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“D.I. Mendeleev Institute for Metrology”

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MULTIFUNCTIONAL REFERENCE STANDARD METER
ENERGOMONITOR 3.1KM

MC3.055.500 МП

Calibration method

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CONTENTS

INTRODUCTION **3**

1 OPERATIONS INCLUDED IN CALIBRATION PROCEDURE **3**

2 MEANS OF CALIBRATION **4**

3 SAFETY REQUIREMENTS **5**

4 ENVIRONMENTAL CONDITIONS DURING CALIBRATION **5**

5 PREPARING FOR CALIBRATION **5**

6 CALIBRATION **6**
- 6.1 Visual inspection 6
- 6.2 Measuring resistance of insulation 6
- 6.3 Clock / memory function testing 6
- 6.4 Accuracy testing 7
- 6.5 Performance testing of frequency outputs and pulse input 15
- 6.6 Testing of firmware 17

7 DOCUMENTING CALIBRATION RESULTS **18**

APPENDIX A **19**

CONNECTION DIAGRAMS **19**

APPENDIX B **23**

APPENDIX C **42**

INTRODUCTION

This document covers multifunctional reference standard meters named Energomonitor 3.1KM, the EM 3.1KM or the DUT (Device under test) below, and describes the operations included in their primary and regular calibration.

This document determines the extent, conditions, methods and means of calibration and establishes the order of representation of calibration results.

This document covers either newly manufactured or newly repaired instruments as well as instruments being in operation.

A period of one calendar year is considered a maximum time between calibrations of the EM 3.1KM, whether it be in operation or storage.

In terms of accuracy characteristics, the EM 3.1KM comes in three modifications:

Energomonitor 3.1KM x-02;

Energomonitor 3.1KM x-05;

Energomonitor 3.1KM x-10.

1 OPERATIONS INCLUDED IN CALIBRATION PROCEDURE

A calibration procedure includes the operations specified in Table 1. 1.

Table 1.1

Operation	Corresponding item of this document	Primary calibration	Regular calibration
Visual inspection	6.1	+	+
Measuring strength of insulation	6.2	+	+
Clock / memory function testing	6.3	+	+
Accuracy testing	6.4	+	+ Excluding section 6.4.3.3
Performance testing of frequency outputs and frequency input	6.5	+	-
Testing of firmware	6.6	+	+

2 MEANS OF CALIBRATION

2.1 It is recommended to use measuring equipment and tools listed in Table 2.1.

Table 2.1

Name and description	Basic specifications	Items of the document
State Primary Standard of electrical power ГЭТ 153	Measuring ranges: voltage range: 1...600 V; Current range: $1{\cdot}10^{-2}$…10 A; Power factor range: -1…0 … +1 Residual systematic error in producing the unit of electrical power (2 …4) $\cdot 10^{-5}$ Standard (root mean square) deviation in producing the unit of electrical power (0.5…1) $\cdot 10^{-5}$	6.4.1, 6.4.3, 6.4.4, 6.4.5, 6.5.1; 6.5.2
Voltmeter-calibrator of DC voltage B2-43	Range of measuring and producing of: DC voltage – 0 to 1000 V, DC current – 0 to 10 A. Limits of the relative intrinsic error in producing and measuring voltage – ±0.001 %. Limits of the relative intrinsic error in producing and measuring current: ±0.002 % at a current up to 200 mA; ±0.005 % at a current from 200 mA to 1A; ±0.01 % at a current from 1 A to 10 A.	6.4.2
Megommeter Ф4101	Output voltage – 1000 V; measuring range –0 to 100 MOhm; intrinsic measurement error – within ±1 %.	6.2
Test System MTS ME 3.1K	Range of generated voltages 1 – 500 V, Range of generated currents 0.005–50 A, Limits of the relative intrinsic error in measuring: current – ± [0.01+0.005 $\lvert(I_{NOM}/I)-1\rvert$] % at I_{NOM} = 0.1 A to 100 A; ± [0.01+0.01$\lvert(I_{NOM}/I)-1\rvert$] % at I_{NOM} = 0.05 A; voltage – ± [0.01+0.005 $\lvert(U_{NOM}/U)-1\rvert$]% active power – ± [0.015+0.005 $\lvert(P_{NOM}/P)-1\rvert$]%	6.4.1; 6.4.3; 6.4.5; 6.4.6; 6.4.7
Generator of special waveforms Г6-33	Frequency setting range – from 0.001 to 99999 Hz; error in setting frequency (relative) – within $\pm 3{\cdot}10^{-6}$; range of setting amplitude – from 0.005 to 5 V.	6.5.2
Frequency meter of counting type Ч3-63	Frequency measurement ranges for: Sinusoidal signal – 0.1 Hz to 1000 MHz; Pulse signal – 0.1 Hz to 200 MHz (0.1to10 V). Ranges for measuring the periods of sinusoidal and pulse signals – 0.1 microseconds to 10^4 s (10 MHz to 10^{-4} Hz). Frequency measurement error– within $5{\cdot}10^{-7}$±1 counts.	6.4.4; 6.5.1
Oscillograph TDS 1012	2-channel; frequency band – 0 to 100 MHz.	6.5.1
Personal computer with Energomonitoring software installed	IBM-PC (P-III 800, 256 k)	6.3
Resistor C2-29B – 2 pcs	2 W; 2 kOhm ±1 %	6.4.5
Resistor C2-23	0.25 W; 10 kOhm ±5 %	6.5.1
Resistor C2-23	0.25 W; 3.9 kOhm ±5 %	6.5.1

2.2 The means of calibration must function properly and have valid Calibration certificates.

2.3 The measuring instruments of reference class must be operated in accordance with their operating instructions.

2.4 Other test equipment having accuracy (metrological) specifications and operating ranges no worse than specified in the above table is acceptable.

3 SAFETY REQUIREMENTS

3.1 When calibrating the EM 3.1KM, safety requirements determined by Russian State standards GOST 12.3.019, GOST 22261, and GOST 24855, as well as “Rules for Operating Electrical Systems By Consumers”, “Interbranch Rules for Labor Safety (Safety Rules) When Operating Electrical Systems” (Energoatomizdat, 2001) and safety requirements described in the User's Manual and all operation documentation for the instruments, devices, tools and any other equipment used during calibration must be observed.

3.2 Persons authorized to carry out calibration must have electrical safety qualification level III (but no less) and must be officially certified as calibrators.

3.3 Measuring equipment must be properly grounded before calibration. Grounding terminals must be connected to the grounding circuit prior to making any other electrical connections and disconnected after disconnecting all other circuits.

