated with LP/ms and FP/mts probes. The FP/mts probes measure soil moisture,  $\theta$  (%), electrical conductivity,  $\sigma$  ( $\text{Sm}^{-1}$ ) and temperature,  $T$  ( $^{\circ}\text{C}$ ), and all of these variables may be selected. The LP/ms probes measure only  $\theta$  and  $\sigma$ , and selection for temperature is inactive for this type of probe.

Each channel has two associated AUX positions for the measurement of probes connected to the device by 1-Wire link, i.e. LP/t temperature and LP/p soil matrix pressure probes. When the user assigns the particular 1-Wire probe to the channel, it cannot be selected again for other channels.

The example selection from **Fig. 11** shows that the device with the serial number TLIA05FE has all channels equipped with LP/ms probes with selected dielectric permittivity, soil moisture and electrical conductivity measurement

values active and two AUX probe in the 1<sup>st</sup> channel for temperature and soil water matrix potential measurements.

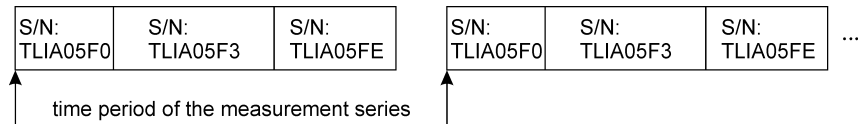
#### *Time period between the measurement series*

When all required probes have been associated with the channels of all connected TDR/MUX devices, the user sets the time distance between the beginnings of the consecutive measurement series. Each measurement series consists of sequential measurement of probes and data readout for the consecutive devices sorted in their serial numbers alphabetical order. The time for the measurement and readout of the individual probes in the measurement system differs with the probe type (**Table 4**).

**Table 4.** The length of time taken for calculation of minimal time period between measurement and data readout from various probes used by TDR/MUX/mpts devices

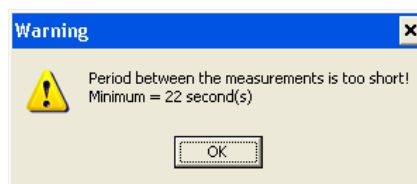
Type of probe	Measured value	Time for the probe measurement and readout (in seconds)
FP/mts	Moisture, $\theta$ and/or dielectric permittivity, $\varepsilon$	1
	Electrical conductivity, $\sigma$	1.5
	Temperature, $T$	3
LP/ms	Moisture, $\theta$	1
	Electrical conductivity, $\sigma$	1.5
LP/t	Temperature, $T$	1
LP/p	Matrix pressure, $P$	1

The example sequence of measurements and time distance between the measurement series are presented in **Fig. 12**. The width of a time window for each device differs because not all channels in the device may be measured. The TDR/MUX/mpts devices controlled by the program are identified by various serial numbers.



**Fig. 12.** Example of the sequence of measurements and time distance between the measurement series for three TDR/MUX/mts devices identified by various serial numbers

If the user enters the time period between the measurement series shorter then the one calculated by the program on the base of **Table 4**, the error Message Box appears with appropriate information (**Fig. 13**). After pressing OK button in this box the Set time period Text Box will contain the minimal value of time period calculated by the program. In case of a single TDR/MUX/mpts measurement system with the probes configuration from **Fig. 11**, the minimal time period between series is 22 seconds.



**Fig. 13.** Information message about too short time period between the series of measurement

### *Writing and reading of the probes assignment to channels*

Selecting the buttons Write Configuration or Read Configuration (**Fig. 11**) the user can load or store the probes to channels assignment for all devices connected to PC computer. The name of the corresponding file is user selectable.

### *Output data format*

Pressing the Start Command Button initiates the Data Logger operation of the TDR/MUX/mpts device. The *ET USB Serial Communicator* will send commands to the device and receive data from the sensors for storage in the text files. Each device connected to the computer will have a separate data file named with its serial number, i.e. for the device TLIA05FE the output data file is named OUT\_FE.txt, etc. Pressing Stop Command Button saves all output data files associated with the TDR/MUX/mpts devices in the system to the same folder where the *ET USB Serial Communicator* program is located (default folder).

```
counter date/time M1 S1 X11 X12 M2 S2 T2 X21 X22 ... M8 S8 T8 X81 X82
0 2005-04-27/16:41:09 +008,2 0,000 +15,1 470 +009,8 0,000 +12,4 +17,7 +17,8 ... +014,3 0,000 +15,3 +17,5 510
1 18:39:31 +008,4 0,000 +14,9 472 +009,9 0,000 +12,8 +17,4 +17,9 ... +006,7 0,000 +15,2 +12,8 513
2 20:37:54 +008,4 0,000 +14,0 470 +010,1 0,000 +12,7 +17,5 +17,2 ... +006,7 0,000 +15,0 +12,6 516
3 22:36:16 +008,5 0,001 +12,9 475 +010,1 0,000 +12,3 +17,6 +17,0 ... +006,2 0,000 +15,7 +12,0 521
...
```

**Fig. 14.** Format of the output data file generated by Data Logger window of the *ET USB Serial Communicator* for the configuration of probes from **Fig. 11**

The format of output data file is presented in **Fig. 14**. The first line of the output data file contains headers. They represent:

- counter: number of the measurement series executions (numeric value starting from zero),
- date/time: date and time for the start of the current measurement series execution (date is written only once a day and updates at midnight), format: YYYY-MM-DD/HH:MM:SS
- M1...M8: value of moisture (%) in channels 1..8, format: +###, #,
- S1...S8: value of electrical conductivity ( $\text{Sm}^{-1}$ ) in channels 1..8, format: #,###,
- T1...T8: value of temperature ( $^{\circ}\text{C}$ ) in channels 1..8, format: +##, #,
- X11..X81 and X12...X82 for probes in AUX channels, format for temperature ( $^{\circ}\text{C}$ ) probes is +##, #, format for matrix pressure (mbar) probes is ###.

The following lines of the output file contain data arranged according to the headers. This format allows importing of the text file into spreadsheet.

### *Exporting Data Logger configuration to the script file to work with MIDL-2 data logger*

The Data Logger window facilitates to export the script file that can be imported by the MIDL-2 data logger device.

Having configured channels in each TDR/MUX/mpts device in the measurement system the user selects Export Script in the File menu to choose the name and location to save of the script file. The created script file can be later loaded to the MIDL-2 data logger using Internet Explorer FTP protocol (see MIDL-2 Instruction Manual).

## **TDR/MUX/mpts**

TDR/MUX/mpts stands for eight-channel laboratory or field meter for the determination of moisture, temperature, salinity and matrix pressure of soils.

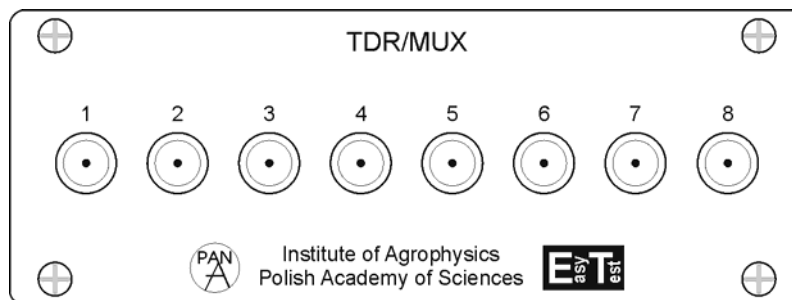
Soil water content and electrical conductivity is measured by FP/ms, FP/mts or FP/mts/ns field probes (see page 36) and LP/ms laboratory probes (see page 38).

LP/p laboratory probes measure soil matrix water potential (see page 40).

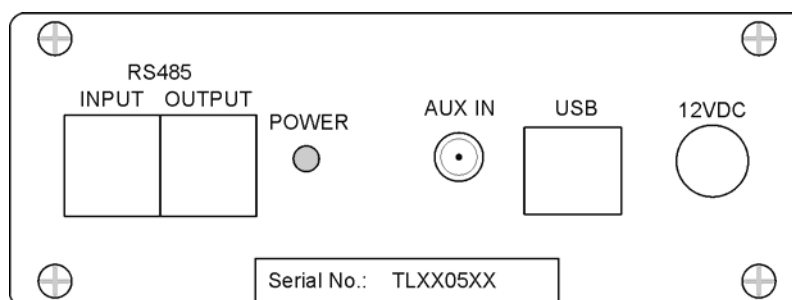
LP/t laboratory probes measure soil temperature (see page 39).

In FP/mts or FP/mts/ns probes the soil temperature is measured in an integrated electronic temperature sensor.

The front and rear panels of the TDR/MUX/mpts device are presented in **Fig. 15** and **Fig. 16**, respectively.



**Fig. 15.** Front panel of the TDR/MUX/mpts



**Fig. 16.** Rear panel of the TDR/MUX/mpts

## **Front panel description**

The front panel of TDR/MUX/mts contains the following:

- Eight ports labelled 1, 2, ..., 8 of MCX or SMA type depending on the kind of connectors attached to the TDR probes. The laboratory probes LP/ms (see page



38) are usually terminated by MCX plugs and FP (see page 36) probes by SMA plugs, although it may depend by the user choice.

- AUX port for auxiliary soil temperature (LP/t – see page 39) or soil matrix pressure (LP/p - see page 40) probes connected in parallel and individually selected by unique serial numbers.

## Rear panel description

The rear panel of TDR/MUX/mts contains the following:

- Power supply socket labeled 12VDC. The supply voltage may be in the range 10-14 VDC, chosen for the possible supply from lead acid 12VDC accumulator or from a filtered and voltage source (the example connections of the measurement system are presented in Fig. 4 and Fig. 5).
- USB connector to PC compatible computer for testing the device or controlling its operation during the measurements by supplied software.
- POWER LED indicating the device connection to the system supply.
- RJ12 socket for serial RS485 INPUT and OUTPUT to connect up to 16 TDR/MUX/mpts devices in a chain (Fig. 17) or MIDL Data Logger.

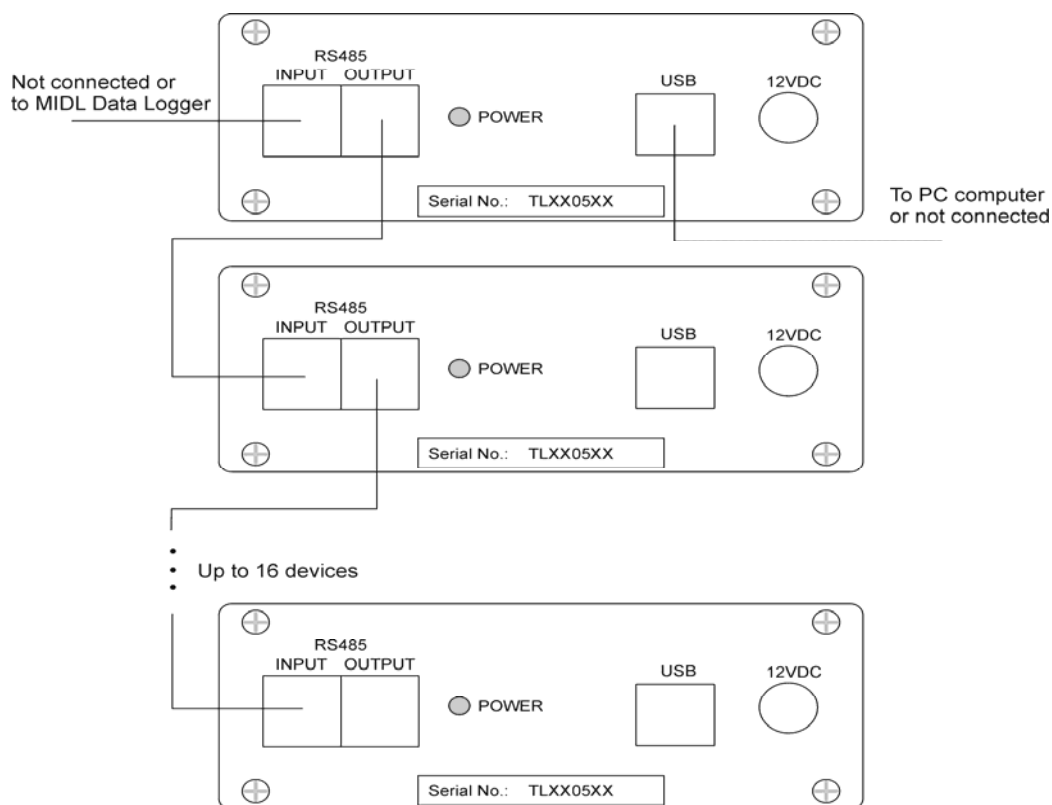


Fig. 17. Connection of multiple TDR/MUX/mpts devices in a chain to control the measurement experiment with up to 128 TDR probes (LP/ms and/or FP)

## Operational modes of the TDR/MUX/mpts device

The measurement system can work in two modes:

- battery supplied data logger mode when the system is controlled by MIDL Data Logger (see MIDL Manual), connected to the first (in the chain) device INPUT,

- mains supplied laboratory mode when the system is controlled by the dedicated software from PC compatible computer connected to any of the TDR/MUX/mpts USB port.

