TPM-250 PORTABLE MODULAR MILLITESLAMETER

USER MANUAL

Contents

This Manual contains information on the design, operation and characteristics of the portable modular type milliteslameter TPM-250 as well as guidelines to ensure its trouble-free operation (intended use, maintenance, routine repairs, storage and transportation).

Under normal operating conditions, the milliteslameter meets GOST 22261 requirements for Tamb (20±5) ºC.

According to rated operating conditions and maximum transportation conditions, the milliteslameter is classified as Group 2 GOST 22261.

The milliteslameter has a remote control capability and can transfer data to an external computer via the USB interface.

1 DESCRIPTION AND OPERATION

1.1 Intended Use

1.1.1 The TPM-250 portable modular milliteslameter is manufactured in accordance with the TU 26.51.43-002-86487402-2017 requirements.

1.1.2 The TPM-250 milliteslameter is designed for measuring:

- three orthogonal components and the magnitude of the magnetic induction vector as well as DC magnetic field strength;
- amplitude, RMS and average-rectified values of the three orthogonal components of the magnetic induction vector. The AC mode ensures measuring magnetic field strength within 0.5 to 400 Hz frequency range.
- maximum amplitude, RMS and average-rectified values of the vector magnitude and the AC magnetic field strength within 0.5 to 400 Hz frequencies, particularly in two- and more-phase electrical installations (systems).

1.1.3 The TPM-250 milliteslameters can be used, in particular, for assessing the sanitary and epidemiological welfare of the population and to solve problems of special workplace assessment that requires measuring magnetic fields generated by magnetic systems and various-purpose electrical devices, power lines and other sources as well as those inside shielded objects

1.2 Technical Features

1.2.1 The milliteslameter performs measurements of:

- three orthogonal components and the magnitude of the magnetic induction vector and the DC magnetic field strength;
- amplitude, RMS (active) and average-rectified values of the three orthogonal components of the magnetic induction vector and the AC field strength within 0.5 to 200 Hz with Type 1 probe and 1 to 400 Hz with Type 2 probe.
- maximum amplitude, RMS and average-rectified values of the magnetic induction vector and the AC field strength, in particular, in two- and more-phase electrical installations (systems) with Type 1 probe (0.5 to 200 Hz) and with Type 2 probe (1 to 400 Hz)

1.2.2 The TPM-250 milliteslameter displays, at the operator's command, the results of measurements in units of magnetic induction or in units of magnetic field strength.

1.2.3 Measurement and calculation range requirements

1.2.3.1 The measurement and calculation range using Type 1 probe:

- B_x, B_y components ….……. 0.001 to 4 mT;

- H_x, H_y components …… 0.8 to 3200 A/m;
- B_z component…… ..…. 0.001 to 8 mT;
- H_z component ……..…… ... .. 0.8 to 6400 A/m;
- vector B magnitude (maximum value in AC measurement mode) … ……0.002 to 10 mT;
- field strength H magnitude (maximum value in AC measurement mode) ……. ……. . 1.6 to 8000 A/m.

Note - At magnetic induction values less than 0.01 mT (magnetic field strength less than 8 A/m), the error is not normalized.

1.2.3.2 Frequency ranges of measured magnetic fields, Type 1 probe:
- AC mode …….. 3 – 200 Hz;
- Low frequency AC mode …….. 0.5 – 20 Hz.

1.2.3.3 DC field measurement and calculation range using Type 2 probe:
- B_x, B_y, B_z components …….…… … 0.01 to 150 mT;
- H_x, H_y, H_z components... ... ……8 A/m to 120 kA/m;
- vector B magnitude. …… ... ……..…….0.02 to 260 mT;
- field strength H magnitude... ... ... …... .... …..16 A/m to 208 kA/m.

Note - At magnetic induction values less than 0.1 mT (magnetic field strength less than 80 A/m), the error is not normalized.

1.2.3.4 AC field measurement and calculation range using Type 2 probe:

- B_x, B_y, B_z components …… 0.5 to 150 mT;
- H_x, H_y, H_z components ….. ..... 400 A/m to 120 kA/m;
- max value of vector B …… .. ……..…….. 0.9 to 260 mT;
- max value of field strength H ……..…… ...720 A/m to 208 kA/m.

1.2.3.5 Frequency ranges of measured magnetic fields, Type 2 probe:
- AC mode …….. 6 – 400 Hz;
- Low frequency AC mode ……..…….. 1 – 50 Hz.

1.2.3.6 The TPM-250 milliteslameter has a special measurement mode for AC magnetic field with a frequency of (50±1) Hz implemented for both probes.

Notes to 1.2.3

1 The B_x component is measured along the longitudinal axis of the probe, the B_y component - perpendicular to the longitudinal axis of the probe in its plane, and the B_z component - perpendicular to the plane of the probe (see Figure 1.1). The same applies to the H_x, H_y, H_z components of the magnetic field strength

2 The instrument measures the amplitude values of the magnetic induction (magnetic field strength) of the AC sinusoidal magnetic field (the first harmonic of the AC field of irregular shape), with the upper measurement limits referring to these values. The displayed (calculated) RMS and average-rectified values are simply the result of multiplying the amplitude values by 0.7071 and 0.6366 coefficients, respectively (which is true only for sinusoidal fields)

1.2.4 The limits of a permissible relative error, δ0,%, in measuring the magnitude of vector B (field strength H) should not exceed the values calculated by formulas (1.1) and (1.2) for Type 1 and Type 2 probes, respectively:

$$\delta_0 = \pm [3{,}0 + 0{,}03 \cdot (A_п/A_и - 1)]; \quad (1.1)$$

$$\delta_0 = \pm [2{,}0 + 0{,}01 \cdot (A_п/A_и - 1)]. \quad (1.2)$$

where,

- $A_и$ – measured value of vector B magnitude, mT (field strength H, A/m);

- $A_п$ – the upper measurement limit for vector B (field strength H) magnitude is 10 mT (8000 A/m) in formula (1.1) and 260 mT (208000 A/m or 2080 A/cm) in formula (1.2).

Notes to 1.2.4.

1 The manufacturer normalizes measurement errors for only the vector B (field strength H) magnitude since the deflection angles of the magnetically sensitive axes of the Hall elements against the orthogonal axes X, Y, Z of the probes are not normalized.

2 When measuring AC magnetic fields, expressions (1.1), (1.2) refer to their amplitude values.

1.2.5 The milliteslameter can measure the frequency of a measured AC magnetic field, f, with absolute error limits Δf, Hz:

$$\Delta_f = \pm (0{,}001 \cdot f + 0{,}1)\text{Hz} \qquad (1.3)$$

1.2.6 The milliteslameter is powered by a built-in battery with a rated voltage of 3.7 V

1.2.7 The warm-up time..... ... ... …….. ... ... 5 min or less.

1.2.8 Continuous operation with a fully charged battery ……. ……12 hr or more

1.2.9 The milliteslameter has the remote control capability and can transfer data to an external computer via the USB interface using the Module-1 software stored on a CD included in the delivery set.

1.2.10 The time after which the milliteslameter turns off automatically is 10 minutes if there is no operator's intervention.

1.2.11 Operating conditions:

- ambient temperature ……..…. +10 to +35°C;
- relative air humidity ..... 80% @Tamb +25 ° C;
- atmospheric pressure …… .. …… 70 to 106.7 kPa.