4 Environmental conditions during calibration

The following environment conditions shall be observed:

- Ambient temperature, °C 20 ± 5 °C;
- Relative humidity, % 30 - 80;
- Atmospheric pressure, kPa (mm Hg) 84 – 106.7 (630 - 800);
- Frequency of supply voltage, Hz 50 ± 2.5;
- Mains voltage, V 220 ± 11;
- Total Harmonic Distortion of power supply circuit, % 5, or less.

5 Preparing for calibration

Prior to calibration, the following steps shall be carried out:

- Keep the device under test (the DUT) under conditions indicated in section 4 for at least 1 hour (in case it was kept under other environment conditions)
- Connect the grounding terminal of each measuring instrument in use to the grounding circuit;
- Connect the EM 3.1KM and means of calibration to mains supply 220V, 50 Hz and keep them powered for a warm-up period (specified in their user manuals).

6 CALIBRATION

6.1 Visual inspection

Visual inspection includes checking the contents of the delivery package, marking and checking the DUT for damages.

6.1.1 The delivery package must include all items listed in the operating documentation for the EM 3.1KM, namely the items are specified in the User's Manual.

6.1.2 Marking must be as described in the operating documentation.
6.1.2.1 The following marks are stenciled on the enclosure:
Name of the instrument (Energomonitor 3.1KM);
Manufacturer's trade mark and logo;
Protection rating IP20;
Power supply type and nominal power supply voltage;
Marking of input and output connectors.
6.1.2.2 The manufacturer's nameplate contains:
Name of the instrument;
Serial number;
Date of manufacture (month and year).

6.1.3 The DUT shall not have mechanical damages that may affect its performance (the body, connectors and cables, display, keypad, indicators and other items listed in the delivery package must not be damaged).

6.2 Measuring resistance of insulation

6.2.1 Resistance of insulation is measured with a megommeter (e.g. Ф4101) that has an operation voltage of 1000 V. The insulation resistance is measured between the following points:

- The ground terminal of the DUT from one side and the voltage inputs (U_A; U_B; U_C; U_N) and current inputs (I_A; I_B; I_C) connected together from the other side;

- The ground terminal of the DUT from one side and the mains supply plug pins connected together and galvanically isolated from the device's enclosure (the "Power" switch is set to Position "ON") from the other side;

- The mains supply plug pins connected together (the "Power" switch is set to Position "ON") from one side and the voltage inputs (U_A; U_B; U_C; U_N) and current inputs (I_A; I_B; I_C) connected together from the other side;

- The voltage inputs (U_A; U_B; U_C; U_N) connected together from one side and the current inputs (I_A; I_B; I_C) connected together from the other side.

Readings are taken in 30 sec (as a minimum) after applying test voltage.

The DUT passes the test if the value of insulation resistance is no less than 20 MOhm

6.3 Clock / memory function testing

6.3.1 These tests confirm that the date/time setting function works correctly and the settings are kept in the memory after removing power from the DUT.

6.3.2 In the course of clock / memory function testing, make the following steps:

- Prepare the DUT for operation as described in the User's manual;
- Power up the DUT; after applying power the display backlight is turned on and a "power up" screen appears in 1…5 seconds (at the conclusion of initialization and initial configuration procedures). The "power up" screen contains manufacturer's name and logo, device type, its accuracy option (02, 05, or 10), firmware version and identification number;

- Enter the password, select a circuit connection scheme and go to the main menu screen, on which the current time (hours, minutes, seconds) and date (day, month, year) are displayed on the top line and circuit connection scheme – on the bottom;
- Make sure that current and voltage measurement ranges and date/time settings are changed appropriately;
- Turn the DUT off, and then turn it on in 5 minutes to make sure that the date/time settings are kept intact in the memory after removing power;
- Activate the “Data Exchange with PC” mode and check the work of the communication ports.

6.3.3 The DUT passes the clock/memory function testing, if its operation is as described in the “Multifunction Reference Standard Energomonitor 3.1KM, User’s Manual” document.

6.4 Accuracy testing

6.4.1 **Determining intrinsic error in measuring AC voltage, current and apparent power**

6.4.1.1 The relative intrinsic error in the measurements of root mean square (effective) values of voltage δ_U and fundamental (1st) harmonic of voltage δ_{U1} is determined in each of 3 voltage measurement channels with use of the State Primary Standard of electrical power ГЭТ 153. The diagram showing electrical connections between the State Primary Standard and DUT is given in Fig. A1, Appendix A.

The parameters of signals from the State Primary Standard applied to the DUT during testing (voltage U_{ref} and frequency f_1) are specified in Table 6.1 (considering the measurement ranges of the DUT being tested). Measurements are carried out in accordance with the operating instructions for the State Primary Standard. The value of THD_U (total harmonic distortion of voltage) of the test signal source must not exceed 0.01%.

The nominal (rated) voltage values of the DUT (U_{NOM}) are specified in Table 6.1 for all test signals.

Table 6.1

U_{NOM}, V	800	480	240	240	240	120	60	30	10	5	2	1	1
U_{ref}, V	600	480	288	120	24	120	60	30	10	5	2	1	0.1
f_1, Hz	53												

Measurement error δ_U is calculated according to the formula:

$$\delta_U = [(U_X - U_{ref}) / U_{ref}] \cdot 100\ \%, \qquad (1)$$

Where U_{ref} is the voltage value set in the State Primary Standard, V;
U_X is the voltage reading taken from the DUT when measuring RMS value of voltage, V.

The measurement error δ_{U1} is calculated according to the formula:

$$\delta_{U1} = [(U_{X1} - U_{ref}) / U_{ref}] \cdot 100\ \%, \qquad (2)$$

Where U_{ref} is the voltage value set in the State Primary Standard, V;
U_{X1} is the voltage reading taken from the DUT when measuring the RMS value of fundamental (1st) harmonic of voltage, V.

The DUT passes the test, if the values of relative intrinsic measurement errors δ_U and δ_{U1} do not exceed the limits of permissible measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.1.2 The relative intrinsic error in the direct (without AC current probes) measurements of the root mean square (effective) values of current δ_I and fundamental (1st) harmonic of current δ_{I1} is determined in each of 3 current measurement channels with use of the State Primary Standard of AC

Power ГЭТ 153. The diagram showing electrical connections between the State Primary Standard and DUT is given in Fig. A1, Appendix A.