When a TDR/MUX/mpts device connected in a chain performs measurements (about 210 mA current consumption in operational mode) the other devices are in low power mode (about 10 mA current consumption in low power mode). In case of the system powered by battery supply and controlled by MIDL Data Logger, all TDR/MUX/mpts devices in the measurement system are in the sleep mode drawing about 10  $\mu$ A from the battery, each.. In the user defined time intervals the MIDL wakes up (70 mA current consumption in the operational mode, 150 $\mu$ A in the sleep mode) and it sequentially wakes up the TDR/MUX/mpts devices, performs measurement on selected probes, stores the received data in the non-volatile memory and enters the sleep mode again.

### **Features of TDR/MUX/mpts device**

- number of channels:
  - for soil moisture (TDR method), electrical conductivity (salinity) and temperature using an integrated FP/mpts probe and/or LP/ms: 8,
  - AUX port for soil temperature using LP/t and/or soil matrix pressure using LP/p probes: up to 16 probes connected in parallel,
- operates with probes with different cable lengths (from 1.5 to 9.5 m),
- connection by USB interface with PC compatible computer for the experiment control and data transfer,
- pulse:  $\sin^2$ -like needle pulse having 200 ps rise-time,
- range of readings
  - volumetric moisture: 0 ÷ 100 %,
  - temperature: -20 ÷ +50°C,
  - electrical conductivity: 0.000 ÷ 1 S/m,
- accuracy:
  - moisture absolute error: displayed water content  $\pm 2$  % or less if the measured soil is individually calibrated,
  - temperature absolute error:  $\pm 0.5^\circ\text{C}$  or less if read from individually calibrated probe,
  - el. conductivity relative error:  $\pm 10$  % for 0 ÷ 1 S/m or less if read from individually calibrated probe,
- resolution of readings:
  - volumetric moisture: 0.1 %,
  - temperature: 0.1°C,
  - el. conductivity: 1 mSm<sup>-1</sup>,
- time of test of a single FP/mpts probe: moisture – 2 s, temperature – 5 s, electrical conductivity – 2 s,
- time of test of a single LP/ms probe: moisture – 2 s, electrical conductivity – 2 s,
- time of test of a single LP/t or LP/p connected to AUX channel: 1 s,
- the device ambient temperature of work: 5°C ÷ +50°C,
- FP/mpts, LP/ms and LP/t probes can work in the -20°C ÷ +50°C temperature range,
- dimensions: 180 x 85 x 58 mm,
- weight: 0.35 kg,

- maintenance: the meter is not user serviceable. No special maintenance means are required.
- temperature of storage:  $-10 \div +50^{\circ}\text{C}$ . In case of the measurement system work with MIDL Data Logger

### **TDR/MUX/mpts/dlog**

TDR/MUX/mpts/dlog stands for multichannel laboratory or field meter for the determination of moisture, temperature, salinity and matrix pressure of soils, which is equipped with a data logger. It is an enhanced version of TDR/MUX/mpts meter and contains features that enable to store the measured data in the internal memory of the meter. These data can be exported to the memory of PC computer using USB link and the free of charge DL100.exe application.

The meter can work in two modes:

- in connection with PC computer to set up the data logging schedule or export the data collected in the internal flash memory of the TDR/MUX/mpts/dlog device to the text file on the PC computer,
- in autonomous mode to collect data from the probes and store the data in the internal flash memory.

DL100.exe application runs under Microsoft Windows and controls only one device connected to the PC computer.

### **Starting the DL100.exe application**

After starting the DL100.exe application the following window appears (Fig. 18). It contains several elements for working in the modes mentioned above. The pushbuttons and entry fields have hints that appear on the screen when the mouse pointer is over it.

The first thing the user should do is to select the appropriate serial port and mark it on the Select ComPort menu item. The correct port for selection can be determined from Fig. 3 and its description on page 8.

Then the user should press search devices to communicate and confirm connection with the device. A proper connection is marked by appearing the serial number of the connected device in the field with a hint choose serial number of connected devices. It is planned to connect several TDR/MUX/mpts/dlog devices in chain by serial RS485 link. However at the moment of editing the current Manual only one device is controlled by the DL100.exe application.

### **Synchronizing the device with PC computer clock**

The device contains internal real time clock that should be synchronized with the PC computer clock. This is done by pressing Set Date / Time pushbutton and the current date and time will appear above this pushbutton. When the POWER LED is ON, the device is busy and it cannot complete the command. The user should repeat pressing the POWER button to update the date and time of the device. Another pushbutton Read Date / Time serves for checking the effect of this operation.

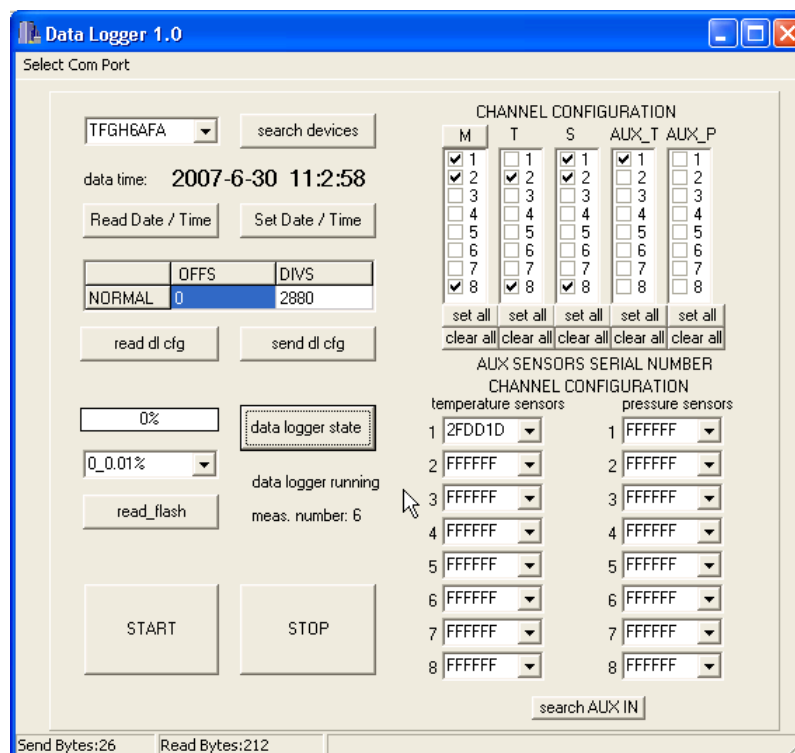


Fig. 18. DL100.exe application window

### Setting up measurement periods

The pushbuttons **read dl cfg** and **send dl cfg** are for reading from and sending to the device the measurement time schedule of the meter, respectively. The **NORMAL** configuration is defined by two parameters: **DIVS** (in seconds) that defines the number of measurement series during 24 hours period and **OFFS** (in seconds) that defines the offset from the calculated value. This feature is intended for future use when many (up to 16) TDR/MUX/mpts/dlog devices connected by RS485 serial link will be read by a single USB connection with PC computer.

The value **DIVS=2880** in Fig. 18 means that the series of measurement will start every  $24 \times 3600 / 2880 = 30$  second.

The user can enter the required number of series (on the base of the calculation as above) in the **DIVS** field and press the **send dl cfg** pushbutton. Reading the entered value and checking can be done by pressing the pushbutton **read dl cfg**.

### Configuration of sensors in measurement channels

On the right side of the window in Fig. 18 there are two selection tables for marking probes and variables that should be measured in the selected channels. They are named:

- **CHANNEL CONFIGURATION** – the table for choosing sensors in eight channels of the device. M, T, S stand for moisture, temperature and salinity variables that can be measured by FP/mts (see page 36) or LP/ms (see page 38) probes connected to the input coaxial channels (type SMA coaxial sockets) of the device. Each of this channel has assigned two auxiliary (AUX) channels, ie. one for the measurement of temperature using LP/t probe (see page 39), the other for the measurement of soil matrix pressure using LP/p probe (see page 40). The pushbuttons **set all** and **clear all** are for collective selecting or

deselecting a chosen variable in all channels. The sign M on the pushbutton marking the name of the first column can be changed for Eps. This is for changing the data in the output file from volumetric moisture (M) to dielectric permittivity (Eps) as is shown in Fig. 18 and Fig. 19 as well as the corresponding Table 5 and Table 6. The data collected in the TDR/MUX/mpts/dlog device contain information about the both variables, M and Eps, and the pushbutton M / Eps is respected only in exporting the data text file to PC computer.

- AUX SENSORS SERIAL NUMBER CHANNEL CONFIGURATION – the table for choosing an individual probe from AUX input by selecting its serial number (see page 19). Before selecting the serial number of the probe connected to AUX port the user should press search AUX IN pushbutton to update the serial numbers of connected probes.

The configuration of sensors in measurement channels should be stored in the internal memory of the device by pressing the pushbutton send dl cfg. Pressing the pushbutton read dl config the use can check the current configuration of the device.