1.2.12 The milliteslameter is enclosed into the heat-, cold- and moisture-resistant package to withstand the extreme transportation conditions:

- ambient air temperature ... ... -25°C to +55°C;
- relative humidity …… 95% @Tamb + 25°C;
- atmospheric pressure ……. …… 70 to 106.7 kPa.

1.2.13 The milliteslameter in the transportation package endures transport shaking with the following parameters:

- shocks per minute …… up to 120;
- maximum acceleration ……. ……. ……. ……... 30 m/s^2.

1.2.14 The milliteslameter meets the electromagnetic compatibility requirements established by GOST R IEC 61326-1-2014 for class B equipment.

1.2.15 The milliteslameter is compatible with GOST IEC 61010-1-2014 requirements.

1.2.16 Electronic block dimensions (length×width×height)..... 210 × 100 × 33 mm or less

1.2.17 Type 1, Type 2 probe dimensions (diameter × length) …… 12 × 200 mm or less

1.2.18 Probe working part dimensions (width×length×thickness)

Type 1, Type 2 probes ……... 6.5 × 105 × 3.5 mm

1.2.19 Probe cable length .....1.5 m or more

1.2.20 Weight .... …….0.6 kg,

including each Type 1, Type 2 probe .... …….. ... . 0.1 kg or less.

1.3 Configuration

1.3.1 The TPM-250 milliteslameter includes an electronic block with a built-in battery and Type 1, Type 2 probes (one of each).

1.3.2 The TPM-250 comes complete with a cable for computer communications, USB interface; power supply (charger), CD with Module-1 software, magnetic screen for setting and adjustment of the device zero

1.4 Structure of the Milliteslameter and Its Components

1.4.1 The milliteslameter converts the orthogonal components B_x, B_y, B_z of the magnetic induction vector into the Hall emf with subsequent processing of these signals and visualization of measurement results on the instrument's display screen.

1.4.2 Each Type 1 and Type 2 probe contains an IC chip the main parts of which are a three-component Hall element, an ADC and a multiplexer. The Type 1 probe IC has a higher sensitivity, the Type 2 probe IC has a wider measurement range.

1.4.3 The IC chip of each probe is installed in the working part of the probe near its end. The probe exterior with dimensions, location of the IC chips and directions of the X, Y, Z axes is schematically shown in Figure 1.1. The working parts of the probes are supplied with cylindrical removable protective caps made of non-magnetic metal. The latter makes it possible to measure the magnitude of the DC magnetic field vector (when the field acting on the Hall element is not distorted by the eddy-current-induced field) without removing the protective cap.

Note - The deflection angles of the magnetically sensitive axes of the Hall elements in the IC chips against the the X, Y, Z axes of the probes are not normalized.

1.4.4 The electronic block contains: the control block; the digital processing block for processing measurement data; the command, service and measurement data display block including an OLED display with a resolution of 128 by 64 pixels; power sources for powering circuit elements, particularly, IC chips with Hall elements.

1.4.5 Operation of the digital processing block

1.4.5.1 In the DC measurement mode, the magnetic induction magnitude is calculated according to the following expression:

$$B = [B_x^2 + B_y^2 + B_z^2]^{1/2} \qquad (1.4)$$

1.4.5.2 The AC magnetic field is normally a result of superposition of magnetic fields that are arbitrarily oriented in space and have different frequency and phases. The resulting magnetic induction vector of this field has at every moment an arbitrary orientation in space while the magnetic field has elliptical polarization. Therefore, for correct assessment of this field (for practical applications, it is important when the magnetic field is generated in two- or more- phase electrical installations and 50 Hz industrial frequency systems), the TPM-250 milliteslameter has the function of measuring the peak magnitude of the magnetic induction vector (along the major axis of the polarization ellipse).

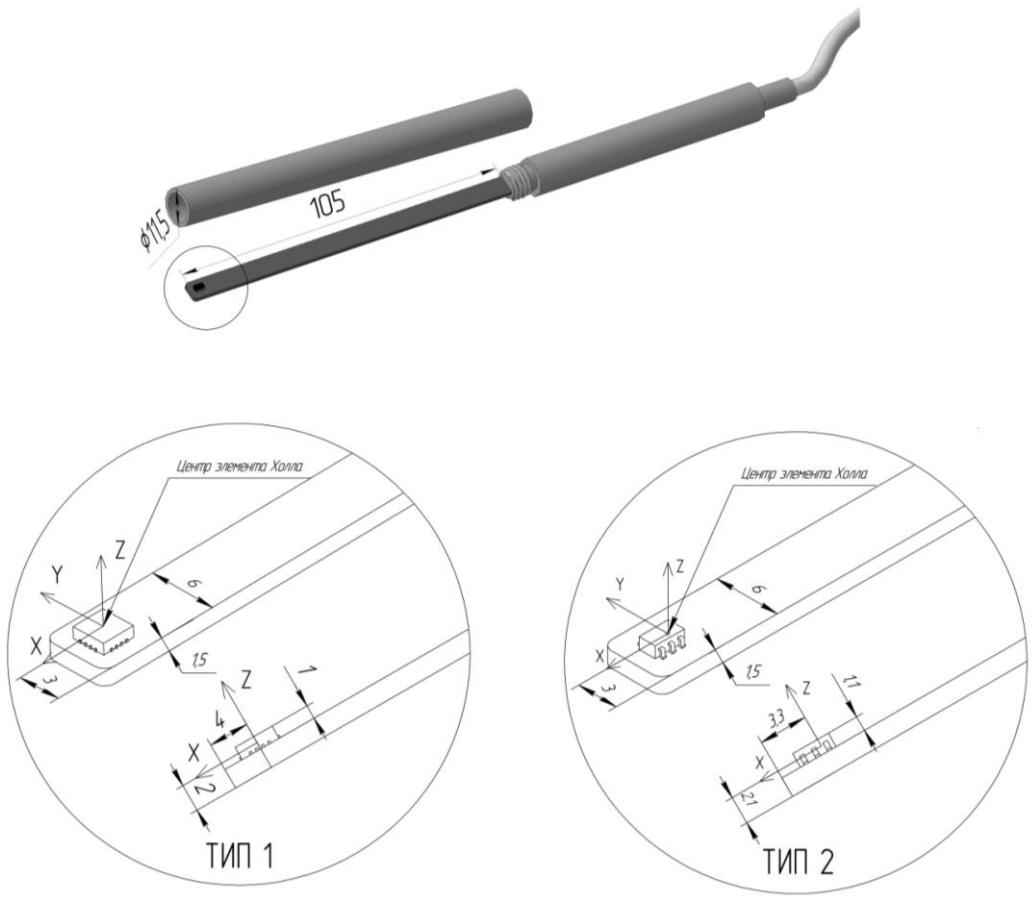

Figure 1.1. External view of the probe (Type 1, Type 2), directions of X, Y, Z axes

1.4.5.3 In the AC measurement mode, the digital processing block performs discrete Fourier transform of signals proportional to the B_x, B_y, B_z components of the magnetic field. Using statistical methods, the instrument automatically determines the frequency 'f' at which the amplitude of the signal has the maximum value (when measured in industrial electrical installations and systems, this is most often 50 Hz or close to it):

$$B_k(t) = B_{k0} \cdot \sin(\omega t + \varphi_{k0}), \quad (1.5)$$

where,

- $B_k(t)$ – instantaneous values of the B_x, B_y, B_z components;
- ω –harmonic frequency of the measured magnetic field, $\omega = 2\pi \cdot f$;
- B_{k0} and φ_{k0} – respectively, amplitude values and initial phases of the B_x, B_y, B_z components.