The parameters of signals from State Primary Standard applied to the DUT during testing (current I_{ref} and frequency f_1) are specified in Table 6.2 (considering measurement ranges of the DUT being tested). Measurements are carried out in accordance with the operating instructions for the State Primary Standard. The value of THD_I (total harmonic distortion of current) of the test signal source must not exceed 0.01%. The values of nominal (rated) current of the DUT (I_{NOM}) are specified in Table 6.2 for all test signals.

Table 6.2

I_{NOM}, A	100	50	25	10	5	2.5	1	1	1	0.5	0.25	0.1	0.05
I_{ref}, A	10	10	10	10	5	2.5	1	0.5	0.1	0.5	0.25	0.1	0.05
f_1, Hz	53												

The measurement error δ_I is calculated according to the formula:

$$\delta_I = [(I_X - I_{ref}) / I_{ref}] \cdot 100\ \%, \qquad (3)$$

Where I_{ref} is the value of current set in the State Primary Standard, A;

I_X is the reading of current taken from the DUT when measuring the RMS value of current, A.

The measurement error δ_{I1} is calculated according to the formula:

$$\delta_{I1} = [(I_{X1} - I_{ref}) / I_{ref}] \cdot 100\ \%, \qquad (4)$$

Where I_{ref} is the value of current set in the State Primary Standard, A;

I_{X1} is the reading of current taken from the DUT when measuring the RMS value of fundamental (1^{st}) harmonic of current, A.

The DUT passes the test, if the values of relative intrinsic measurement errors δ_I and δ_{I1} do not exceed the limits of permissible measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.1.3 The relative intrinsic error in the contactless (with AC current probes) measurements of the root mean square (effective) values of current δ_I and fundamental (1^{st}) harmonic of current δ_{I1} is determined for Energomonitors 3.1KM of modifications x-x-x1x in each of 3 current measurement channels with AC current probes of all types included in the delivery set.

The relative intrinsic error is determined with use of MTS ME 3.1K test system. The AC current probes are connected to MTS ME 3.1K via accessory Blocks of calibrated coils (number of turns in a coil = n). While passing through the calibrated coil, test current is multiplied by n, so, the test current measured by the DUT via the AC current probes would be n times greater than the current set in the generator of MTS ME 3.1K test system. The diagram showing connections between the DUT and MTS ME 3.1K test system is given in Fig. A2, Appendix A.

Measurements are carried out at the nominal (rated) frequency of AC current probes being tested (50 or 60 Hz), and at the following currents generated by MTS ME 3.1K: $1.2I_{NOM}/n$; $0.5I_{NOM}/n$; $0.05I_{NOM}/n$, and $0.01I_{NOM}/n$ (considering measuring ranges of the DUT being tested), where I_{NOM} is the nominal (rated) current of the AC current probes.

The measurement error δ_I is calculated by the formula:

$$\delta_I = [(I_X/n - I_{ref}) / I_{ref}] \cdot 100\ \%, \qquad (5)$$

Where I_{ref} is the reading of current taken from the reference standard Energomonitor (as part of MTS ME 3.1K) when measuring current (RMS) set in the generator of MTS ME 3.1K, A;

I_X is the reading of current taken from the DUT when measuring current (RMS), A.

The measurement error δ_{I1} is calculated according to the formula:

$$\delta_{I1} = [(I_{X1}/n - I_{ref1}) / I_{ref1}] \cdot 100\ \%, \qquad (6)$$

Where I_{ref1} is the reading of current taken from the reference standard Energomonitor (as part of MTS ME 3.1K) when measuring the fundamental (1^{st}) harmonic of current (RMS) set in the generator of MTS ME 3.1K, A;

I_{X1} is the reading of current taken from the DUT when measuring the fundamental (1^{st}) harmonic of current (RMS), A.

The DUT passes the test, if the values of relative intrinsic measurement errors δ_I and δ_{I1} do not exceed the limits of permissible measurement error represented in Tables B2, B4, or B6 (depending on the DUT modification), Appendix B.

6.4.1.4 The relative intrinsic error in the measurements of apparent power δ_S is calculated according to the formula:

$$\delta_S = \delta_U + \delta_I, \%, \tag{7}$$

Where δ_U is the relative intrinsic error in the measurement of AC voltage (RMS), %, δ_I is the relative intrinsic error in the measurement of AC current (RMS), %.

The DUT passes the test, if the values of relative intrinsic measurement errors δ_U and δ_I do not exceed the limits of permissible measurement error represented in Tables B1 and B2, B3 and B4, or B5 and B6 (depending on the DUT modification), Appendix B

6.4.2 **Determining intrinsic error in measuring DC voltage, current and power**

6.4.2.1 The relative intrinsic error in DC voltage measurements (δ_{UD}) is determined in each of 3 voltage channels at the values of voltage (U_{ref}) specified in Table 6.3 (considering measuring ranges of the DUT being tested) with use of DC Voltmeter-Calibrator B2-43. The values of nominal (rated) voltage of the DUT (U_{NOM}) are specified in Table 6.3 for all test signals.

Table 6.3

U_{NOM}, V	800	480	240				120	60	30	10	5	2	1	1
U_{ref}, V	1000	800	400	200	100	24	200	100	50	17	8.5	3.4	1.7	0.1

The measurement error δ_{UD} is calculated according to the formula:

$$\delta_{UD} = [(U_X - U_{ref}) / U_{ref}] \cdot 100 \%, \tag{8}$$

Where U_{ref} is the voltage taken from the Calibrator, V; U_X is the reading taken from the DUT, V.

The DUT passes the test, if the values of relative intrinsic measurement error δ_{UD} do not exceed the limits of permissible measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.2.2 The relative intrinsic error in DC current measurements (δ_{ID}) is determined for Energomonitors 3.1KM of modifications x-x-1in each of 3 current measurement channels with use of the following calibration equipment: DC Voltmeter-Calibrator B2-43, multimeter 3458A and reference-class reactance-free current shunts of RS series (included in the State Standard of electrical power ГЭТ 153). Measurements are carried out at the values of current (I_{ref}) specified in Table 6.4 (considering measuring ranges of the DUT being tested). Calibrator B2-43 generates test DC current; Multimeter 3458A measures DC current using indirect method, namely it measures the voltage drop across the shunt (shunt types are specified in Table 6.4).