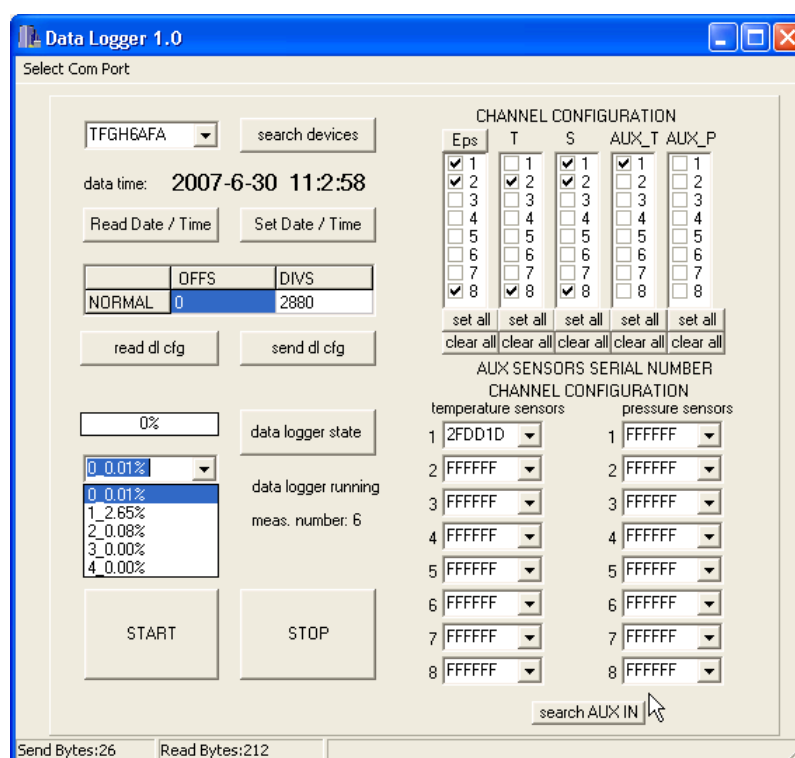


Fig. 19. DL100.exe application window with opened selection for choosing the required flash memory area with user data

## Starting and stopping the measurement

The pushbuttons START and STOP are for starting and stopping the measurements of selected probes according to the fixed time schedule. After starting the measurements the user can unplug the USB cable from the device and let it work in autonomous mode. The TDR/mpts/dlog will start measurements and after completing the measurement series it will enter into the sleep mode with minimal current consumption from the supply battery (about 30  $\mu$ A in sleep mode). It will wake up according to the time schedule fixed by the user, perform measurements and again enter into the sleep mode, etc. One of the major criterion of TDR/MUX/mpts/dlog

design was the minimization of power consumption so as to allow long term measurements while supplying the system by a small 12VDC accumulator. The 7Ah accumulator can supply the device (measurement of 8 FP/mts, 8 LP/t and 8 LP/p probes) for at least 1 year with 3600 seconds measurement period.

The user can stop the measurement series by connecting the USB cable of the PC computer to the device, start the DL100.exe application (see page 27) and press STOP pushbutton. The user should be aware that the commands sent to the device while it is performing measurements (the POWER LED is ON) will be ignored. Therefore before sending the STOP command he should check the state of the device by pressing data logger state pushbutton. The text below shows: data logger running or data logger stop. The latter text informs that the device will respect the user commands.

### Format of data in the flash memory and output file

The whole flash memory in TDR/MUX/mppts/dlog device is divided into maximum number of 32 user data areas, where the data are stored. They are marked nn\_pp.pp%, which is presented in Fig. 19 in the pull-down box.

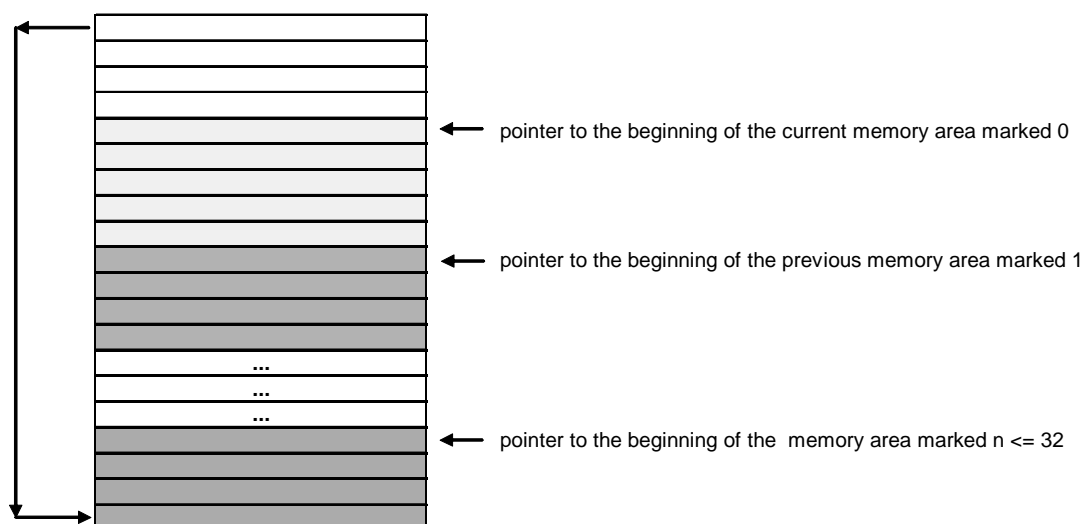


Fig. 20. Configuration of the internal memory in the TDR/MUX/mppts/dlog device.

nn stands for the number of the user data area and pp.pp% stands for percentage of full flash memory capacity occupied by the selected memory area. The division is dynamic and cycling (Fig. 20). Dynamic means that the data from current execution of DL100.exe application are always stored in the area marked 0. If the user stops the execution of the program and starts it again, the data from the previous execution will be marked as 1. The next start of the data collection by pressing the START pushbutton will result in collection the new data in the memory area 0, while the previous memory areas will be marked with the old numbers + 1. When the whole memory will be completely filled by data, the new data will be stored starting from the bottom address of the memory erasing the whole memory area occupying this place. This way it is possible to have only one continuous memory area with the number of several thousands most current records of data.

## Exporting the measured data to the PC text file

When the device is stopped, i.e. the message under the data logger state pushbutton is data logger stop, the user can export the measured data from the device into a PC text file. Its default location is the folder with DL100.exe application and the name of the file is build from the device serial number, date and time when the file was created. The example file TFGH6AFA\_2007\_6\_30\_10\_59\_33.txt format is presented in Table 5 and Table 6. The first part of the name is the device serial number (TFGH6AFA), the next part is date (2007\_6\_30) in the format yyyy\_mm\_dd, the last part is time of creation in the format hh\_mm\_ss.

Table 5. Output file TFGH6AFA\_2007\_6\_30\_10\_59\_33.txt data format with moisture (M in volume percentage) data. Electrical conductivity S in mS/m, temperature in centigrade.

date	time	M1	M2	M8	T2	T8	S1	S2	S8	AUX_T1
2007-6-30	10:53:0	-2.9	2.0	5.0	23.2	21.5	0	0	0	24.4
2007-6-30	10:53:30	-2.9	2.0	5.1	23.2	21.5	0	0	0	24.4
2007-6-30	10:54:0	-2.9	2.2	5.1	23.2	21.5	0	0	0	24.4
2007-6-30	10:54:30	-2.9	2.1	5.0	23.2	21.5	0	0	0	24.4
2007-6-30	10:55:0	-2.9	2.0	5.1	23.3	21.5	0	0	0	24.4
2007-6-30	10:55:30	-2.9	2.1	5.1	23.3	21.5	0	0	0	24.4
2007-6-30	10:56:0	-2.9	2.3	5.0	23.3	21.5	0	0	0	24.4
2007-6-30	10:56:30	-2.9	2.0	5.1	23.3	21.5	0	0	0	24.4
2007-6-30	10:57:0	-2.9	2.2	5.1	23.3	21.5	0	0	0	24.4
2007-6-30	10:57:30	-2.9	2.0	5.1	23.3	21.5	0	0	0	24.4
2007-6-30	10:58:0	-2.9	2.0	5.1	23.3	21.5	0	0	0	24.4
2007-6-30	10:58:30	-2.9	2.0	5.1	23.3	21.5	0	0	0	24.4
2007-6-30	10:59:0	-2.9	2.1	5.1	23.3	21.5	0	0	0	24.5

Table 6. Output file TFGH6AFA\_2007\_6\_30\_11\_0\_5.txt data format with dielectric permittivity (Eps) data. . Electrical conductivity S in mS/m, temperature in centigrade.

date	time	E1	E2	E8	T2	T8	S1	S2	S8	AUX_T1
2007-6-30	10:53:0	1.47	2.81	3.83	23.2	21.5	0	0	0	24.4
2007-6-30	10:53:30	1.48	2.82	3.88	23.2	21.5	0	0	0	24.4
2007-6-30	10:54:0	1.47	2.86	3.85	23.2	21.5	0	0	0	24.4
2007-6-30	10:54:30	1.48	2.85	3.84	23.2	21.5	0	0	0	24.4
2007-6-30	10:55:0	1.47	2.82	3.85	23.3	21.5	0	0	0	24.4
2007-6-30	10:55:30	1.47	2.85	3.86	23.3	21.5	0	0	0	24.4
2007-6-30	10:56:0	1.47	2.89	3.84	23.3	21.5	0	0	0	24.4
2007-6-30	10:56:30	1.47	2.81	3.87	23.3	21.5	0	0	0	24.4
2007-6-30	10:57:0	1.47	2.86	3.87	23.3	21.5	0	0	0	24.4
2007-6-30	10:57:30	1.47	2.82	3.85	23.3	21.5	0	0	0	24.4
2007-6-30	10:58:0	1.48	2.82	3.88	23.3	21.5	0	0	0	24.4
2007-6-30	10:58:30	1.48	2.82	3.86	23.3	21.5	0	0	0	24.4
2007-6-30	10:59:0	1.48	2.83	3.86	23.3	21.5	0	0	0	24.5

The data in Table 5 refer to the situation when M (moisture) is selected, while the data in Table 6 refer to the situation when Eps (dielectric permittivity) is selected in the CHANNEL CONFIGURATION setting (Fig. 18 and Fig. 19).

## FOM/mts – HANDHELD METER

FOM/mts (Fig. 21) is a TDR (Time-Domain Reflectometry) based, handheld, portable, battery operated, microprocessor-controlled device designed for *in situ* field measurements of soil moisture, temperature and salinity (bulk electrical conductivity) from the same probe.



Fig. 21. FOM/mts – handheld field operated meter for the determination of moisture, temperature and salinity of soils

It is designated for periodic measurements at random and/or fixed locations where moisture, salinity and temperature distribution is to be determined by readings taken at various levels of the soil profile. It utilizes the FP/mts-type probe. FOM/mts is equipped with a 160 by 128 dot matrix graphic LCD to display data and TDR trace simultaneously. The TDR trace is a voltage-versus-time record of the voltage pulse round-trip along the probe. It is helpful to check the probe status during (break, short) and after its installation (excessive attenuation of the pulse). FOM/mts provides readout of volumetric water content according to the empirical calibration of Malicki (*Malicki et al., Eur. J. Soil Sci., 64, 1996*) or the readout of the apparent dielectric constant of the measured soil for the application of user calibration. Also FOM/mts is equipped with the USB serial port for connection with PC compatible computer to data transmission.

#### **Features of FOM/mts handheld devices**

- light handheld enclosure,
- ability to register and store up to 1000 labelled readings,
- internal temperature sensor and real time clock,
- operates with probes with different cable lengths (from 1.5 to 9.5 m),
- keyboard and LCD display (160x128 dots) with user friendly operating software,
- optionally equipped with GPS module for geographical localization,
- connection by USB interface with PC compatible computer for data transfer,



- lithium-polymer rechargeable battery supply (without memory effect enabling charging at any time), 3.6 V, 1500 mAh,
- pulse:  $\sin^2$ -like needle pulse having 200 ps rise-time,
- range of readings:
  - volumetric moisture:  $0 \div 100 \%$ ,
  - temperature:  $-20 \div +50^\circ\text{C}$ ,
  - electrical conductivity:  $0.000 \div 1 \text{ S/m}$ ,
- accuracy:
  - moisture absolute error: displayed water content  $\pm 2 \%$ ,
  - temperature absolute error:  $\pm 0.5^\circ\text{C}$  or less if read from individually calibrated probe,
  - el. conductivity relative error:  $\pm 10 \%$  for  $0 \div 1 \text{ S/m}$  or less if read from individually calibrated probe,
- resolution of readings:
  - volumetric moisture:  $0.1 \%$ ,
  - temperature:  $0.1^\circ\text{C}$ ,
  - el. conductivity:  $0.001 \text{ Sm}^{-1}$ ,
- time of test: less than 5 s,
- ambient temperature of work:  $0 \div +50^\circ\text{C}$ ,
- dimensions: 180 x 85 x 58 mm,
- weight: 0.35 kg with battery,
- battery charger: automatic, overcharge-safe, wall charger.