In general, the initial phases of the B_x, B_y, B_z components of the AC magnetic field are not equal.

Further, using classical methods of mathematical analysis the peak (maximum) value B of the expression B (t) is obtained as follows:

$$B(t) = [B_x(t)^2 + B_y(t)^2 + B_z(t)^2]½ \quad (1.6)$$

The obtained peak value B of the magnetic induction vector (along the major axis of the polarization ellipse) and the magnetic field frequency 'f' (when measured for purposes of special workplace

assessment, this is most often the industrial 50 Hz frequency) are output to the display screen of the milliteslameter.

Figure 1.2. The front and rear panels of the TPM-250 milliteslameter

1.4.6. The external view of the front and rear panels of the electronic block of the TPM-250 milliteslameter are shown in Figure 1.2.

1.4.7 TPM-250 key descriptions

1.4.7.1 The key serves to turn the instrument on and off. When the milliteslameter is turned on, the display shows the readings of the previously active operating mode.

The leftmost symbol in the top row of the display means that the measurement process is in progress; the symbol in the same place indicates that the measurement process is stopped; the rightmost symbol indicates the battery charge level

1.4.7.2 The key sets the instrument for measuring the magnetic induction of the AC/DC magnetic fields, low frequency AC magnetic field and 50 Hz AC magnetic field.

In the DC measurement mode (the device operation in this mode is indicated by the = symbol at the top right of the display), the milliteslameter displays the B_x, B_y, B_z components with respective signs and the magnetic induction vector B magnitude (see Figure 1.3).

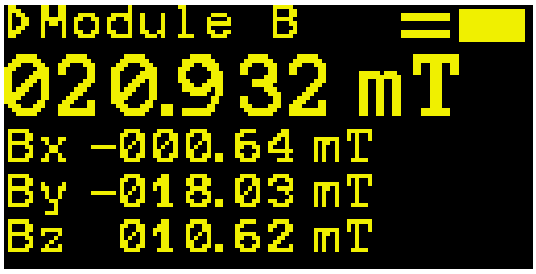

Figure 1.3. DC magnetic field measurement mode

In all AC measurement modes (the ~ symbol at the top right of the display), the milliteslameter, depending on the current key [Знач.] [Value] position, displays the B_x, B_y, B_z components and the peak magnitude of the magnetic induction vector B or the peak value of the magnetic induction and the frequency of the measured magnetic field (see Figures 1.4 and 1.5, respectively). At the operator's command, amplitude, RMS or average-rectified values are displayed.

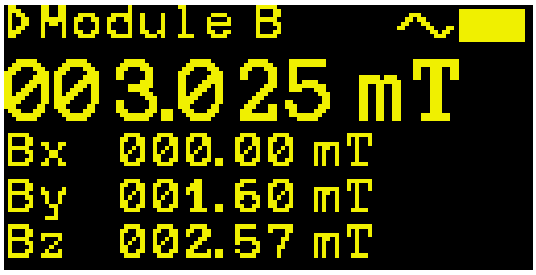

Figure 1.4. AC magnetic field measurement mode.
Displaying the B_x, B_y, B_z components and vector B magnitude.

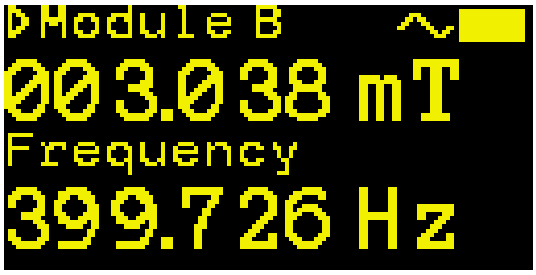

Figure 1.5. AC measurement mode.
Displaying Vector B magnitude and frequency.

1.4.7.3 Press the key [B/f] to toggle between AC parameter groups displayed.

1.4.7.4 Press the key [<0>] for the instrument zero adjustment which is performed automatically when the key is pressed in the DC measurement mode.

1.4.7.5 Press the key [Ед. изм.] [“Units”] to set the units in which the measurement results are displayed. The following units are set: tesla, gauss, amperes per meter, oersted; basic units or submultiples are displayed.

1.4.7.6 The key [M] depression saves the last measurement result into a memory cell for further loading into the computer. The display shows the type of measured magnetic field and the

number of the memory cell where the result is saved. 100 DC field memory cells and 100 AC field memory cells are available.

1.4.7.7 Press the key to visualize the current selected settings. The first depression of this key displays the type of the measured field (AC, DC); the connected probe type (determined automatically when the probe is connected to the electronic block); the value (amplitude, root-mean-square, average-rectified) of the AC magnetic field induction; the unit in which measurement results are displayed; the number of filled memory cells (Figure 1.6).

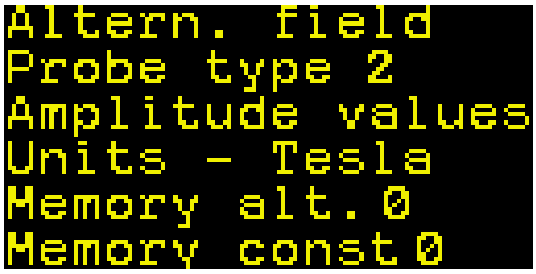

Figure 1.6. Instrument settings displayed at the first depression of the key

At the second key depression the display shows general information about the milliteslameter (type, serial number and ID number of the instrument) and the battery charge level (in percent) or the current battery condition (for illustration see Fig. 1.7 showing that the battery is being charged while the instrument operates from a charger).

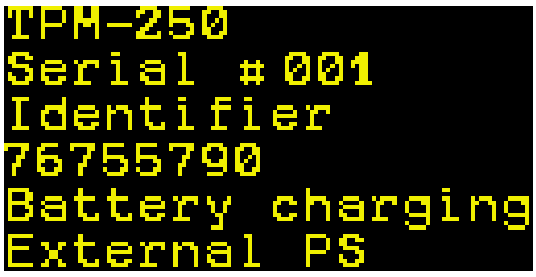

Figure 1.7. Instrument settings at the second key depression

Further key depression displays the contact information about the manufacturer – LLC "Electronic Equipment Plant" (LLC "ZET"), see figure 1.8.

Figure 1.8. Instrument settings after the third depression of the key .

1.4.7.8 Press the key to stop the measurement. The measurement process stops, the display shows the latest measurement results. In this mode it is possible to change the settings that do not require the restart of measurements (in the AC mode, it is possible to switch between the modes

of displaying the B_x, B_y, B_z components and the measured field frequency). Pressing other settings keys will resume the measurement process in the new mode. At a second key II depression the message "Measurement" appears on the screen and the instrument switches to the measurement mode in accordance with the latest settings.

1.4.8 A USB connector is located on the bottom side face of the electronic block for connecting the computer or the charger to the instrument as well as a green LED indicating the battery charging from the power supply unit (charger) or the computer. When charging is complete, the LED is off.

1.4.9 The communication between the milliteslameter and the computer is provided by the Module-1 software stored on a CD included into the instrument delivery set. The SW description and performance are given in the Appendix "Module 1 Software. Operator's manual".