Table 6.4

I_{NOM}, A	100	50	25	10	5	1			0.5	0.25	0.1	0.05
I_{ref}, A	10	10	10	10	7.5	1.5	0.5	0.1	0.75	0.37	0.15	0.05
Shunt	RS-10					RS-1.0	RS-0.5	RS-0.1	RS-1.0	RS-0.5		RS-0.1

The measurement error δ_{ID} is calculated according to the formula:

$$\delta_{ID} = [(I_X - I_{ref}) / I_{ref}] \cdot 100\ \%, \tag{9}$$

Where I_{ref} is the current generated by the Calibrator, A; I_X is the reading taken from the DUT, A.

The DUT passes the test, if the values of relative intrinsic measurement error δ_{ID} do not exceed the limits of permissible measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.2.3 The relative intrinsic error in DC power measurements is determined for Energomonitors 3.1KM of modifications x-x-1 according to the formula:

$$\delta_{PD} = \delta_{UD} + \delta_{ID},\ \%,$$

Where δ_{UD} and δ_{ID} are the relative intrinsic errors in the measurements of DC voltage and DC current respectively.

The DUT passes the test, and the measurement error δ_{PD} lies within its permissible limits specified in Tables B1, B3, and B5, if the values of relative intrinsic measurement errors δ_{UD} и δ_{ID} do not exceed their limits of permissible measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.3 **Determining intrinsic errors in active power and power factor measurements**

6.4.3.1 The relative intrinsic error in the direct (without AC current probes) measurements of single-phase active power (δ_P) is determined in each measurement channel with use of the State Primary Standard of electrical power ГЭТ 153. The parameters of test signal (voltage, current, power factor) are specified in Table 6.5 (considering measuring ranges of the DUT being tested) together with the nominal (rated) voltage (U_{NOM}) and current (I_{NOM}) values of the DUT.

The diagram of connections between the State Primary Standard and the DUT is shown in Fig. A3, Appendix A.

The measurement error δ_P is calculated according to the formula:

$$\delta_P = [(P_X - P_{ref}) / P_{ref}] \cdot 100\ \%, \tag{11}$$

Where P_{ref} is the active power set in the State Primary Standard, W; P_X is the reading taken from the DUT, W.

The DUT passes the test, if the values of relative intrinsic measurement error δ_P do not exceed the limits of permissible measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.3.2 The relative intrinsic error in the direct (without AC current probes) measurements of three-phase active power (δ_{P3}) is determined when the measurement channels of the DUT are connected according to a single-phase scheme (3 voltage measurement circuits of the DUT are connected in parallel, and 3 current measurement circuits are connected in series).

The parameters of test signal are specified in Table 6.5 (considering measuring ranges of the DUT being tested) together with the nominal (rated) voltage (U_{NOM}) and current (I_{NOM}) values of the DUT.

The diagram of connections between the State Standard ГЭТ 153 and the DUT is shown in Fig. A1, Appendix A.

The measurement error δ_{P3} is calculated according to the formula:

$$\delta_{P3} = [(P_X/3 - P_{ref}) / P_{ref}] \cdot 100\%, \tag{12}$$

Where P_{ref} is the active power set in the State Primary Standard, W; P_X is the reading taken from the DUT, W.

Table 6.5

Measuring range		**Test signal parameters**		
U_{NOM}, V	**I_{NOM}, A**	**U, V**	**I, A**	**Cos φ**
800	5	600	5	1.0
480	5	480	5	1.0
480	5	480	5	0.5L
480	5	480	2.5	0.5C
240	1	220	1	1.0
240	1	220	1	0.5L
240	1	220	0.5	0.5C
240	1	220	0.1	0.5L
120	1	100	1	1.0
120	1	100	0.5	0.5L
120	1	100	0.5	0.5C
120	1	100	0.5	0.2C
120	1	100	0.5	0.2 L
60	5	66	6	1.0
60	5	60	2.5	0.5L
60	5	60	0.5	0.5C
30	1	30	1	0.5L
10	1	10	1	0.5C
5	1	5	1	1.0
1	1	1	1	1.0

The DUT passes the test, if the values of relative intrinsic measurement error δ_{P3} do not exceed the limits of permissible measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.3.3 The additional relative intrinsic error in measuring active power caused by crosstalk of measurement channels (δ_{P3Cr}) is determined only in the course of primary (post-manufacture) calibration. The error is determined on MTS ME 3.1K test system for each channel (A, B, and C). The parameters of test signal are as follows: frequency – 50 Hz; voltage – 220 V (U_{NOM} = 240 V); current – 1 A (I_{NOM} = 1 A); cos φ = 1.0 and cos φ = 0.5 (φ = 60° and φ = 300°). The diagram showing connections between the DUT and MTS ME 3.1K is given in Fig. A4, Appendix A.

The measurement error δ_{P3Cr} is calculated according to the formula:

$$\delta_{P3Cr} = \delta_{P1} - \delta_{P2}, \% \qquad (13)$$

Where δ_{P1} is the error in measuring active power; the error is determined for one measurement channel on the basis of readings taken from the reference meter of MTS ME 3.1K test system on condition that test voltage is applied only to the measurement channel under review, %;

δ_{P2} is the error in measuring active power; the error is determined for one measurement channel on the basis of readings taken from the reference meter of MTS ME 3.1K test system on condition that test voltage is applied to each of three measurement channels of the DUT, %.

The DUT passes the test, if the values of δ_{P3Cr} do not exceed 50% of the limits of permissible intrinsic measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.3.4 The relative intrinsic error in the contactless (with AC current probes) measurements of active power ($\delta_{P)}$ is determined for Energomonitors 3.1KM of modifications x-x-x1x in each of three measurement channels with use of MTS ME 3.1KM test system. The parameters of test signal are specified in Table 6.6 (considering measuring ranges of the DUT being tested) together with the values of nominal (rated) voltage U_{NOM} of the DUT for all test signals.

The diagram showing connections between the DUT and MTS ME 3.1KM test system is given in Fig. A5, Appendix A.

The AC current probes are connected to MTS ME 3.1K via accessory Blocks of calibrated coils (number of turns in a coil = n). Since the test current going through the coils is multiplied by n, the DUT shows the readings of current and power that are n times greater than the values set in MTS ME 3.1K.

The measurement error δ_P is calculated according to the formula:

$$\delta_P = [(P_X/n – P_{ref}) / P_{ref}] \cdot 100 \%, \qquad (14)$$

Where P_{ref} is the active power set in MTS ME 3.1K, W;

P_X is the reading taken from the DUT, W.