## Maintenance

The meter is not user serviceable. No special maintenance means are required. If the apparatus is to be stored, recharge the battery each three - four months.

Temperature of storage:  $-10 \div +50^\circ\text{C}$ .

## FOM/mts operation

### *External connections*

There are three external connections to the FOM/mts device, which are easy to recognize by the user. At the top there is a SMA coaxial jack for connecting FP/mts probe. At the bottom there are two connectors: USB socket for cable connection of the device to the PC computer and battery charging socket for connection of the supplied battery charger (ZI 10W, Output: 6VDC/500mA).

### *Battery supply and battery charging*

Battery compartment contains Lithium-Polymer rechargeable 3.6V battery of 1.5 Ah capacity. It can be easily detached from the device enclosure for replacement. The fully charged battery can perform about 1000 measurements that can be stored in the internal memory of the device. In case of dead battery it is strongly recommended to order a new battery compartment in the FOM/mts producer or distributor.

Charging of the device battery is automatic, i.e. the battery charging terminates automatically and the charging current is adjusted to the battery charging state, and the charging period does not usually exceed 3 hours. The

user is recommended to observe the of the battery state icon on the right top side of the LCD display (Fig. 22).

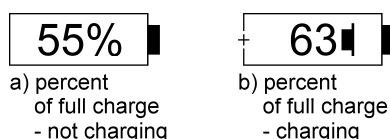


Fig. 22. Information icons on the LCD display about the state of battery in the work mode - (a) and in the charging mode - (b)

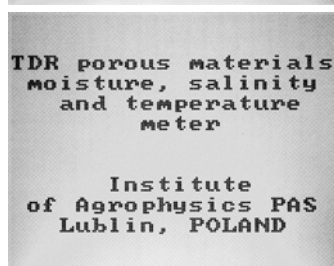
### Manual operation

The operation of the FOM/mts handheld meter working in manual mode will be presented below in Table 7. In this mode the user controls the device by means of a simple keyboard (Fig. 21), having four arrows and OK pushbuttons as well as the LCD display showing text information and commands available at the moment.

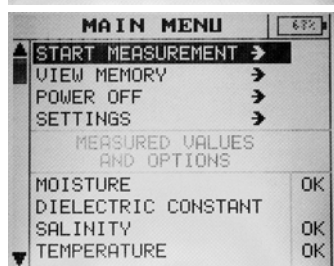
Table 7. Information and commands in the LCD window of the device



Pushing the OK button invokes this screen. To turn the device on – follow the command. The device will turn off automatically and the screen disappear if you will not follow the command for about 20 seconds.



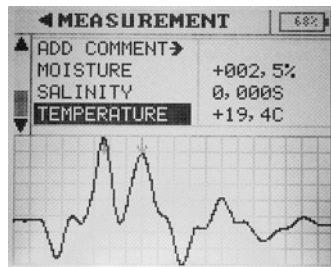
This screen appears after holding the OK button for about 3 seconds. It contains the names of the device and the producer. After about 5 seconds the display changes to show the Main Menu (see below).



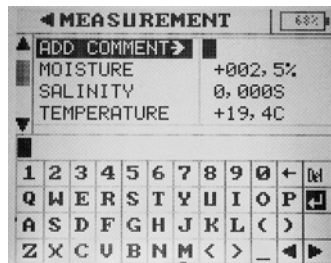
In the upper part of the Main Menu window the user can: Start Measurement, View Memory – examine the stored data, Power Off the device and adjust Settings.



In the lower part the user can choose the measured and displayed value: either soil moisture (in volume %) or dielectric constant, salinity (i.e. soil electrical conductivity in S/m) and temperature. OK sign in the line with the variable means that it will be measured and displayed. Optionally it is possible to add comment to each of the measured value. FOM/mts devices can be equipped with GPS modules (not active option).



Pressing Start Measurement pushbutton in the Main Menu initiates the display of the Measurement window and running measurement of selected values. The measurement results are displayed together with the reflectogram. Distinct peaks marked with arrows confirm the user that the TDR soil moisture determination is valid.



From the Measurement window the user can select Add Comment and from the lower part of the window he can select up to 25 characters associated with the performed measurement for storage in the device memory. This memory may be imported to the PC computer using “ET USB Communicator” program.

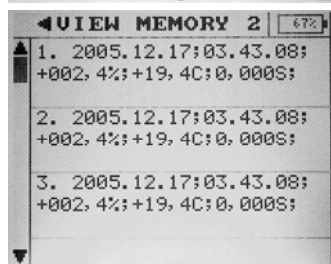


The user selects the characters using the keyboard arrows and OK pushbutton. The comment should be accepted pressing ↵ sign. Then Store command from the Measurement window sends the data with the comment to the memory.

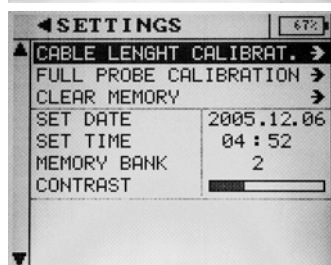


Store Complete information in the LCD display confirms that the data are successfully placed in the selected memory bank.

The selection of the current memory bank is done in the Settings window



The contents of the device internal memory can be inspected by pressing View Memory command in the Main Menu. The stored data records contains the following fields separated by semicolon: date and time of measurement, volume percent of moisture, temperature end electrical conductivity of the soil.



The window Settings enable to perform Cable Length Calibration, Full Probe Calibration, Clear Memory banks, Set Date, Set Time, select current Memory Bank (three banks are available, each for about 300 data records) and the Contrast of the LCD display.



The device can use FP/mts probes with cable length from 1.5 to 9 m. When changing a probe the user should perform Cable Length Calibration to determine in time the scanning window of the TDR sensor reflectogram. The displayed value in meters is approximate.

To increase accuracy of the TDR moisture measurement the user is advised to perform Full Probe Calibration to store the individual parameters of the applied FOM/mts probe in the device internal memory.

Selection of Full Probe Calibration is followed by the information "Leave probe in air".

As soon as the measurement is done in air the new information window appears to "Insert probe into deionized water...". Water temperature significantly influences the calibration, therefore the probe temperature sensor should have enough time to equilibrate its temperature with water.

During calibration in water the user should keep the needles of the TDR sensor fully inserted in water and not less than 2 cm away from the walls of the water container.

After the user confirmation to apply new calibration, the data from "Full probe calibration" procedure will be accounted for in further calculations of soil water content.

## FP/m, FP/mts - FIELD PROBE FOR MOISTURE, TEMPERATURE AND SALINITY OF SOIL

FP (Fig. 23) is a Time-Domain Reflectometry (TDR) probe for momentary or semi-permanent installation. Thin-wall PVC body of the probe provides ultimate low heat conductivity, thus allowing avoiding the parasite "thermal bridge" effects on distribution of soil moisture in the probe's sensor vicinity. Through a preaugered pilot hole it can reach any depth without destroying either the soil structure or disturbing the heat and mass transport in the soil. For semipermanent installation the probe can be inserted horizontally through a sidewall of a soil pit or slantwise, from the soil surface. The probe installed once may be left intact in the soil for as long as necessary, then drawn out at the end of the experiment.

FP/m is a probe for *in situ* field measurement of the soil moisture whereas FP/mts is its version for simultaneous measurement of moisture, temperature and salinity (electrical conductivity) of the soil from the same sampling volume.

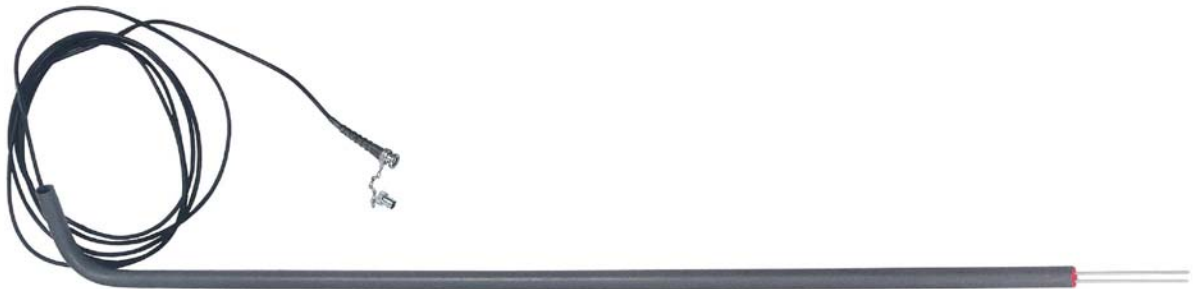


Fig. 23. FP/m, FP/mts - field probe for moisture, temperature and salinity of soil

Both probes are suitable for periodic measurements at random and/or fixed locations, where instantaneous profiles of water content, temperature and salinity are to be determined by readings taken at various levels of the soil profile (Fig. 24). Each of them may also be applied as a mobile probe for momentary measurements in surface layer of the soil, by walking over the field and inserting the probe in the soil surface layer at chosen sites.

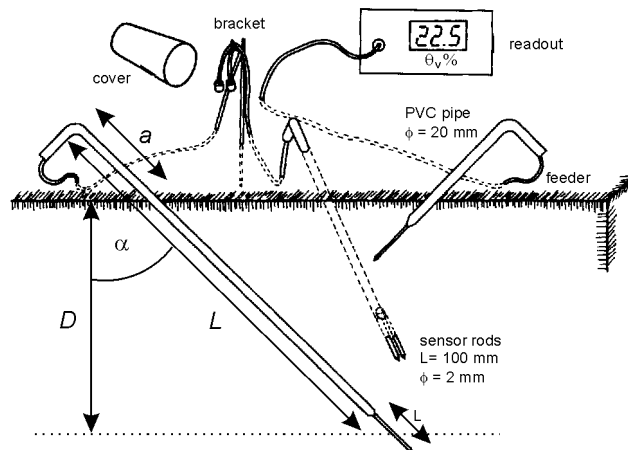


Fig. 24. The principle of installation of the FP-type probes. In order to minimize disturbances in the soil structure the probes are inserted into the soil via pilot holes, circularly distributed over the soil surface. The holes run slantwise and converge along a chosen vertical line. The cables are buried below the soil surface to protect them against the UV sun radiation as well as against rodents.

Features of FP/mts probes:

- sensor: a section of a transmission line made of two, 100 mm long parallel stainless steel rods having 2 mm diameter and separated by 16 mm,
- sensor support: a section of a PVC tube having 2 cm outer diameter and optional length (15 cm - 150 cm or longer) dependent on the intended depth of the sensor installation,
- cable length: from 1.5 to 9 m from the sensor to the terminating connector,
- region of influence (Fig. 25): a cylinder having approximated diameter of 5 cm and height of 11 cm, circumferenced around the sensor rods.

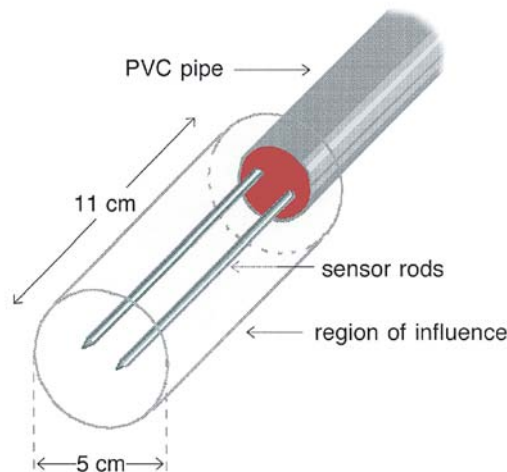


Fig. 25. A draft illustrating the approximate region of influence of the FP probe, defined as a solid beyond of that changes in water content do not markedly affect readings of moisture

### LP/ms - LABORATORY MINIPROBE FOR SOIL MOISTURE AND SALINITY

LP/ms - a laboratory miniprobe (Fig. 26) designed for monitoring changes in water and salt distribution in soil columns or in soil cores sampled with standard sampling equipment.