1.5 Marking and sealing

1.5.1 The front panel of the TPM-250 milliteslameter contains the following marking data:
- надпись МИЛЛИТЕСЛАМЕТР ТПМ-250;
- товарный знак предприятия-изготовителя;
- знак утверждения типа средств измерений.
- name MILLITESLAMETER TPM-250;
- trademark of the manufacturer;
- type of measuring instrument.

Key designations are placed directly on the keys.

1.5.2 The rear panel of the electronic block is marked as follows:
- name of manufacturer: LLC "ZET";
- Milliteslameter designation: TPM-250;
- TU 26.51.43-002-86487402-2017 standard;
- Made in Russia;
- three-digit serial number according to the manufacturer's numbering system;
- year of manufacture.

1.5.3 The probe designation (Type 1 probe is marked '1', Type 2 probe is marked '2') is put on the probe case near the cable while at the opposite side of the case there is a three-digit serial number of the milliteslameter according to the numbering system of the manufacturer.

1.6 Packing

1.6.1 The TPM-250 milliteslameter is packed in accordance with Category KU-3 requirements of GOST 23170-78 for Group III, protection class B3-0, packing format VU-5 according to GOST 9.014-2005.

1.6.2 Packaging is performed in closed ventilated rooms at Tamb from +15 to +40°C and relative air humidity up to 80% at 20°C, with corrosive agents in the air not exceeding the level established for Type I atmosphere as per GOST 15150 -69 standard.

2 GENERAL OPERATION GUIDELINES

2.1 Caution

2.1.1 The working parts of the probes are sensitive to mechanical stress. The probes should be protected from these effects and, where possible, the working parts should be covered with protective caps.

2.1.2 Using measurement probes other than those included in the delivery set of this milliteslameter can cause intolerably large measurement errors. Use probes from the delivery set only.

2.1.3 When measuring DC fields with induction of less than 1 mT, the instrument is recommended to be zeroed on a regular basis, at least once every 10 minutes.

2.1.4 To charge the battery, use the charger only from the milliteslameter delivery set.

2.2 Operating Instructions

2.2.1 After unpacking the milliteslameter, the visual inspection of the instrument is performed to make sure there are no external damages. Check the completeness of the delivery set according to the packing list and that the factory numbers on the Type 1 and Type 2 probes coincide with the factory number on the electronic block.

2.2.2 Ensure that the milliteslameter does not operate under conditions beyond the permissible operating limits.

2.2.3 After exposure of the TPM-250 to the environment not conformant to the appropriate operating conditions, keep it for at least 4 hours before the power up under conditions conformant to the operation requirements.

2.2.4 When using the milliteslameter for special workplace assessment purposes, observe the requirements 2.2.4.3359-16 of the Sanitary Rules and Regulations (SanPiN). The instrument measures the components and the magnitude of the DC magnetic induction vector, particularly in shielded spaces; the components and maximum values of the AC magnetic induction vector, including industrial frequency in two- or more-phase electrical installations (along the major axis of the field polarization ellipse). The values measured are magnetic induction or magnetic field strength.

2.2.5 In AC/DC measurements, the display shows the numerical values of the magnetic induction (strength), the orthogonal components of the magnetic field and its frequency. The manufacturers of IC chips containing Hall elements do not normalize deviations of the magnetically sensitive axes of the Hall element from the Cartesian coordinate system referenced to the edges of the IC package. Accordingly, the milliteslameter manufacturer is not able to normalize deviations of the magnetically sensitive axes of the Hall element from the axes of the probe.

2.2.6 During measurements, it may happen that one of the orthogonal B_x, B_y or B_z components of the magnetic induction vector exceeds the established measurement limit of 4 or 8 mT (Type 1 probe) or 150 mT (Type 2 probe), assuming its magnitude does not exceed the established limits (10 mT for Type 1 probe, 260 mT for Type 2 probe). In this case, «Перегрузка» [Overload] message will appear on the display (see Figure 2.1) instead of the numerical value of a corresponding component and the vector magnitude (since it has been calculated incorrectly). Try to find such a position of the probe relative to its X, Y, Z axes at which all three components of the magnetic induction vector do not exceed the measurement limits. If this could not be done and Type 1 probe is connected to the milliteslameter, replace it with Type 2 probe and, if necessary, try again to find the position of the probe relative to its X, Y, Z axes where all three components do not exceed the measurement limits. Should the operation with Type 2 probe also fail, it means that for any orientation of the probe in space at a point measured, at least one of the vector components exceeds 150 mT (although the magnetic induction magnitude may be below 260 mT).

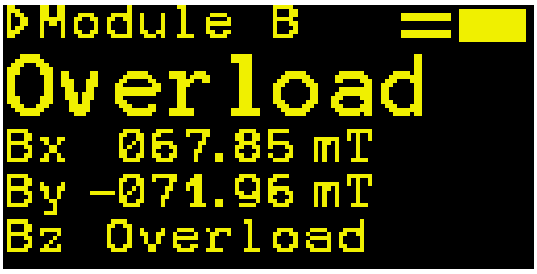

Figure 2.1. An example showing one of the vector components that exceeds the measurement limit of the instrument

2.2.7 The guidelines of item 2.2.6 refer both to AC and DC measurements. In the latter case, it should be remembered that the milliteslameter measures the amplitude values of the magnetic induction. The displayed RMS and averagely-rectified values are simply the result of multiplying the amplitude values by 0.7071 and 0.6366 coefficients, respectively, which is true only for sinusoidal fields (e.g. when measuring in industrial electrical installations and systems).

2.2.8 If during AC measurements the field level is below the sensitivity threshold of the milliteslameter, the display shows the displayed numbers as noise – letter "n" to the right from "Module B" (see Figure 2.2, Type 2 probe is connected).

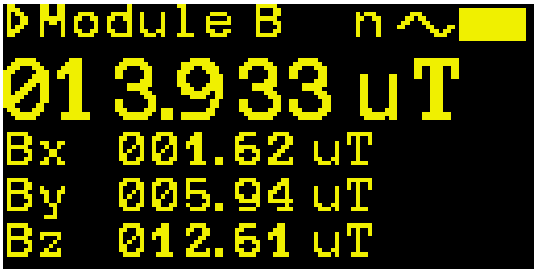

Figure 2.2. The display shows that the measured AC field level is below the sensitivity threshold of the instrument

2.2.9 For remote control of the instrument and data transfer to an external computer, install the Module-1 software on the computer and connect the computer with the milliteslameter with a USB cable. The software CD and the cable are included in the delivery set.

2.2.10 The milliteslameter is allowed to work with the charger connected.

2.3 Safety

2.3.1 Before using the TPM-250 milliteslameter, read this Manual.

2.3.2 The milliteslameter may be operated/serviced only by trained personnel qualified for work with electrical and radio measurement tools and with PC knowledge at the user level

2.4 Instrument Preparation

2.4.1 Connect the probe to the electronic block; the probe type is chosen depending on the measurement task (Type 1 - the upper limit of measuring the components is 4 mT, the upper limit of vector magnitude is 10 mT; Type 2 - 150 mT and 260 mT, respectively).

2.4.2 For operation with a remote computer, connect the computer with the instrument and install the software by performing the operations specified in section 4 of the Application '"Module 1 Software. Operator Guide".