Table 6.6

Measure-ment range	**Parameters of test signal**		
U_{NOM}, V	**U, V**	**I, A**	**Cos φ**
800	480	$1.2I_{NOM}/n$	1.0
480	480	$1.2I_{NOM}/n$	1.0
480	480	$0.2I_{NOM}/n$	0.5L
480	480	$0.2I_{NOM}/n$	0.5C
240	220	$0.1I_{NOM}/n$	1.0
240	220	$0.05I_{NOM}/n$	0.5L
240	220	$0.05I_{NOM}/n$	0.5C
240	220	$0.01I_{NOM}/n$	1.0
240	220	$0.1I_{NOM}/n$	0.2C
240	100	$0.1I_{NOM}/n$	0.2L
120	100	I_{NOM}/n	0.5C
60	60	I_{NOM}/n	0.2C
30	30	I_{NOM}/n	0.2L
10	10	I_{NOM}/n	1.0
5	5	I_{NOM}/n	0.5L
2	2	I_{NOM}/n	0.5C
1	1	I_{NOM}/n	0.5L

The DUT passes the test, if the values of δ_P do not exceed the limits of permissible intrinsic measurement error represented in Tables B2, B4, or B6 (depending on the DUT modification), Appendix B.

6.4.3.5 The absolute intrinsic error in the measurements of power factor Δ_{PF} is determined according to the formula:

$$\Delta_{PF} = (\delta_P - \delta_S)\cdot PF/100 \%, \qquad (15)$$

Where δ_P is the relative intrinsic error in active power measurements (P), %;

δ_S is the relative intrinsic error in apparent power measurements (S), %;

PF = P/S is the power factor.

The DUTs passes the test, and the measurement error Δ_{PF} does not exceed its permissible limits, if the measurement errors δ_P and δ_S do not exceed their limits of permissible measurement error specified in:

Tables B1, B3 or B5 (depending on the DUT modification) – for the DUT tested without AC current probes;

Tables B2, B4 or B6 (depending on the DUT modification) – for the DUT of modifications x-x-x1x tested with AC current probes.

6.4.4 Determining intrinsic error in measuring AC frequency

The absolute intrinsic error in the measurements of AC frequency Δ_F is determined with a frequency meter (e.g. Ч3-63) in the “Measurement of period” mode. Measurements are carried out at the nominal (rated) values of voltage. The test values of frequency set in the Primary State Standard ГЭТ 153 are: 42.5; 53; 60, and 70 Hz. The DUT is set to the “Harmonics” or “Current PQP values” mode.

The diagram of connections between the DUT and Primary Standard is shown in Fig. A1, Appendix A.

The measurement error Δ_F is calculated by the formula:

$$\Delta_F = 1000/T_{ref} - f_1, \text{ Hz}, \quad (16)$$

Where T_{ref} is the reading taken from the electronic frequency meter, ms; f_1 is the reading taken from the DUT, Hz.

The DUT passes the test, if the values of Δ_F do not exceed the limits of permissible measurement error represented in Tables B1, B3, or B5 (depending on the DUT modification), Appendix B.

6.4.5 Determining intrinsic error in phase angle measurements

6.4.5.1 The absolute intrinsic error in the direct measurements (without AC current probes) of phase angle between the fundamental harmonics of voltage and current in the same phase $\Delta\varphi_{UI}$ (on condition that the angle equals zero) is determined with MTS ME 3.1KM test system using a reactance-free 1000 Ohm resistor (2 resistors C2-29B; 2 W; 2 kOhm ±1 % connected in parallel).

Connection of the DUT with the reactance-free resistor to MTS ME 3.1KM is shown in Fig. 6, Appendix A.

Set the generator of MTS ME 3.1K system to generate an AC voltage of 50V.

Set the DUT to measure phase angles.

The error in the measurements of phase angle between the fundamental harmonics of voltage and current in the same phase $\Delta\varphi_{UI}$ (provided that the angle equals zero) is calculated according to the formula:

$$\Delta\varphi_{UI} = \varphi_{UI} \quad (17)$$

Where φ_{UI} is the the value of phase angle between the fundamental harmonics of voltage and current in the same phase measured by the DUT.

The DUT passes the test if the value of absolute error $\Delta\varphi_{UI}$ does not exceed the values specified in Tables B1, B3 or B5 (depending on the DUT modification).

6.4.5.2 The absolute intrinsic error in the contactless (with AC current probes; for the Energomonitors 3.1KM of x-x-x1x modifications) measurements of phase angle between the fundamental harmonics of voltage and current in the same phase ($\Delta\varphi_{UI}$) on condition that the angle equals 45; 60; 300 and 315 degrees is determined with use of MTS ME 3.1K test system for each of 3 measurement channels. The parameters of test signal are specified in Table 6.9 (considering measuring ranges of the DUT being tested) along with the values of nominal (rated) voltages of the DUT.

Table 6.9

Measuring range	**Test signal parameters**		
U_{NOM}, V	**U, V**	**I, A**	**φ, °**
240	220	I_{NOM}/n	0
240	220	$0.5I_{NOM}/n$	45
240	220	$0.1I_{NOM}/n$	60
240	220	$0.05I_{NOM}/n$	-45
240	220	$0.1I_{NOM}/n$	-60

The connection diagram is shown in Fig. A2, Appendix A. The current channels of the DUT are connected to the generator via Blocks of calibrated coils (number of turns in a coil = n).

The measurement error $\Delta\varphi_{UI}$ is calculated by the formula:

$$\Delta\varphi_{UI} = \varphi_{UIref} - \varphi_{UI}, \text{ degrees}; \quad (18)$$

Where φ_{UIref} and φ_{UI} are the phase angle readings (in degrees) taken from the reference standard Energomonitor (as part of MTS ME 3.1KM) and from the DUT respectively.

The DUT passes the test if the values of absolute error $\Delta\varphi_{UI}$ do not exceed the permissible limits specified in Tables B2, B4 or B6 (depending on the DUT modification).

6.4.6 Determining intrinsic errors as applied to testing of voltage instrument transformers

The absolute intrinsic errors as applied to testing of voltage instrument transformers (VTs) are only determined for Energomonitors 3.1KM of x-x-xx1modification with use of MTS ME 3.1KM test system and comparator KHT-03.

The diagram showing how to connect the DUT and KHT-03 to MTS ME 3.1K is given in Fig. A7, Appendix A.

Enable the “mains synchronization” mode in the generator of MTS ME 3.1KM test system.

Enable the “Calibration of VTs” mode in the DUT.

In the DUT, select a measuring range represented in Table 6.10 by its nominal (rated) voltage U_{NOM}.