Fig. 26. LP/ms - Laboratory miniProbe for soil moisture and salinity

Several LP/ms can be inserted through the sidewall of a soil column or a steel sampling cylinder (Fig. 27), thus allowing for vertical scanning of the instantaneous moisture and electrical conductivity profiles. Such an array, when combined with similarly installed minitensiometers (LP/p), makes it possible to collect a set of corresponding water content and matrix pressure gradient data from drying or wetting front transition. From this one can obtain a complete set of the soil unsaturated water flow characteristics, i.e. water retention (PF-curve), water conductivity (k-function), and differential water capacity and unsaturated water diffusivity.

Features of LP/ms probes:

- installation hole: metric thread diameter of 8mm, height of 3.3 mm,
- sensor: a section of a transmission line made of two, 53 mm long parallel stainless steel rods diameter of 0.8, separated by 5 mm,
- cable length: 2 m from the sensor to the terminating connector (or multiplexer),
- sphere of influence: a cylinder having diameter of about 5 mm and height of about 60 mm, circumferenced around the sensor rods.

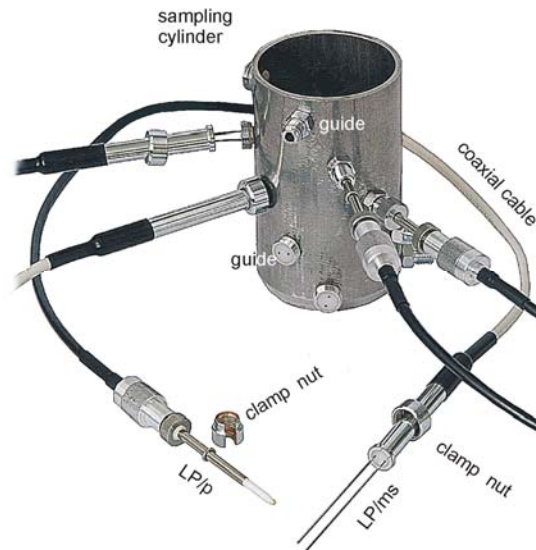


Fig. 27. A set of LP/ms and LP/p LOM controlled miniprobes inserted through a 2.75 mm thick wall of a sampling steel cylinder, having height of 100 mm and 55 mm inner diameter. The wall of the cylinder is provided with tapped holes equally distributed along the cylinder height in order to monitor independent layers of the soil. The holes are aligned spirally to minimize mutual shadowing in the vertical

## LP/t - LABORATORY PROBE FOR SOIL TEMPERATURE

LP/t is a laboratory probe (Fig. 28) for monitoring instantaneous profiles of soil temperature in soil columns or in undisturbed soil cores. Thin-wall half-rigid polyethylene body of the probe provides ultimate low heat conductivity, thus allowing avoiding the parasite “thermal bridge” effects. Several LP/t probes can be inserted through the wall of the soil column or the sampling cylinder, thus allowing for vertical recording of the instantaneous profiles of temperature. Such an array, when combined with miniprobes for soil moisture/salinity and also probes for matrix pressure (see LP/ms and LP/p flyers), makes it possible to collect a set of corresponding temperature data from non-isothermal transition of drying or wetting front, from which readings of bulk electric conductivity as well as matrix pressure can be temperature corrected. Also heat transport coefficients (thermal conductivity, thermal diffusivity, specific heat) can be determined if a heat flux meter (not provided by Easy Test) is installed in the column under investigation.

The wall of the cylinder containing a soil core is provided with tapped holes (8 mm diameter). A guide is screwed into the hole prior to the probe installation. This guide helps to avoid air gap around the probe, which otherwise might result while installing. LP/t is pushed into the soil core and fixed with a screwed gland.

Features of LP/t probes:

- sensor: a temperature dependent current source,
- range: temperature between  $-20^{\circ}\text{C}$  and  $+60^{\circ}\text{C}$ ,
- resolution:  $0.01^{\circ}\text{C}$ ,
- absolute error: not more than  $\pm 1^{\circ}\text{C}$  or  $\pm 0.1^{\circ}\text{C}$  if individually calibrated,
- cable length: 2 m or other length when requested,
- installation hole: 8 mm diameter tapped with 8/1.5 mm thread.



Fig. 28. LP/t - laboratory probe for soil temperature

### LP/p - LABORATORY MINIPROBE FOR SOIL WATER CAPILLARY PRESSURE

LP/p (Fig. 29) is a laboratory miniprobe designed for monitoring instantaneous profiles of soil water capillary pressure (matrix pressure, suction force) in soil columns or in undisturbed soil cores sampled with standard sampling equipment.



Fig. 29. LP/p - laboratory miniprobe for soil water capillary pressure

The wall of a cylinder containing the soil core is provided with tapped holes (8 mm diameter). A guide is screwed into the hole prior to the probe installation. This guide helps to avoid air gaps between the ceramic suction cup and the soil, which otherwise might result while inserting the probe into the soil.

LP/p is pushed into the soil core and fixed with a clamp nut. Several LP/p can be inserted through the wall of a soil column or a steel sampling cylinder, thus allowing for vertical scanning of the instantaneous water pressure profiles (see below). Such an array, when combined with similarly installed miniprobes for soil moisture (see the LP/ms flyer), makes it possible to collect a set of corresponding water content and matrix pressure data from drying or wetting front transition.



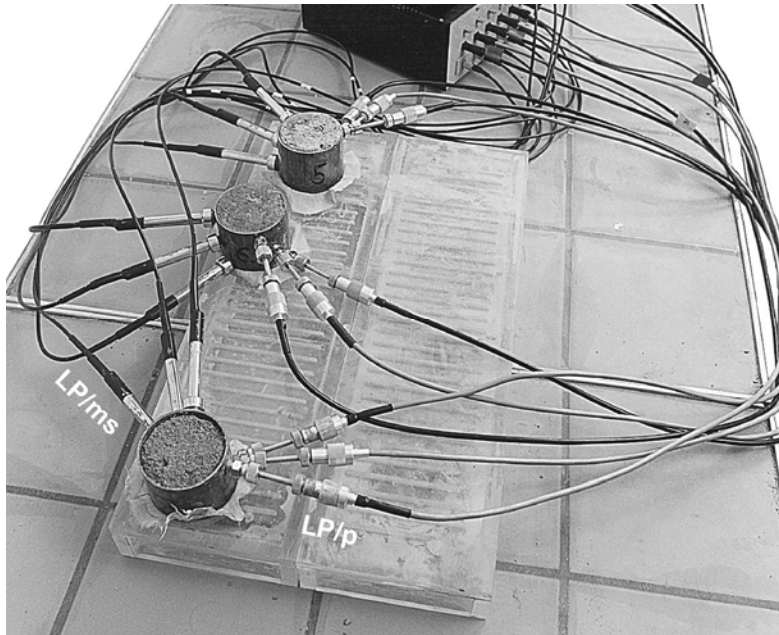


Fig. 30. Reading instantaneous profiles of soil water capillary pressure, moisture and salinity from arrays of the LP/p and LP/ms miniprobess

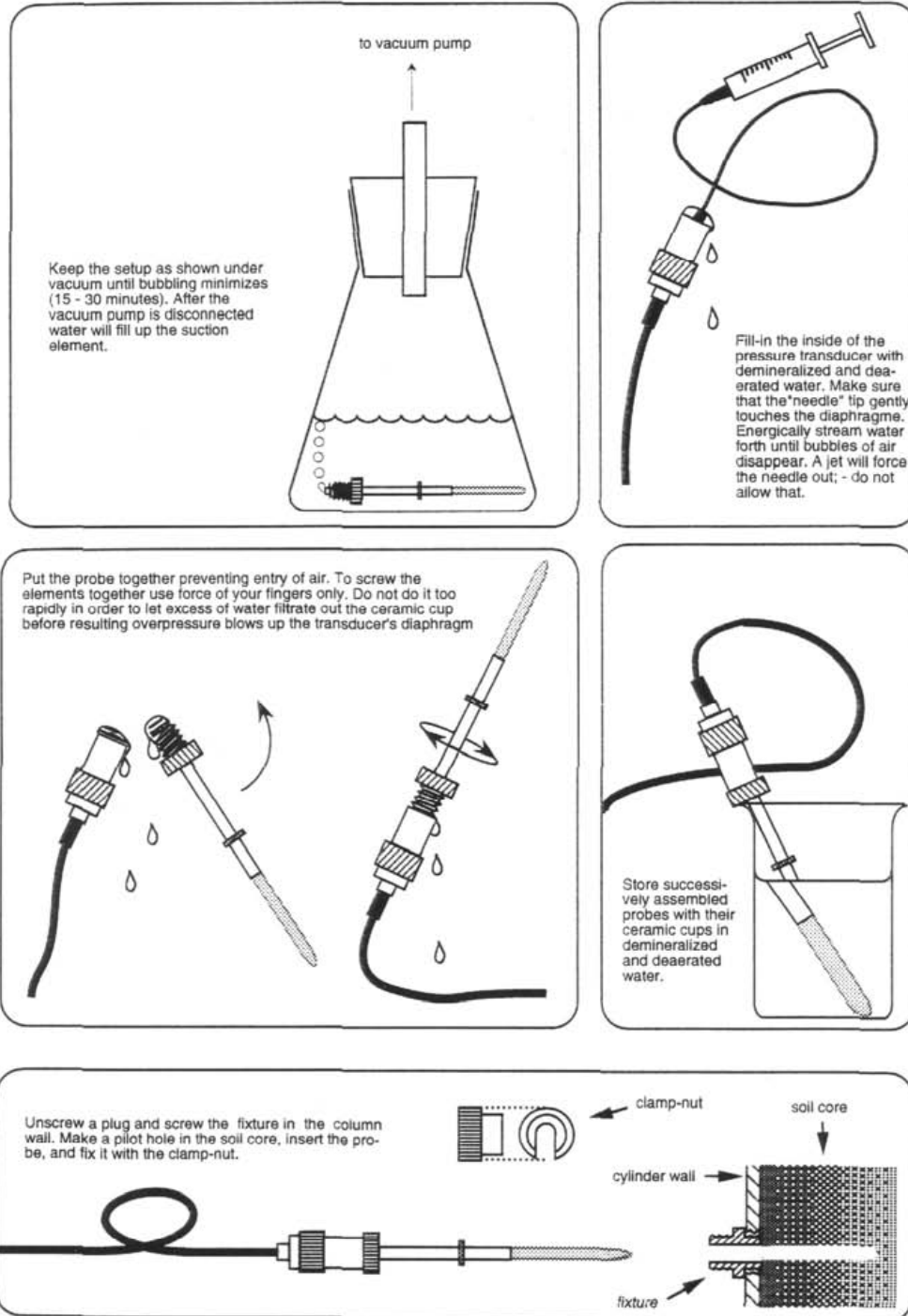
From the collected data set, after further processing, one can obtain a complete set of the unsaturated water flow characteristics of the soil, that is: water retention (pF-curve), unsaturated water conductivity (k-function), differential water capacity and unsaturated water diffusivity.

Features of LP/p probes:

- Sensor:
  - pressure diaphragm: a 15 mm long ceramic cup, 3 mm in diameter,
  - pressure transducer: an integrated, fully active Wheatstone bridge with four piezoresistive strain gauge resistors diffused into a silicon diaphragm,
  - air entry pressure: about 900 mbar,
- offset drift:  $\pm 20$  mbar/month,
- relative error:  $\pm 15$  %,
- resolution: 1 mbar,
- delay: 0 to 800 mbar in about 120 s, 800 to 0 mbar in about 3 s,
- cable length: 2 m,
- installation hole: 8 mm diameter,
- tapped with 8x1 mm thread.