2.4.3 Turn on the instrument. The display will show the modes and results of measurements preceding the turn-off of the milliteslameter.

2.4.4 Check the battery charge indicator (the rectangle at the top right of the display) to make sure the battery is sufficiently charged. In case of doubt, press the key  twice and read the battery charge level in percent on the display. If necessary, recharge the battery.

3 OPERATING PROCEDURE

3.1 Description of Operation Modes

The measurement modes and functions of the milliteslameter are cycled by successive depression of a corresponding key; the set mode (function) is visualized on the display. Any key depression is accompanied by a beep signal.

3.1.1 Press the key  successively to set the measurement modes “AC”, “DC”, “Low Frequency AC” or “50 Hz AC” that are displayed on the instrument screen.

3.1.2 In the “DC” mode, the display shows the magnetic induction B magnitude as well as the B_x, B_y and B_z components with appropriate signs (for the selected probe orientation in the measured field) or the same parameters of the magnetic field strength H.

3.1.3 In the “AC”, “Low Frequency AC” and “50 Hz AC” modes, the display shows the magnetic induction B magnitude and the B_x, B_y and B_z components or the same parameters of the magnetic field strength H. Depending on the current key 

[Value] position, the display shows either the amplitude, RMS or average-rectified values of the B_x, B_y and B_z components and the maximum magnetic induction (particularly, for two- or more-phase electrical systems), or amplitude, RMS or average-rectified values (particularly, for two- and more-phase systems) of the maximum magnetic induction and the frequency of the measured magnetic field. Press the key 

to switch between the AC parameter groups displayed.

3.2 Operating Procedure

3.2.1 Perform operations of item 2.4, then set a required field type by pressing the key  .

3.2.2 For DC measurements, set the instrument to zero. To do so, place the probe in the magnetic screen and press the key 

. When measuring magnetic fields with induction of less than 1 mT, it is recommended to set the instrument to zero regularly at least once every 10 minutes.

3.2.3 Press the key 

[Units] successively to set the units for magnetic induction or field strength measurements. Depending on the selected measurement unit and the measured value of magnetic induction, the instrument automatically selects and displays this value in submultiples of magnetic induction or magnetic field strength.

3.2.4 For AC measurements, press the key 

[Value] successively to select magnetic induction values (amplitude, RMS or average-rectified) to be displayed, then press the key 

to select displayed parameter groups: B_x, B_y, B_z components and the maximum value of the magnetic induction, or the maximum value of the magnetic induction and the frequency of the measured magnetic field. The same applies to the magnetic field strength.

3.2.5 Put the probe to a required point of space and perform measurements. When measuring for the assessment of the sanitary and epidemiological welfare or the special workplace assessment, observe SanPiN instructions 2.2.4.3359-16 “Sanitary and Epidemiological Requirements for Physical Factors at Workplaces”.

3.2.6 To secure the last measurement result, press the key  . The display shows the current selected settings and measurement results. Pressing this key again outputs the message “Measurement” and the instrument switches to the measurement mode in accordance with the current settings.

3.2.7 To save the last measurement result in a memory cell with its subsequent loading to the computer, press the key  . The display will show the type of the measured magnetic field and the number of the memory cell that saved the result.

3.3 Using the Milliteslameter in Measurement Systems

3.3.1 When using a remote computer, it is possible to automate the operation of the milliteslameter and ensure its operation in various-purpose measuring systems. For this purpose the Module-1 software has been developed. The Module-1 software CD is included in the instrument's delivery set; the software description is given in the Annex “Module-1 SW” to this Manual. The milliteslameter can be used with the remote computer, for example, for magnetic environment monitoring with data accumulation and transfer via communication lines.

4 MAINTENANCE

4.1 General Instructions

4.1.1 Maintenance is performed by personnel trained to operate the TPM-250 to ensure its trouble-free operation throughout the entire service life.

4.1.2 The maintenance includes:

- visual inspection of the milliteslameter;
- dirt removal;
- performance check;
- periodic verifications.

4.2 Maintenance Procedure

4.2.1 Visual inspection of the milliteslameter should be carried out prior to each power-on.

4.2.2 Dirt removal should be performed at least once every 6 months.

4.2.3 Verification instructions are given in the document RT-MP-4910-551-2017 “GSI. TPM-250 Portable Modular Milliteslameters. Verification Procedure” approved by FBU “Rostest-Moscow” in November 2017

5 ROUTINE REPAIRS

5.1 Routine repairs of the TPM-250 milliteslameter include restoration of damaged cables and connectors. In case of the instrument failure, the electronic block and probes are subject to repair or replacement at the manufacturer’s site.

6 STORAGE

6.1 Before putting to operation, the TPM-250 milliteslameter should be stored in a warm ventilated room under the following conditions:

- in the manufacturer's packaging: according to 1(L) GOST 15150-69 at Tamb. +5 to +40 °C and RH up to 80% @ +25°C;

- without the packaging: in the Type I atmosphere as per GOST 15150-69 at Tamb. +10 to +35 °C and RH up to 80% @ +25°C.

6.2 The storage room should be free from dust, vapors of acids and alkalis, corrosive gases and other harmful impurities that cause corrosion.

Keep the TPM-250 away from direct sunlight.

7 TRANSPORTATION

7.1 The TPM-250 milliteslameter in the manufacturer's packaging can be transported by all means of transport to any distance:

- transportation by railway should be carried out in covered clean cars;
- when transported in open vehicles, boxes with TPM-250 milliteslameters must be covered with waterproof material;
- when transported by air, boxes should be placed in a sealed warm compartment;
- when transported by water and sea transport, boxes must be placed in the lower hold of the ship.

7.2 Boxes in vehicles must be placed and secured so as to ensure their stable position in transit and avoid displacement and impacts against each other.

7.3 When loading and unloading, it is necessary to observe the marking put on the transportation packaging.

7.4 Transportation conditions:

- temperature from -25°C to +50°C, assuming gradual stabilization of the temperature during unloading to +5 to +40°C, with subsequent stay under normal conditions for 24 hours;
- humidity up to 95% at a temperature of +25°C;
- vehicle shaking with acceleration not exceeding 30 m/s^2 and less than 120 shocks per minute.

ANNEX

"MODULE-1" SOFTWARE OPERATOR'S GUIDE

1 Purpose

1.1 The Module-1 software is intended for reading data, saving it in the memory of an external computer as well as for remote control of the measurement process via the USB interface of the TPM-250 milliteslameter.

1.2 The TPM-250-milliteslameter software corresponds to the "high" level of security according to item 4.5 R 50.2.077-2014 of "GSI. Testing of Measuring Instruments for Type Approval. Software Security Check". To protect the software from failures, deliberate and non-deliberate alteration of executed files and calibration data, the following measures are introduced:

1) the metrologically significant part of the software (calibration data, measurement data processing algorithms) is located in the hardware processor;

2) the hardware is protected from unauthorized intervention by design (the software cannot be altered through the USB interface);

3) the hardware is located inside the sealed housing of the electronic block;

4) the “Module-1” remote control software does not contain a metrologically significant part.

2 SW Structure

2.1 The milliteslameter software consists of two parts: metrologically significant part and an executable program module installed by the manufacturer and protected from interventions during the milliteslameter operation;

The “Module 1” software is intended for remote control of the instrument using an external computer. The milliteslameter is connected to the external computer via a USB cable. The software CD is included in the TPM-250 delivery set.