Successively (one by one) apply voltage test signals with the parameters specified in Table 6.10 from MTS ME 3.1K to the DUT and comparator KHT-03, each time performing “Zero correction” of measurement channels A and B in the DUT prior to testing. Select “Start measurement” in the DUT and measure modular and angle errors with the DUT and comparator KHT-3. Memorize the readings of comparator KHT-03 as reference readings (δ_{ref}) and the readings taken from the DUT as test readings (δ_{DUT}).

Table 6.10

Nominal voltage of the DUT (U_{NOM}), V	Parameters of test signals generated by MTS ME 3.1K			Expected values of modular and angle errors	
	U_A, V	U_B, V	φ_{UAB}, degrees	δ, %	θ, min
120	120	120	0.00	0.00	0.0
	120.24	120	0.17	0.20	10.0
	119.76	120	-0.17	-0.20	-10.0
120	100	100	0.00	0.00	0.0
	100.2	100	-0.17	0.20	-10.0
	99.8	100	0.17	-0.20	10.0
120	80	80	-0.17	0.00	-10.0
	80.16	80	0.17	0.20	10.0
	79.84	80	0.00	-0.20	0.0
60	60	60	0	0.00	0.0
	60.12	60	0.17	0.20	10.0
	59.88	60	-0.17	-0.20	-10.0

The absolute intrinsic modular δ_{CU} and angular θ_{CU} errors of the DUT are calculated according to the formulae:

$$\delta_{CU} = \delta_{DUT} - \delta_{ref}\text{ , \%} \qquad (19)$$

$$\theta_{CU} = \theta_{DUT} - \theta_{ref}\text{ , min;} \qquad (20)$$

Where: δ_{ref} and δ_{DUT} are the readings taken from KHT-03 and the DUT while measuring modular error, %;

θ_{ref} and θ_{DUT} are the readings taken from KHT-03 and the DUT while measuring angular error, min. The DUT passes the test if the values of intrinsic errors δ_{CU} and θ_{CU} do not exceed the values specified in Tables B7 and B8 (depending on the DUT modification), Appendix B.

6.4.7 Determining intrinsic errors as applied to testing of current instrument transformers

The absolute intrinsic errors as applied to testing of current instrument transformers (CTs) are only determined for Energomonitors 3.1KM of x-x-xx1modification complete with the accessory Current transformer calibration switch CTCS using MTS ME 3.1KM test system and comparator KHT-03.

The diagram showing how to connect the DUT, CTCS and KHT-03 to MTS ME 3.1K is given in Fig. A8, Appendix A.

Enable the “mains synchronization” mode in the generator of MTS ME 3.1KM test system.

Enable the “Calibration of CTs” mode in the DUT.

In the DUT, select a measuring range represented in Table 6.11 by its nominal (rated) current I_{NOM}.

Successively (one by one) apply current test signals with the parameters specified in Table 6.11 from MTS ME 3.1K to the DUT and comparator KHT-03, each time performing “Zero correction” of measurement channels A and B in the DUT prior to testing. Select “Start measurement” in the DUT and measure modular and angle errors with the DUT and comparator KHT-3. Memorize the readings of comparator KHT-03 as reference readings (δ_{Iref}, θ_{Iref}) and the readings taken from the DUT as test readings (δ_{IDUT}, θ_{IDUT}).

Table 6.11

Nominal Current of CTCS, A	Parameters of test signals generated by MTS ME 3.1K			Expected values of modular and angle errors	
	I_A, A	I_B, A	φ_{UAB}, degrees	δi, %	θi, min
10	6.01200	6.00000	0.17	0.2	10
5	4.99000	5.00000	-0.17	-0.2	-10
5	1.00200	1.00000	-0.17	0.2	-10
2.5	2.50500	2.50000	-0.17	0.2	-10
1	1.00200	1.00000	-0.17	0.2	-10
0.25	0.25050	0.25000	-0.25	0.2	-15
0.05	0.04990	0.05000	0.50	-0.2	30

The absolute intrinsic modular δ_{CI} and angular θ_{CI} errors of the DUT are calculated according to the formulae:

$$\delta_{CI} = \delta_{IDUT} - \delta_{Iref}\text{ , \%} \qquad (21)$$

$$\theta_{CI} = \theta_{IDUT} - \theta_{Iref}\text{ , min;} \qquad (22)$$

Where: δ_{Iref} and δ_{IDUT} are the readings taken from KHT-03 and the DUT while measuring modular error, %;

θ_{Iref} and θ_{IDUT} are the readings taken from KHT-03 and the DUT while measuring angle error, min.

The DUT passes the test if the values of intrinsic errors δ_{CI} and θ_{CI} do not exceed the values specified in Tables B7, B8 or B9 (depending on the DUT modification), Appendix B.

6.5 Performance testing of frequency outputs and pulse input

6.5.1 Performance testing of frequency outputs

6.5.1.1 Frequency output F_{OUT} (TTL) is tested when the DUT is in the “Active power” measurement mode. Testing is carried out with use of the State Primary Standard of AC power ГЭТ 153 and includes measuring the amplitude, duration and pulse repetition rate of a signal on the frequency output with the following equipment: oscillograph TDS 1012, frequency meter Ч3-63, and resistor C2-23 0.25 W; 10 kOhm ±5% (R_1), which is connected to the tested output.

In the DUT, select the measurement ranges U_{NOM} = 60 V and I_{NOM} = 5 A; for the internal frequency divider, select division ratio =1 (no division). In the State Primary Standard, select the parameters of test signal as specified in Table 6.12.

Table 6.12

Test signal parameters			
U, V	**I, A**	**Cos φ**	**P, W**
66	5.051	1	1000

The amplitude and pulse duration readings are taken from the oscillograph. The readings of pulse repetition rate are taken from frequency meter Ч3-63.

The DUT passes the performance test if the following conditions are fulfilled:

Signal on the frequency output (F_{OUT} (TTL)) is a sequence of voltage square pulses of positive polarity with the characteristics as follows (provided that the resistance of output load is at least 10 kOhm):

- Logical 0 – U_0 < 0.4 V;
- Logical 1 – U_1 > 4.0 V;
- Pulse duration – (14 ± 2) microseconds;
- Pulse repetition ratio of the signal on the frequency output is proportional to the measured active power (P) and equals (13.33333 · P ± 0.5) Hz.