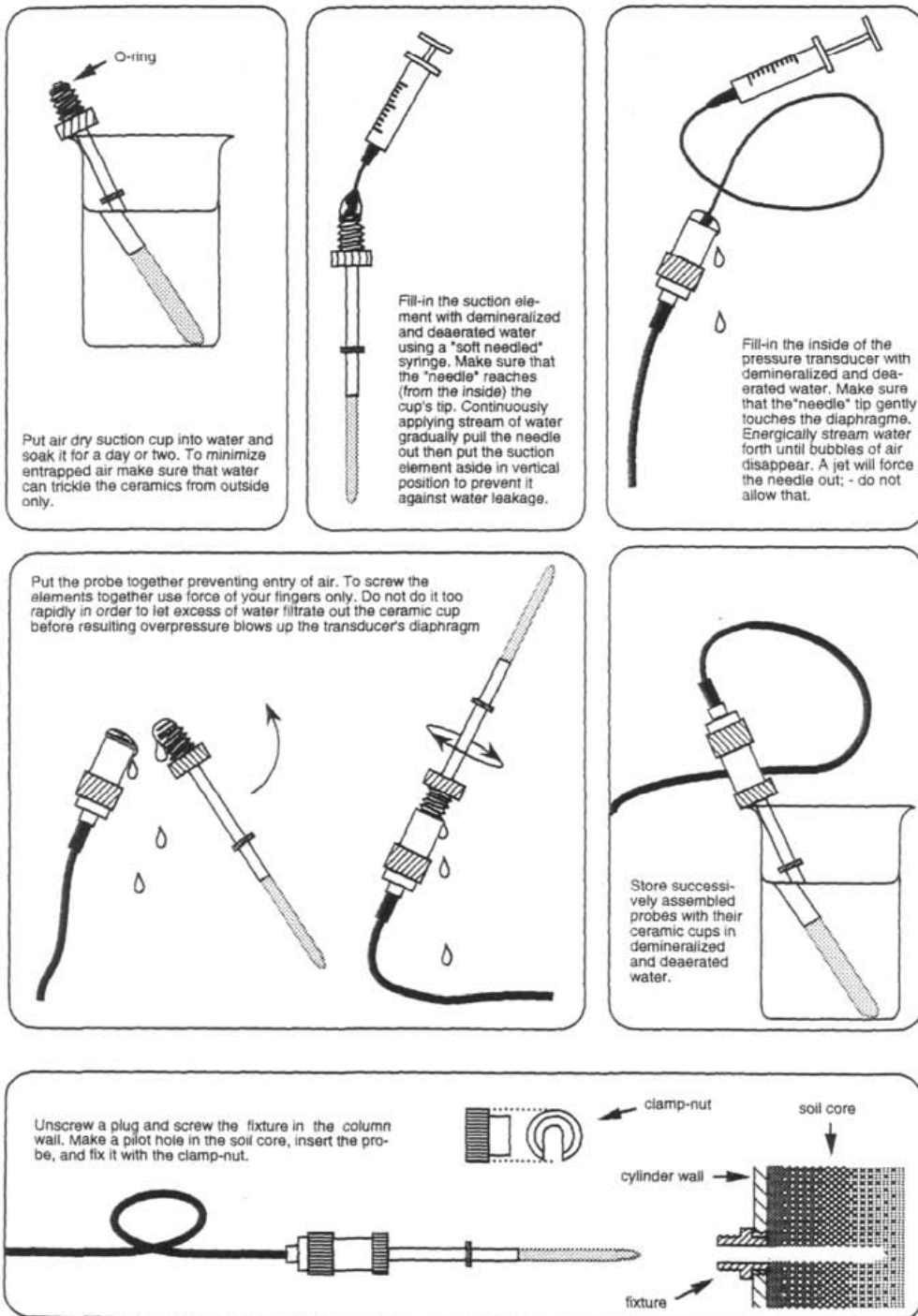
## APPENDIX 1. WATERING OF LP/P PROBES

### Watering LP/p under vacuum



Preparing the LP/p to work. The goal is to obtain the minitensjometer's void filled with demineralized, de-aerated water. To store a ready to work probe keep its capillary-porous cup submerged in water. Be aware that the cable side of the transducer encapsulation is not watertight.

## Watering LP/p under ambient pressure



Preparing the LP/p to work. The goal is to obtain the minitensjometer's void filled with demineralized, deaerated water. To store a ready to work probe keep its capillary-porous cup submerged in water. Be aware that the cable side of the transducer encapsulation is not watertight.

## **APPENDIX 2.**

The program “easy\_test.exe” in the supplied CD-ROM solves temporarily the problem with the bug that resulted in importing by “ET USB Communicator” only 112 records from each of the internal memory banks of FOM/mts meters.

In future version of the “ET USB Communicator” the bug will be eliminated.



## Introduction to MIDL-2 GPRS data logger

MIDL-2 is a data logger for data collected from TDR/MUX/mpts [1] meters of soil moisture (by TDR method), water potential, temperature and electrical conductivity (salinity), developed and manufactured in the Institute of Agrophysics, Polish Academy of Sciences. MIDL-2 is the modification of MIDL data logger [2] by introduction of GPRS communication and reduction of the old data logger complexity in respect of internal hardware and software as well as the way of operation.

The configuration of the MIDL-2 data logger is done by means of the *ET USB Configurator* application program, provided free of charge by the producer of MIDL-2.

Management of measurements and data transmission between MIDL-2 data logger and the Internet server, where user data are stored, is done by means of an Internet browser (ex. Internet Explorer or Mozilla Firefox).

The manual gives basic information about the functions of the data logging system, its configuration and operation. More details can be found on the WEB site of the Institute of Agrophysics PAS, in the part assigned to the commercial activities under the name of Easy Test; <http://easytest.ipan.lublin.pl>.

## Functional description

The functional scheme of the measurement system with MIDL-2 data logger is given in Fig. 1. It consists of up to 16 TDR/MUX/mts meters connected in chain with the data logger. The data collected in the internal memory of MIDL-2 are transmitted using FTP data transmission protocol in defined time schedule by GPRS modem to the Internet server. GPRS (General Packet Radio Services) is a mobile data service available to users of GSM mobile phones. GPRS data are billed per kilobytes of information transmitted.

The data collected by MIDL-2 data logger is user accessible by means of Internet browser (ex. Internet Explorer or Mozilla Firefox) after giving individual login and password. The user can also change remotely the configuration of the conducted experiment.

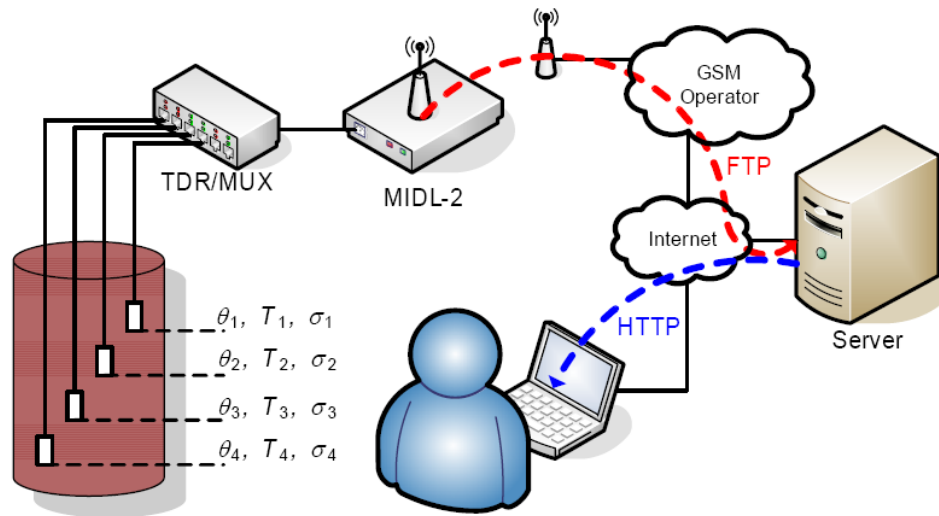


Fig. 1. Example measurement setup with one 8-channel TDR/MUX/mts meter and MIDL-2 data logger ( $\theta$ ,  $T$ ,  $\sigma$  stand for soil volumetric water content, temperature and electrical conductivity, respectively)

The design assumption of the presented measurement-communication system is to minimize its management and power consumption. This is accomplished by remote communication between the system and selection of specialized hardware and software design providing energy efficiency that enables battery supply for the period of several months depending on the planned frequencies of measurement and GPRS modem communication schedule. Additionally, there is also the possibility to charge the supply battery from a solar panel.

The measurement system from Fig. 1 can operate in two modes:

- controlled from PC computer by *ET USB Configurator* program,
- controlled from MIDL-2 data logger configuration downloaded from the Internet server using GPRS communication.

Operation of the measurement system under control of *ET USB Configurator* program is presented in [1]. The description below concerns the autonomous operation controlled by the MIDL-2 data logger. However initial configuration of the system requires connection to PC compatible computer and running the *ET USB Configurator* program.

The following actions are performed during wireless connection with the Internet server:

1. MIDL-2 updates the current measurement configuration stored in its internal memory (measurement frequency, channel numbers and variables to measure, time schedule of GPRS connections).

2. All data stored in MIDL-2 is exported to the Internet server. After confirmation of successful data storage in the server, this data is deleted from the MIDL-2 internal memory to make room for new data. If the data storage is not confirmed, the data will be transmitted again during the next GPRS connections.

## Front panel

Front panel view of the MIDL-2 data logger is presented in Fig. 2. It contains:

- GPRS – SMA female type connector for connecting antenna directly or by means of 50-ohm coaxial cable,
- USB – to connect PC compatible computer for testing and configuration of the data logger (Fig. 4).

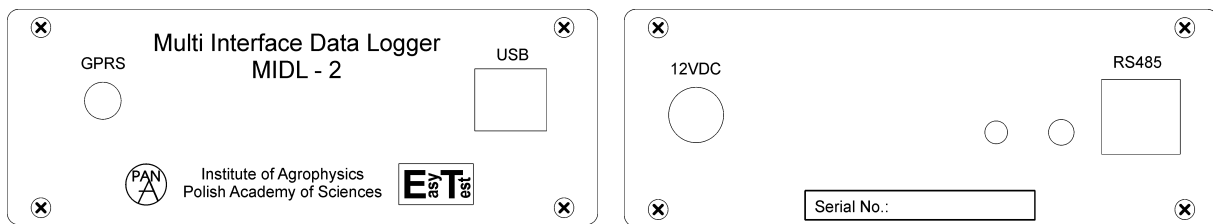


Fig. 2. Front (left) and rear (right) panels view of the MIDL-2 data logger

## Rear panel

Rear panel view of the MIDL-2 data logger is presented in Fig. 2. It contains:

- 12VDC – socket for connecting power supply (12VDC),
- RS485 – RJ45 socket for connecting in chain measurement devices [1]
- LED – diode that is on when the MIDL-2 data logger is working (communicates with TDR/MUX/mps devices, performs GPRS connection with the Internet server),
- Pushbutton – presently not used.

## Initial configuration of MIDL-2 data logger

### SIM card installation

Before starting initial configuration of MIDL-2 data logger the user should install the SIM card.



Fig. 3. SIM card location inside the MIDL-2 enclosure

### PC computer and MIDL-2 connection

Initial configuration of the MIDL-2 data logger requires its connection to PC compatible computer (Fig. 4) and running *ET USB Configurator* program.