3 External computer requirements

3.1 The external computer requirements are shown in Table 3.1.

Table 3.1

OS	Windows XP, Windows Vista, Windows 7, Windows 8, Windows 8.1, Windows 10
Processor clock rate	1000 MHz or more
Memory	1024 MB or more
USB Interface	USB 1.1, USB 2.0, USB 3.0
Videosubsystem	Resolution 1280×1024 pixels or more
Computer communication cable	USB interface

4 Installation of the "Module-1" Software

4.1 The “Module-1” SW used for remote control of the TPM-250 milliteslameter is installed from the CD included in the delivery set of the instrument. The SW is installed by installation of the TPM-250 USB interface driver and the TPM-250.EXE executable module.

4.2 Installing the TPM-250 USB interface driver

4.2.1 Connect the TPM-250 and the computer with the USB cable (Connection in the ON state is allowed).

4.2.2 Turn On and boot the computer if it was Off .

4.2.3 Turn On the TPM-250.

4.2.4 Then, the Windows will automatically detect the new USB device connected and open the USB driver installation dialog. When in the USB driver installation dialog, specify the item “Install Driver from Specified Location” [«установка драйвера из указанного места»], then specify the path to the driver files. The driver files are located on the installation CD in the \Driver folder.

4.3 The installation of the TPM-250.EXE executable module is performed by transferring the \TPM-250 directory from the installation disk to any convenient directory on the computer.

5 Description of the "Module-1" Software

5.1 The TPM-250 milliteslameter operates under control of an external computer in a dialog mode. The man-machine interaction is carried out by displaying information on the computer display screen. Turn on the TPM-250 before running the SW program. When the program starts, the connected instrument will be searched. In case of successful detection of the TPM-250, the current settings, calibration data and other parameters will be obtained and self-testing will be performed.

5.2 The main window of the TPM-250 "Module-1" software is shown in Figure A.1.

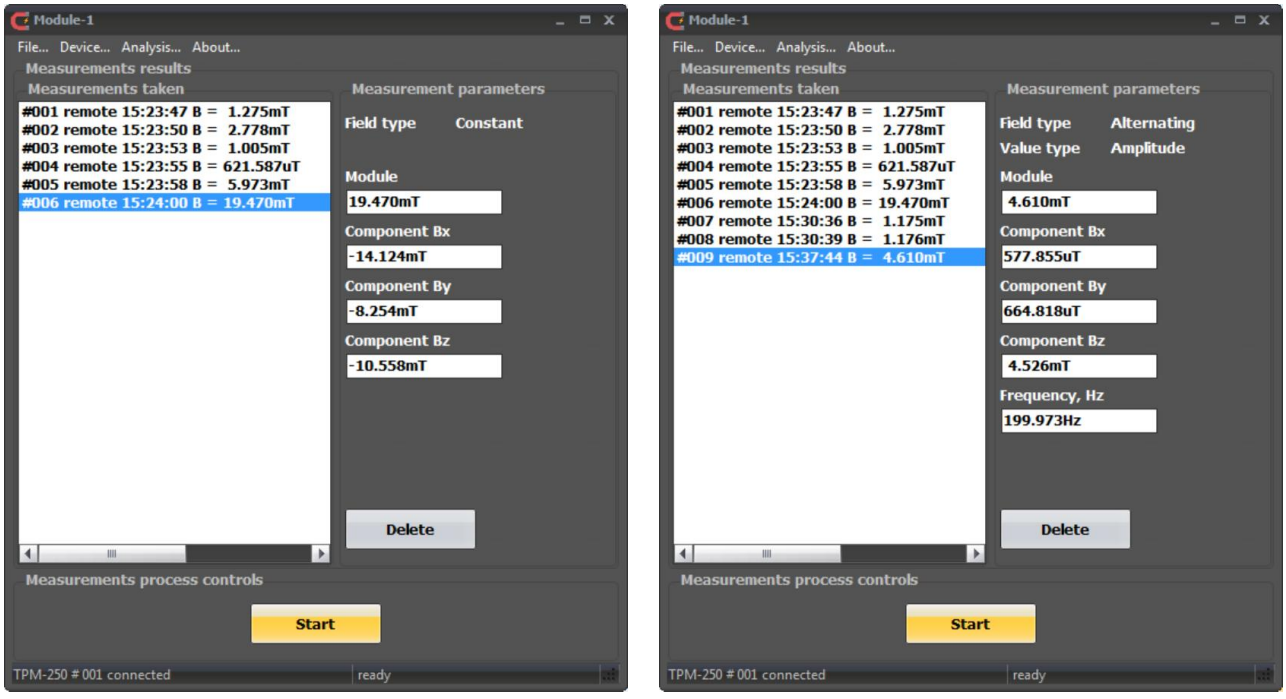

Figure A.1. The main window of the "Module-1" software displaying the results of DC (left) and AC (right) measurements

5.2.1 The main part of the window is the “Measurement Results” area displaying information about measurements taken. Each measurement is displayed in a separate row in the “Measurements Taken” list. The row contains:

- serial number of the measurement since the start of the “Module-1” software;
- note of how the measurement was made (remotely or read from the instrument’s memory);
- current measurement time (for remote measurements) or memory cell number (if data is loaded from the instrument's memory);
- magnitude of the measured magnetic induction (or magnetic field strength).

5.2.2 When a row is selected from the list, detailed measurement results are displayed in the “Measurement Parameters” area on the right as follows:

- type of measured field (DC or AC);
- type of measured value (amplitude, RMS or average-rectified) in the AC mode
- magnitude of measured magnetic induction (maximum magnitude in the AC mode);
- B_x component of the measured magnetic induction vector;
- B_y component of the measured magnetic induction vector;
- B_z component of the measured magnetic induction vector;
- measured frequency of the AC magnetic field.

5.2.3 Press the “Delete” button to delete the marked measurement result, which may be needed for further saving the results array.

5.2.4 Pressing the “Start” button in the “Measurement Process Controls” area triggers a single measurement with the current settings. In case of successful measurement, the measurement result will be added to the “Measurements Taken” list.

5.2.5 The status bar at the bottom part of the window displays the following (Figure A.2):

- the left-hand part - the TPM-250 factory number, the current state of the connection "... connected" and "No connection with the TPM-250";
- the right-hand part - the current state of the measurement process “Ready”, “Measurement ...”, “Error”, “Not Ready”.

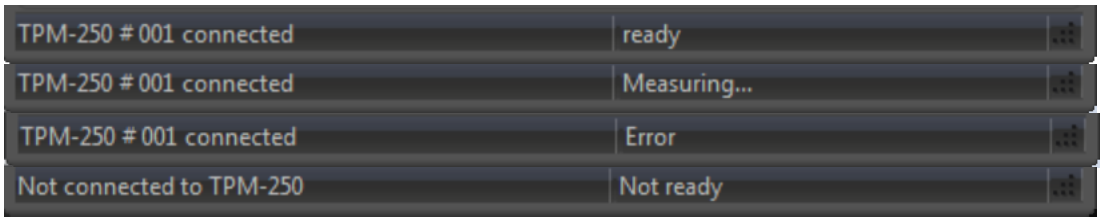

Figure A.2. Possible options of the status bar displaying information on the current state of the connection with the TPM-250 and the measurement process

5.3 The main menu of the “Module-1” SW (top row in the main window) contains 4 submenus (see Figure A.3):

- “File ...” - measurement result handling menu (save or clear);
- “Device ...” – control of the connected milliteslameter;
- “Analysis ...” - starting additional modes of the “Module 1” software (magnetic field monitoring mode, AC spectral characteristics investigation mode);
- “About program ...” - opening the window with program information.