6.5.1.2 Frequency output F_{OUT} (TM) is tested when the DUT is in the “Active power” measurement mode. Testing is carried out with use of the State Primary Standard of AC power ГЭТ 153. Test procedure consists of measuring the output resistance in the “closed” and “open” states and measuring the pulse duration and pulse repetition rate of a signal on the tested output with the following equipment: oscillograph TDS 1012, frequency meter Ч3-63, and resistor C2-23 0.25 W; 3.9 kOhm ±5 % (R_2), which is placed between the “open collector” terminal of F_{OUT} (TM) and “plus” terminal of the DC power supply 24V (the “minus” terminal of the DC power supply is connected to the second terminal of F_{OUT} (TM)).

In the DUT, select the measurement ranges U_{NOM} = 60 V and I_{NOM} = 5 A; for the internal frequency divider, select division ratio =1 (no division). In the State Primary Standard, select the parameters of test signal as specified in Table 6.12.

With oscillograph TDS 1012, measure the voltage drop across F_{OUT} (TM) when the output is in the “closed” state, voltage drop across the resistor R_2 when it is in the “open” state, and pulse duration of the output pulse sequence.

Measure the pulse repetition rate on F_{OUT} (TM) output with frequency meter Ч3-63.

The DUT passes the performance test if the following conditions are fulfilled:

- Voltage drop across F_{OUT} (TM) does not exceed 1.17V in the “closed” state, i.e. the resistance of the output circuit does not exceed 200 Ohm);
- Voltage drop across the resistor R_2 when F_{OUT} (TM) is in the “open” state does not exceed 1.73V, i.e. the resistance of the output circuit does not exceed 50 kOhm.
- Pulse duration is (14 ± 2) microseconds;
- Pulse repetition ratio of the signal on the frequency output is proportional to the measured active power (P) and equals (13.33333 · P ± 0.5) Hz.

6.5.2 Performance testing of pulse input

Pulse input is tested while the DUT is in the “Calibration of meters” mode. Testing is carried out with use of the State Primary Standard of AC power ГЭТ 153 and generator Г6-33. The diagram showing connections among the above-mentioned devices is given in Fig. A1, Appendix A.

In the DUT, select the measurement ranges U_{NOM} = 60 V and I_{NOM} = 5 A. Go to the meter calibration entry screen and enter the value of meter constant = 36000 imp/kWh. Go to the “meter calibration start” screen and enter the number of input (meter-under-test) pulses =100. For the internal frequency divider, select division ratio =1 (no division). In the State Primary Standard, select the parameters of test signal as specified in Table 6.12.

Connect the F_{in} connector on the DUT to the output III of the generator Г6-33. Apply test signal to the F_{in} connector of the DUT. The test signal is a sequence of square pulses with the following characteristics: amplitude – 3.5 to 5 V; duration – at least 10 microseconds; frequency – (10 ± 0.001) Hz. Select “Start measurement” in the “Meter calibration” screen of the DUT.

The value of measurement error will be displayed in up to 10 seconds as (0.00 ± δ) %, where δ is the limit of permissible intrinsic error (relative) in measuring active power specified in Table B1, B3, or B5 (depending on the DUT modification).

Apply test signals to the F_{in} connector of the DUT as follows:

- Frequency (11.000 ± 0.001) Hz; the value of the measurement error will be indicated as (10.00 ± δ) %;
- Frequency (9.000 ± 0.001) Hz; the value of the measurement error will be indicated as (-10.00 ± δ) %.

The DUT passes the test if the indicated values of measurement error do not exceed the ranges mentioned above.

6.6 Testing of firmware

6.6.1 The firmware (FW) module of the DUT is tested by checking the following identification data for consistency:

- Name of the metrologically significant FW component;
- Version of the metrologically significant FW component;
- Checksum of the metrologically significant FW component.

The identification information on the metrologically insignificant FW component is given just for reference and is not checked.

6.6.2 The FW is identified in the following steps:

- Prepare the DUT for operation as described in its User’s manual;
- Power up the DUT; after applying power the display backlight is turned on and a “power up” screen appears in 1…5 seconds (at the conclusion of initialization and initial configuration procedures). The “power up” screen contains manufacturer’s name and logo, device type, its accuracy option (02, 05, or 10), firmware version (2.01) and identification number (its last three digits relate to the manufacturer’s code);
- Press the ENT key to display the password screen;
- Enter the 2nd level password (the default one is 222222222; if the customer has changed the 2nd level password, it is necessary to restore the default one prior to sending the DUT for calibration);
- Press ENT to go to the “Circuit connection” screen;
- Press ENT to go to the main menu;
- Select “Extra settings” from the main menu;
- Select the “About” option; the display will show:

Identification code;

Firmware version (e.g. 2.01),

M-PROG CRC — Cyclic Redundancy Checksum for the metrologically significant firmware components;

PROG CRC — Cyclic Redundancy Checksum for the firmware module;

Identification number of the instrument (xxx.xxx.xxx).

6.6.3 The DUT passes the test if the displayed name of the DUT (considering its accuracy option), number of its FW version (**VERSION**) and Cyclic Redundancy checksum (**M-PROG CRC**) of the firmware match those pictured in Fig. 1 and Fig. 2.

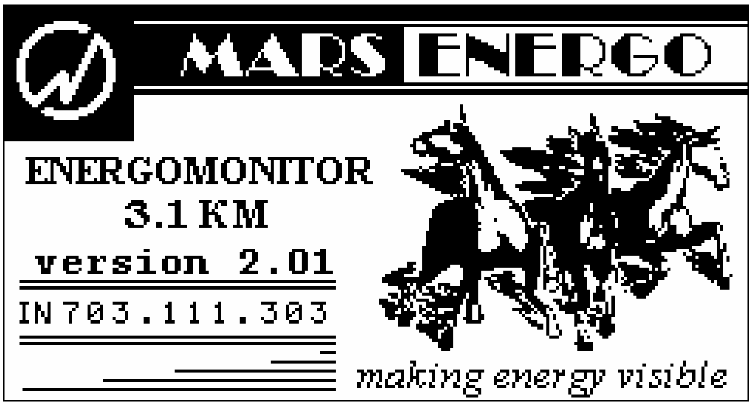

Fig. 1

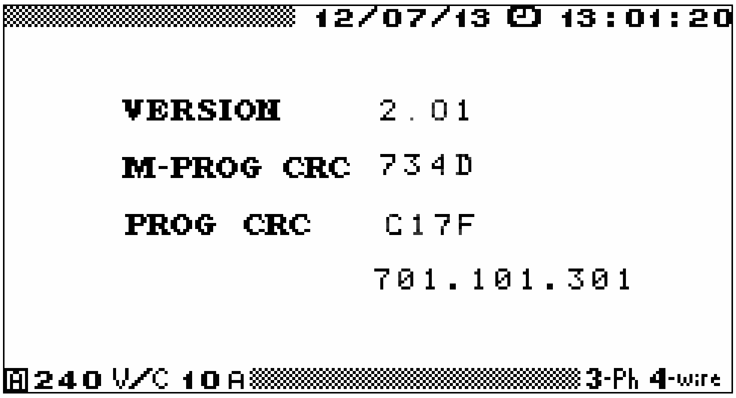

Fig. 2

7 DOCUMENTING CALIBRATION RESULTS

7.1 If calibration results are considered good, the DUT is accepted for operation and provided with a Calibration Certificate.