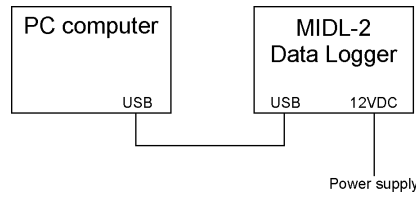


Fig. 4. Connecting the MIDL-2 data logger to PC computer

## Operation with Easy Test Configurator application

The supplied application program *easy\_test.exe* (*Easy Test Configurator*) allows the user to:

- Configure the internal GPRS modem to communicate with the internet ftp server located in IA PAS, Lublin, Poland,
- Receive information about the data loggers configuration (number of connected probes, addresses of the TDR/MUX devices, etc.)

The window of the *easy\_test.exe* program is presented in Fig. 5 and the description of the respective terms is presented below in Table 1.

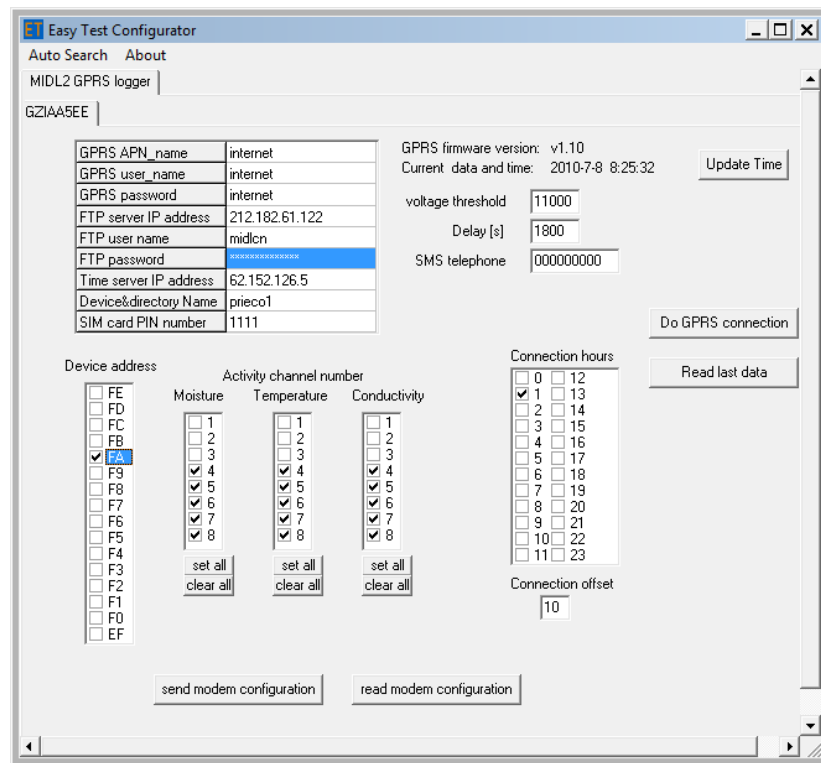


Fig. 5. Entry window of *Easy Test Configurator* program application for GPRS configuration and giving information about the MIDL-2 data logger and user files stored in the Internet server located in IA PAS, Lublin, Poland

Table 1. Parameters of GPRS connection

Parameter name	Comments
GPRS_APN name GPRS_user name GPRS password	Please consult with your GPRS provider to fill in these parameters

FTP server IP address	IP address of the ftp server located in IA PAS, Lublin, Poland. The user space for incoming data are allocated in this server. Access to the data is guarded by the user login and password.
FTP user name	Name of the user (provided by the admin of the ftp server from IA PAS)
FTP password	Password of the user (provided by the admin of the ftp server from IA PAS)
NTP time server IP address	For example: 198.123.30.132 (ntp-nasa.arc.nasa.gov) 204.152.184.72 (clock.isc.org) or other local server address
Directory&directory Name	Name of the user data directory in the internet server (provided free)
SIM card PIN number	User filled SIM card number. The user should buy a new SIM card, activate it and put its number here.
Voltage threshold (mV)	Accumulator voltage lower limit for sending SMS emergency information to the user (the accumulator needs charging)
Update Time	After pushing this button the MIDL-2 device updates date and time from the connected PC computer
Delay (s)	Period between the series of measurements from the selected TDR/MUX devices
SMS telephone	Number of the mobile that receives SMS emergency message about the low battery voltage of the accumulator (contact IA PAS for details)
Do GPRS connection	After pushing this button the MIDL-2 makes GPRS connection and sends the lastly collected data to the server using ftp protocol. It uses the data filled-in earlier by the user.
Send modem configuration	After pushing this button the MIDL-2 device stores the user configuration data in the device memory
Read modem configuration	MIDL-2 device loads the stored configuration data to the application program.

## Operation with Internet browser

Communication with MIDL-2 data logger for changing the measurement script file and importing measured data is done by means of the Internet server that can be installed by the user or Internet server working in IA PAN, Lublin, Poland. Individual installation of the server by a user may involve troubles therefore it is strongly recommended to use the existing Internet server.

The entry address to this server is <http://midl.ipan.lublin.pl:8080/midl2/>. The data stored on this server is accessible for the user after specific login and password filled in by the user in the entry window (Fig. 6).

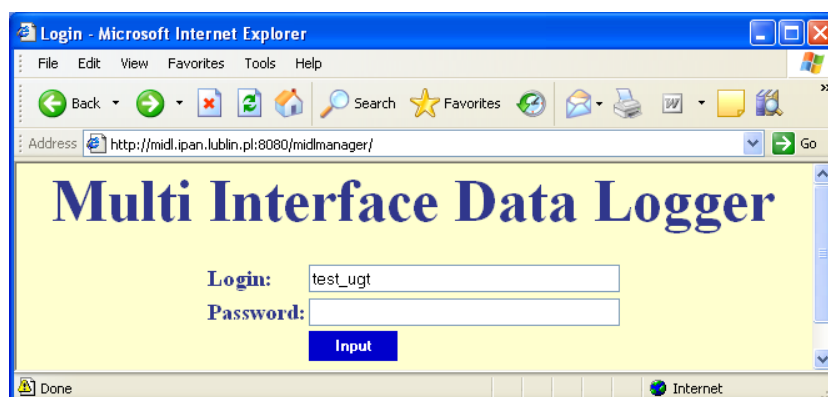


Fig. 6. Entry window for the management of MIDL-2 data logger and user files stored in the Internet server located in IA PAN, Lublin, Poland

After successful login a new window is displayed (Fig. 7). The user can select the following bookmarks: User data, Data, Help, Logout.

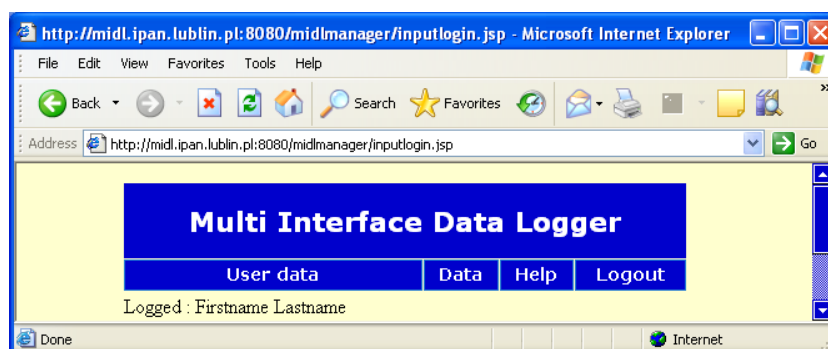


Fig. 7. Main window of the Internet browser application controlling MIDL-2 data logger

## User data bookmark

Selection of User data bookmark opens the window presented in Fig. 8.

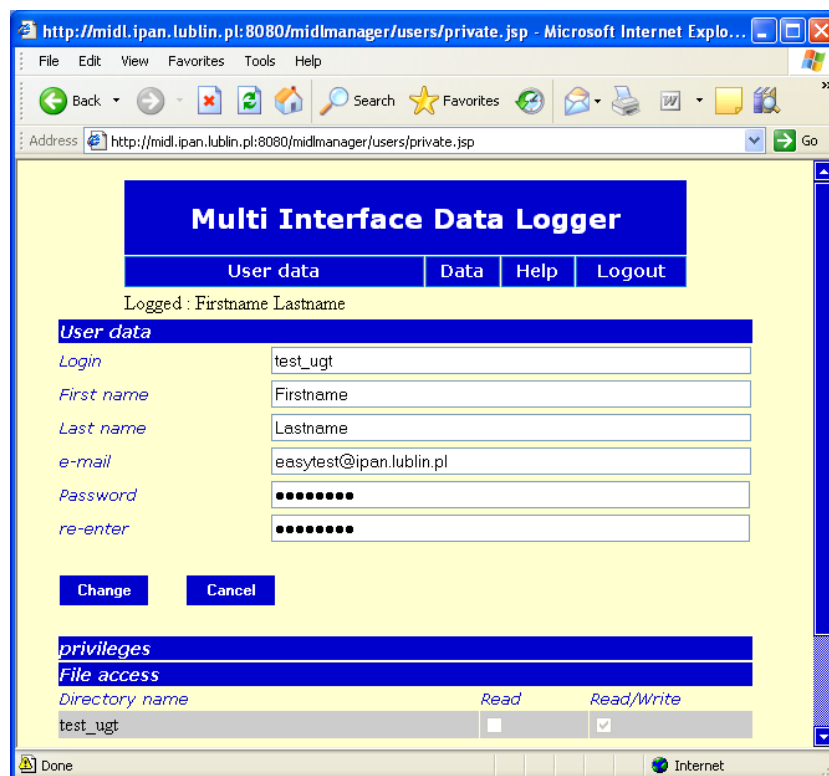


Fig. 8. User data window for setting up user data

The description of the elements in this window is given in the Table 2.

Table 2. Content of the User data window

Name	Description
Login	Unique name of the MIDL-2 data logger (in parenthesis). It must be the same as the name of the folder in the Internet server where the incoming data will be collected. Example: "test_ugt".
Firstname	First name of the user (optional)
Lastname	Last name of the user (optional)
e-mail	e-mail address of the user (optional)
Password	Password of the user

The data coming from the measurement devices by the specific MIDL-2 data logger may be accessible for many users having different privileges, i.e. read or read/write.

## Data bookmark

The window accessible for the user after pressing Data bookmark is presented in Fig. 9. The user can select directory with data he wants to access.

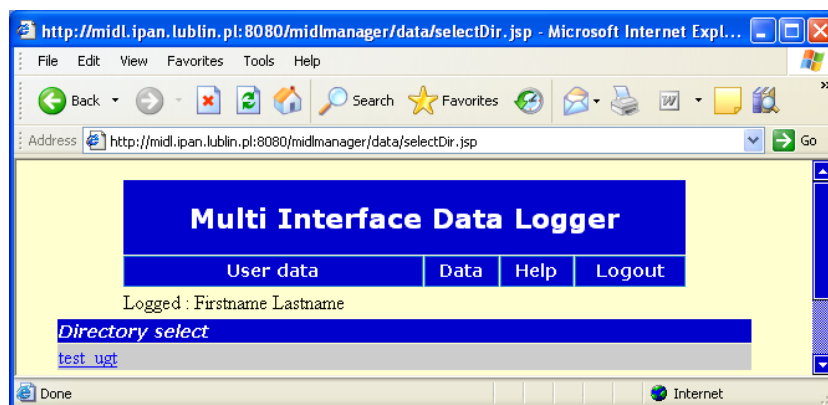


Fig. 9. Content of Data bookmark

After selection of the required directory the user can download or delete data from the remote MIDL-2 data logger using the window presented in Fig. 10.