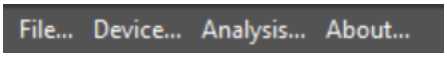

Figure A.3. Main menu of "Module-1" SW

5.3.1 The “File ...” menu is used for saving or clearing measurement results and consists of two parts (see Figure A.4):

- “Save results ...” saves measurement results in the text format or in MS Excel format. When selected, this option opens the standard Save File dialog;
- “Clear results” deletes the results of measurements. Selecting this option will start a dialog to confirm or cancel clearing.

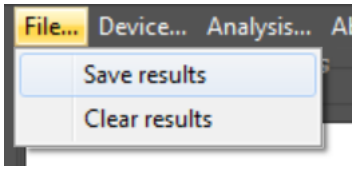

Figure A.4. “File…” Menu

5.3.2 The “Device ...” menu establishes connection with the milliteslameter and sets the TPM-250. It consists of the following items (see Figure A.5):

- “Connection” - establishes connection with the TPM-250;
- “Settings ...” - opens the TPM-250 settings window, it is described in detail in 5.4;
- “Zero setting” - sets the Zero when operating a selected probe (duplicates the key <0> on the milliteslameter, active only in the DC mode);
- “Read memorized data” - reads data previously stored in the TPM-250 memory and visualizes it in the “Measurement results” list in the main program window;
- “Clear memory” - deletes all previously saved measurement results from the memory of the TPM-250. When clicked, it opens a dialog to confirm or cancel the memory operation clearing.

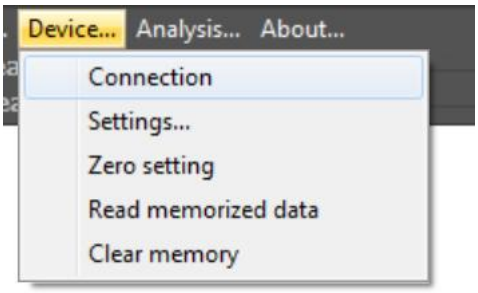

Figure A.5. "Device ..." Menu

5.3.3 The “Analysis...” menu selects additional "Module-1" modes. It contains the following menu items (see Figure A.6):

- “Monitoring...” - opens the magnetic field monitoring window (see Figure A.9);
- “Spectral composition ...” – opens the window for analysis of the spectral composition of the measured AC field components (see Figure A.10).

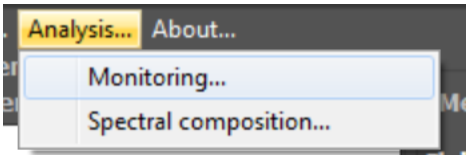

Figure A.6. The " Analysis..." menu

5.3.4 The “About...” menu opens the window “About” (see Figure A.7)

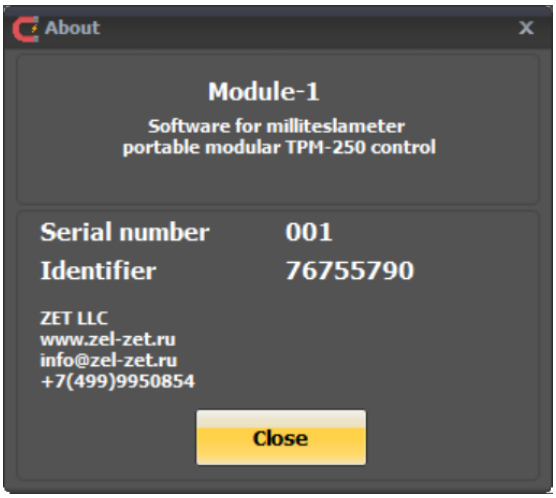

Figure A.7. “About” window

The “About” window displays:

- SW name: Module-1
- TPM-250 factory serial number;
- TPM-250 identifier;
- Manufacturer contact information - ZET LLC.

5.4 The TPM-250 settings window (see Figure A.8) accessible in the “Device ...” menu is used for remote receiving, updating, and setting the TPM-250 milliteslameter. It contains the following controls and displays:

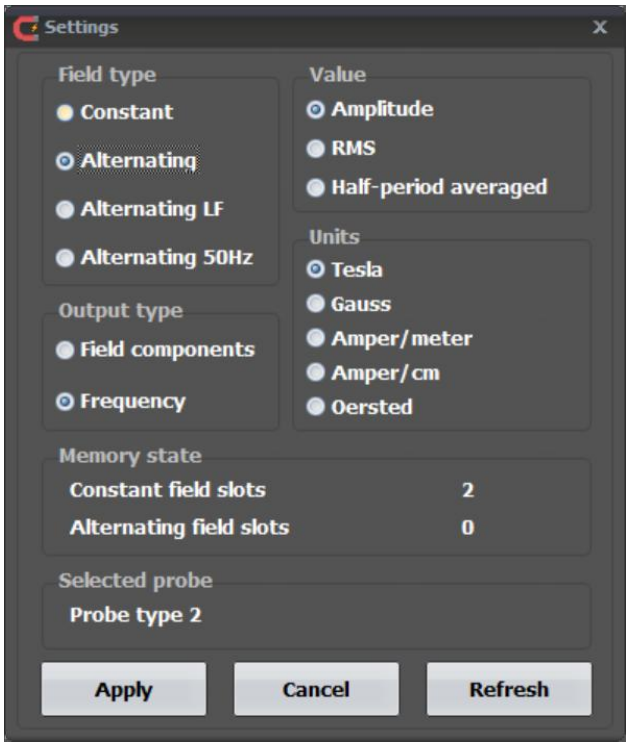

Figure A.8. TPM-250 settings window

- the “Field Type” area is selected to switch between the DC, AC, Low Frequency AC and (50±1) Hz AC measurement modes;
- the “Value” area displays the AC field value - amplitude (measured), RMS or average-rectified (calculated);
- the “Output Type” area is selected to switch between groups of AC field parameters displayed. It displays either the maximum AC field value and its components or the maximum AC field value and the frequency of the first harmonic (duplicates the key B/f on the milliteslameter);
- the “Units” area is used to display the measurement result in required units (magnetic induction or magnetic field strength);
- the “Memory State” area displays the current status of the TPM-250 memory;
- the “Selected Probe” area displays the type of the probe connected (Type 1 or Type 2 is determined automatically);
- the “Apply” button is used to transfer the settings to the TPM-250;
- the “Cancel” button is clicked to cancel the changes made in the TPM-250 Settings window and returns all selection areas to the state corresponding to the current settings of the TPM-250;
- the “Refresh” button brings all selection areas into the state corresponding to the current milliteslameter settings (in case any changes were made in the settings using the TPM-250 keys after calling the “Module-1” software settings window).

5.5 The “Monitoring” window in the “Analysis...” menu performs continuous magnetic field measurements at specified time intervals to track changes in the magnetic field parameters. The window is shown in Figure A.9 and contains the following controls:

- the “Settings” area sets time intervals in minutes (from 0.01 to 10 minutes) and selects magnetic field parameters (the total value and B_x, B_y, B_z components of the magnetic induction vector) displayed on the measurement results graph. The measurement time is not set, the current time is determined by the computer;
- the “Control” area starts the measurement procedure (“Start” button), stops the measurement procedure (“Stop” button), and clears the results graph (“Clear” button);
- the “Results Graph” area displays measurement results on a graph. The total magnitude and any component (s) of the magnetic induction vector can be displayed simultaneously.

For saving measurement results in the monitoring mode see 5.3.1.

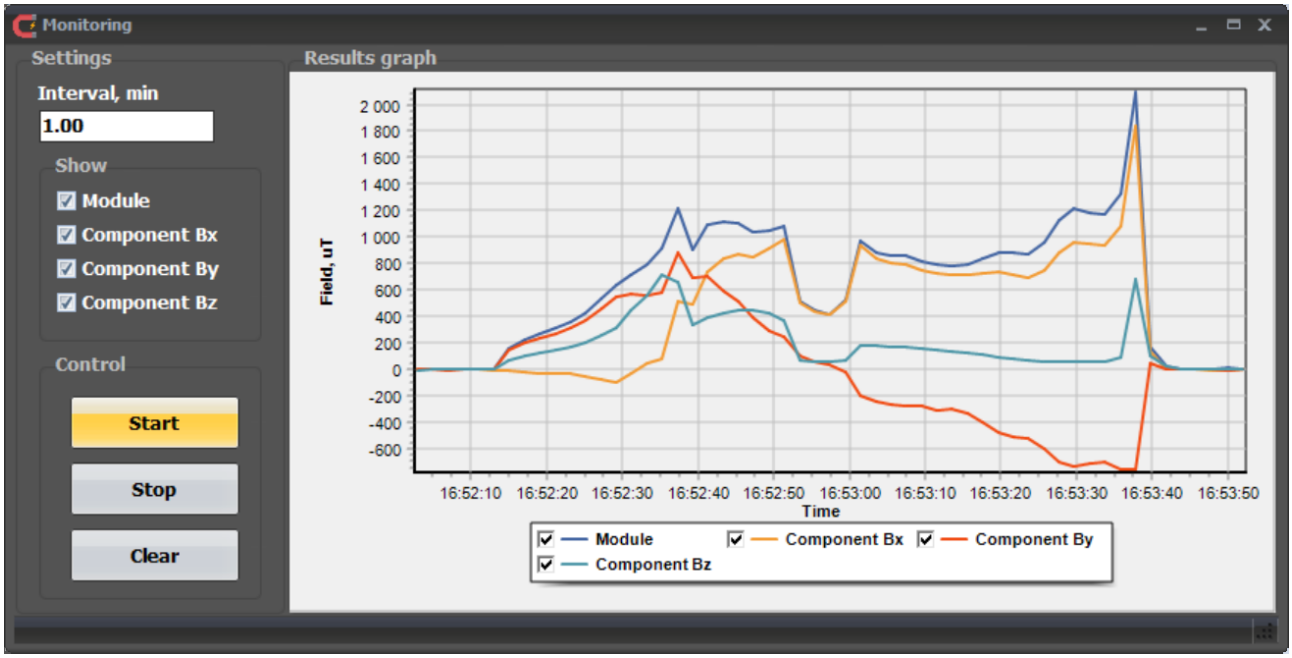

Figure A.9. Monitoring window

5.6 The “Spectral Composition” window is used for investigation of the spectral composition of the measured AC field. It is shown in Figure A.10.

The “Spectral Composition” window consists of the following items:

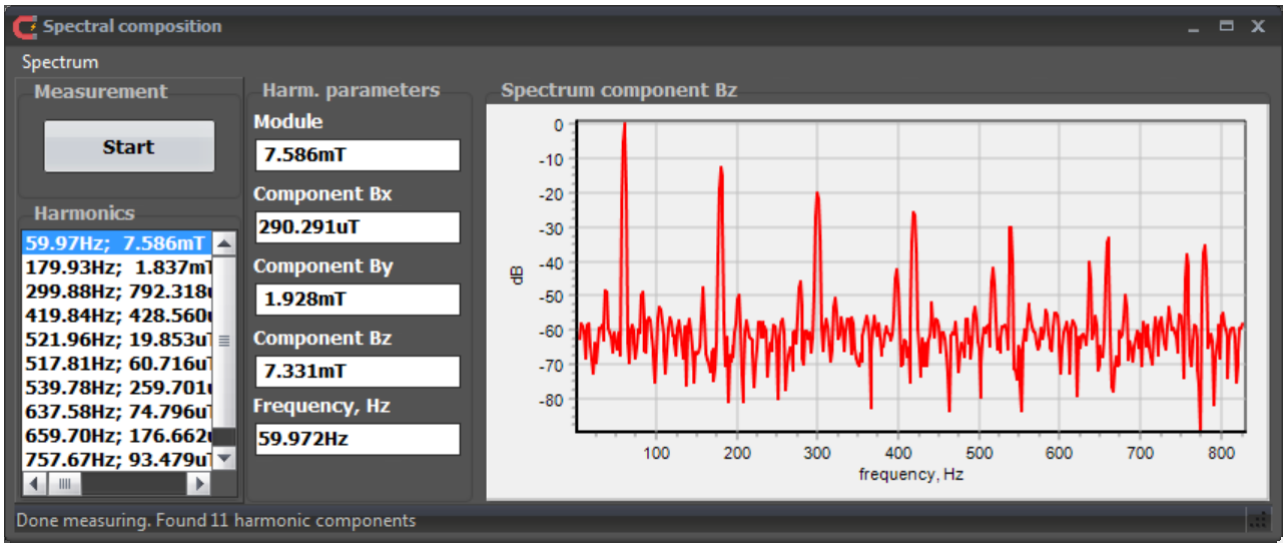

Figure A.10. "Spectral composition" window

- The “Spectrum” menu consisting of three items (see Figure A.11) is called to select the B_x, B_y or B_z components and represent the spectrum of a selected component.

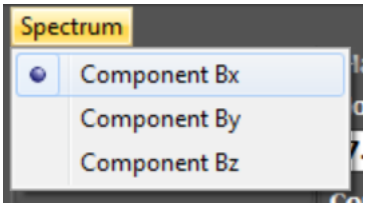

Figure A.11. The “Spectrum” menu

- the “Measurement” area with the “Start” button starts the measurement process;
- the “Harmonics” list displays all found harmonic components of the measured component B_x, B_y, B_z of the magnetic induction vector (frequency and amplitude values of harmonics that exceed the noise level depending on the selected probe and the magnetic situation at a point under study);
- • the “Harm. Parameters” area displays the following parameters of the selected harmonic component:
    - maximum value of the magnetic induction vector
    - B_x component
    - B_y component
    - B_z component
    - frequency
- The graph “Component Spectrum” displays the spectrum of the respective component B_x, B_y or B_z selected in the “Spectrum” menu. Values are displayed in decibels relative to the harmonic component having the highest value.

Notes

1 For the algorithm of calculating the frequency of the first harmonic and the maximum value of the magnetic induction vector of the AC magnetic field, see item 1.4.5.3 of the Manual.

2 See item 2.2.8 of the Manual.

RECORD OF CHANGES

Change	Sheet (page) number(s)				Total number of sheets (pages) in the document	Document No.	File No. and date	Sign.	Date
	altered	replaced	new	cancelled					