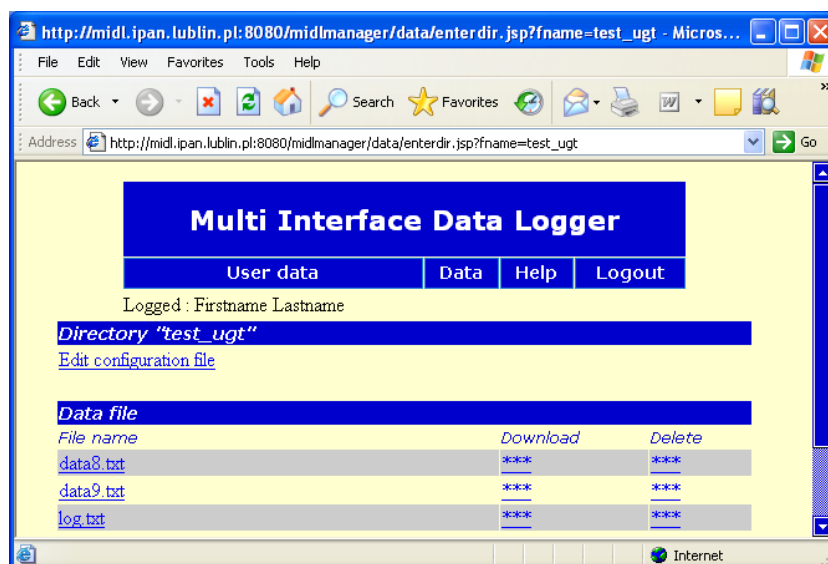


Fig. 10. User data management window

There are three files for selection:

- data8.txt and data9.txt that contain data values collected from the measurement devices according to the selected measurement configuration (measurement script file). Table 3 presents a part of the data8.txt file with the first eight values (after date and time), four values of soil temperature and eight values of conductivity measured every ten minutes. The measured probes and variables of selected probes are controlled by the user with the Activity channel number window (Fig. 12).

Table 3. Example data8.txt text file with measured data downloaded from the Internet server

```

100707013000 +013,3 +073,4 +012,0 +065,8 +020,9 +059,8 +016,8 +057,8 +18,6
+14,3 +19,2 +13,5 +18,1 +14,5 +18,2 +14,4 0,001 0,024 0,001 0,020 0,003 0,019
0,003 0,016
100707020000 +013,3 +073,1 +012,1 +066,5 +020,8 +060,0 +016,8 +058,5 +18,6
+14,4 +19,2 +13,5 +18,1 +14,5 +18,2 +14,4 0,001 0,024 0,001 0,020 0,003 0,019
0,003 0,016

```

- log.txt contains information for diagnosing the performance of the measurement and communication system. The example from Table 4 shows the content of this file with the highest system diagnostic level. +CSQ informs the user about the power of the GSM signal (it is recommended to change the position of the MIDL-2 data logger when this number is below 5). VCC is battery voltage in mV. The data are transmitted by the modem in raw format in the file 0611021301554MD.dat (061102 is the date in the format YYMMDD, 130155 is the time of transmission in the format HHMMSS).

Table 4. Example log.txt text file with diagnostic and performance data downloaded from the Internet server

```

ftp_time-100707020300
AT01,089
AT13,003
AT74,019
AT82,004
AT85,008
AT86,012
AT87,010
AT91,010 LCT:040 VCC:12959 +CSQ: 18,99 0010AD

```

## Measurements and GPRS communication time schedule

Probes measurement and GPRS communication schedules are defined by the user in Data bookmark after pressing Edit configuration file hyperlink, in the window presented in Fig. 11. The description of this window is presented in Table 5 and the following pages.

Table 5. Setting of measurement and GPRS transmission time schedule

Name	Description
<u>GPRS connection table</u>	Presents time in hours when the GPRS communication is initiated by MIDL-2. The hyperlink switches to the GPRS connection table editor (Fig. 13).
Application version	Version of the server software
Delay between measurements	Time in seconds between the beginnings of subsequent script file executions
Offset to first measurement	Time distance in seconds between the scheduled start of the script file execution and real execution (to avoid collision in time with GPRS connection)
System log level	Level of tracing the execution of the measurement script file and GPRS communication (higher level means more detailed tracing)

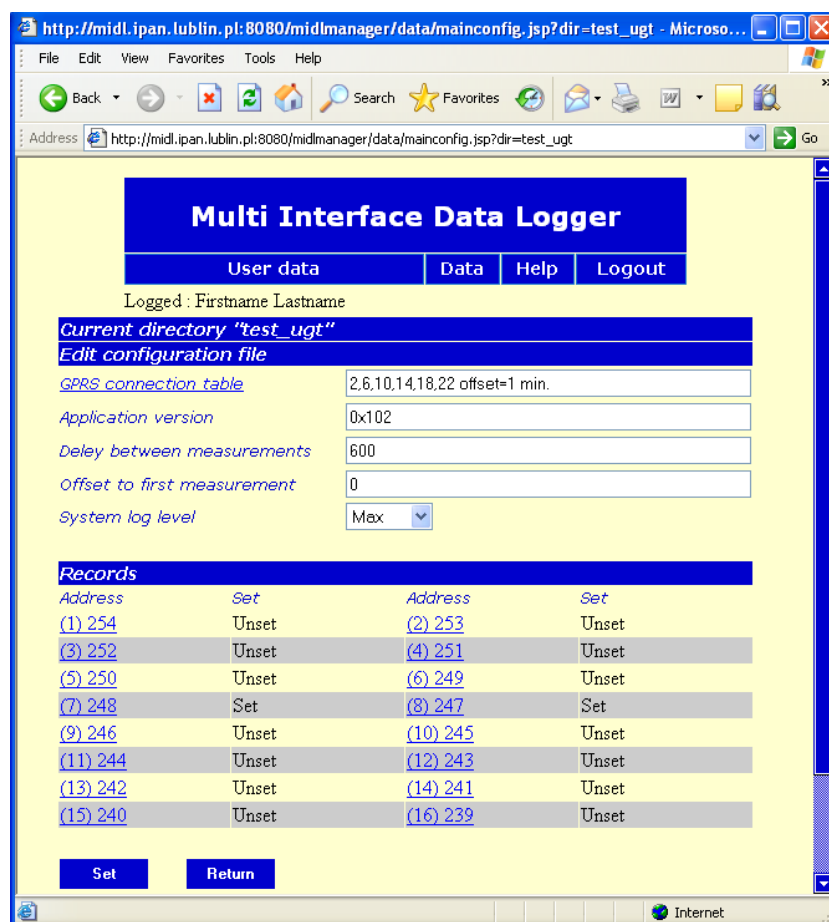


Fig. 11. Measurement and transmission time schedule window

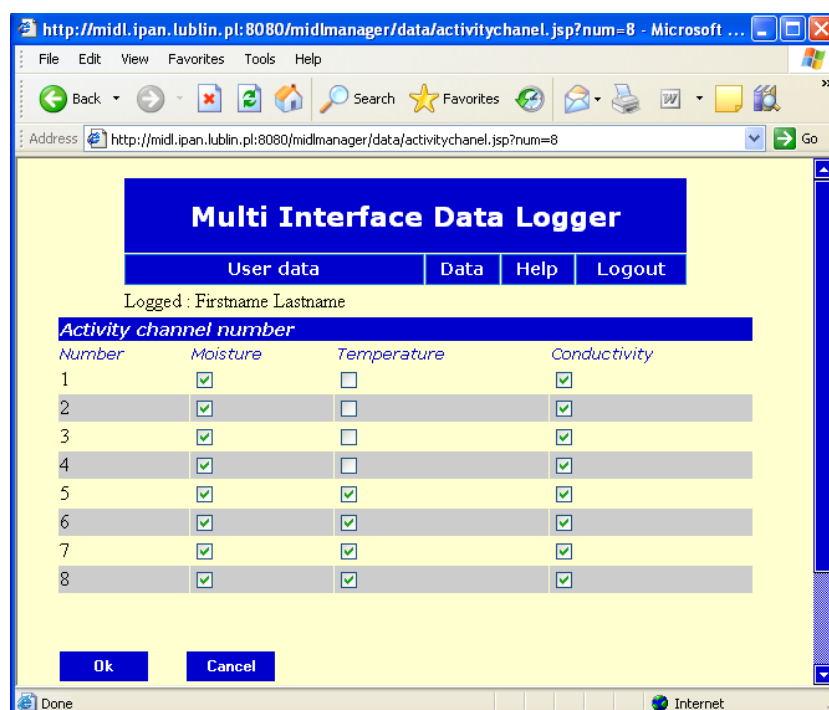


Fig. 12. Setting the activity of individual channels in selected TDR/MUX/mps device

The section Records in Fig. 11 enables to activate measurement channels in up to 16 TDR/MUX/mps devices connected to the MIDL-2 data logger. They are identified by addresses from 254 to 239, which corresponds to the last two characters in the serial numbers of TDR/MUX/mps devices, i.e. from ...FE to ... EF. The active devices are marked as Set, inactive as Unset. Pressing the hyperlink in the device number the user can select measurement channels in individual devices. The example Activity channel number is presented in Fig. 12.

In total number of 8 channels all are selected for measurements; channels from 1 to 4 measure two variables: moisture and electrical conductivity while channels from 5 to 8 measure three variables: moisture, electrical conductivity and also temperature. Modification of active channels should be confirmed by pressing OK pushbutton and then by pressing Set pushbutton in the Records field of the Edit configuration file window.

**Multi Interface Data Logger**

User data   Data   Help   Logout

Logged : Firstname Lastname

**Edit bitmask**

Hour	Set	Hour	Set
00.00	<input checked="" type="checkbox"/>	12.00	<input checked="" type="checkbox"/>
01.00	<input type="checkbox"/>	13.00	<input type="checkbox"/>
02.00	<input checked="" type="checkbox"/>	14.00	<input checked="" type="checkbox"/>
03.00	<input type="checkbox"/>	15.00	<input type="checkbox"/>
04.00	<input checked="" type="checkbox"/>	16.00	<input checked="" type="checkbox"/>
05.00	<input type="checkbox"/>	17.00	<input type="checkbox"/>
06.00	<input checked="" type="checkbox"/>	18.00	<input checked="" type="checkbox"/>
07.00	<input type="checkbox"/>	19.00	<input type="checkbox"/>
08.00	<input checked="" type="checkbox"/>	20.00	<input checked="" type="checkbox"/>
09.00	<input type="checkbox"/>	21.00	<input type="checkbox"/>
10.00	<input checked="" type="checkbox"/>	22.00	<input checked="" type="checkbox"/>
11.00	<input type="checkbox"/>	23.00	<input type="checkbox"/>

Offset (min.)

**Ok**   **Cancel**

Fig. 13. GPRS connection table editor window

The window for modification of GPRS connection time is presented in Fig. 13. The wireless connection cannot be initialized when the execution of the measurement script file takes place. In such an instant there will be no GPRS connection. Therefore the user should synchronize these two events. For this purpose the GPRS connections setting marked in Fig. 13 has an offset (in minutes) set by the user.

The increase of GPRS connection frequency will significantly increase power consumption of the remote measurement system, which is important in case of battery power supply. From the other hand frequent updating gives the user near real time information from the remote experiment.



## References

1. FOM/mts and TDR/MUX/mpts. Manual. Institute of Agrophysics PAS, Lublin, 2006.
2. MIDL: Data logger for field monitoring of soil and ground physical and chemical parameters. Operation Manual. Institute of Agrophysics PAS, Lublin, 2004.
3. Skierucha W., Wilczek A., Walczak R.T.: Recent software improvements in moisture (TDR method), matric pressure, electrical conductivity and temperature meters of porous media. *International Agrophysics*, 20, 189-193, 2006.