7.2 The enclosure of the DUT is sealed by the calibrator’s stamp.

7.3 The results of calibration and date of calibration are entered in the appropriate page of the User’s manual and confirmed by the calibrator’s stamp.

7.4 If the DUT fails on even one of the calibration criteria, it is withdrawn from operation and provided with a notification of unsuitability that includes the reasons of the withdrawal. The previous calibrator’s stamp is canceled.

7.5 A sample calibration report is given in Appendix B.

Appendix A

Connection diagrams

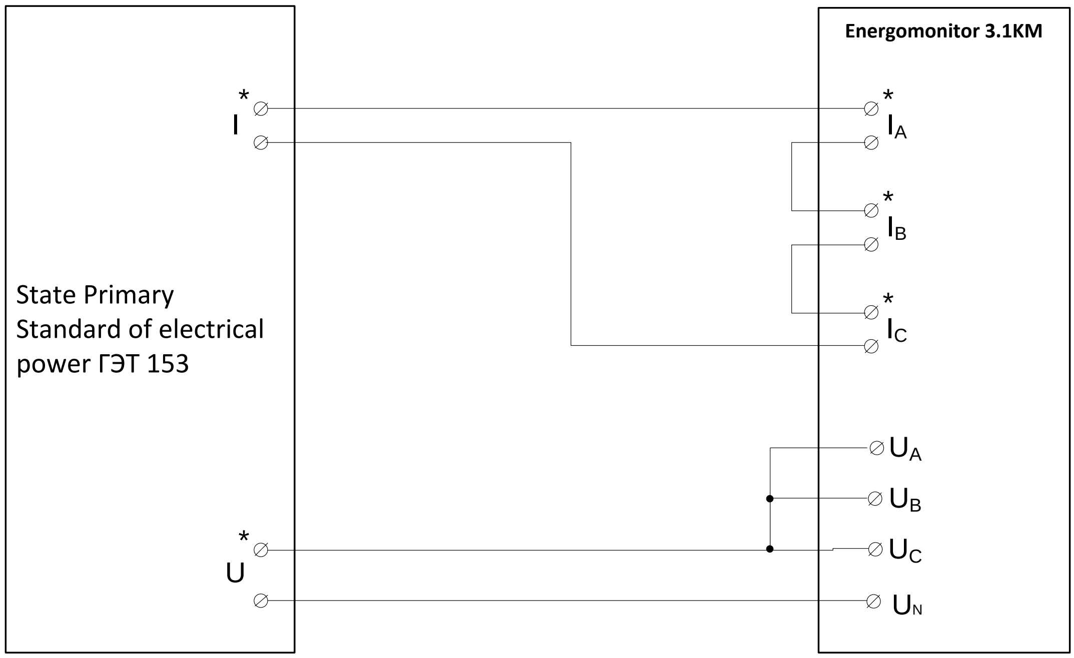

Fig.A1 Connecting the DUT to the State Primary Standard ГЭТ153
(three-phase 4-wire configuration)

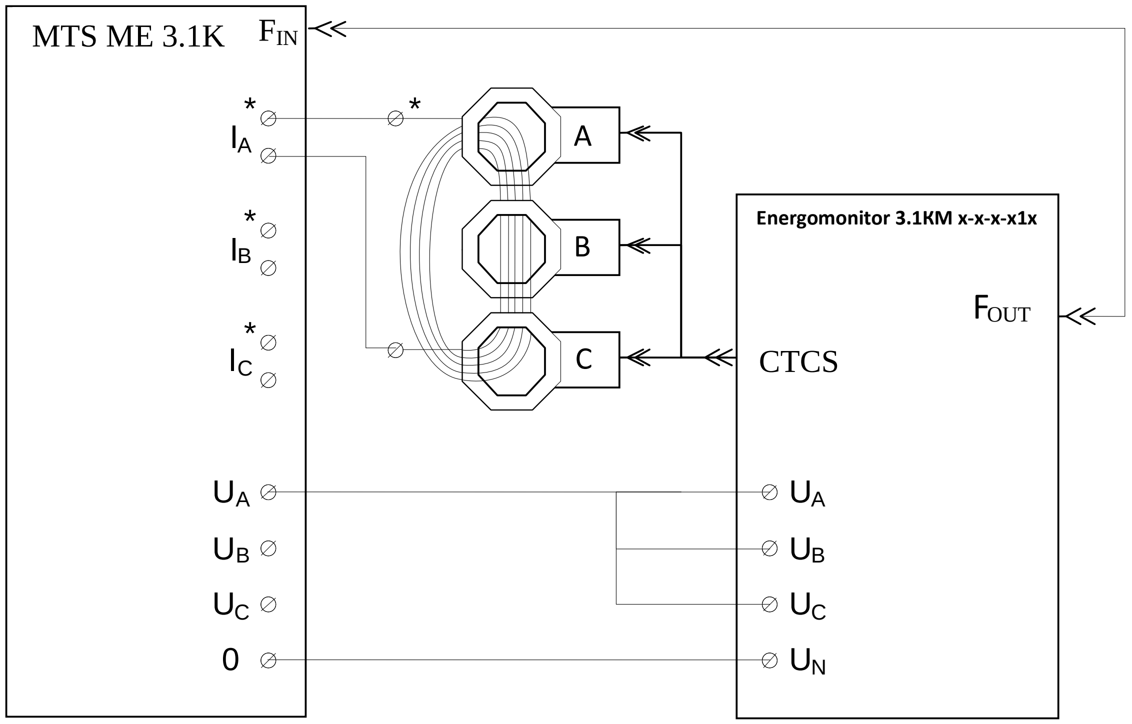

Fig. A2 Connecting the DUT to the MTS ME 3.1KM test system using AC current probes
(three-phase 4-wire configuration)

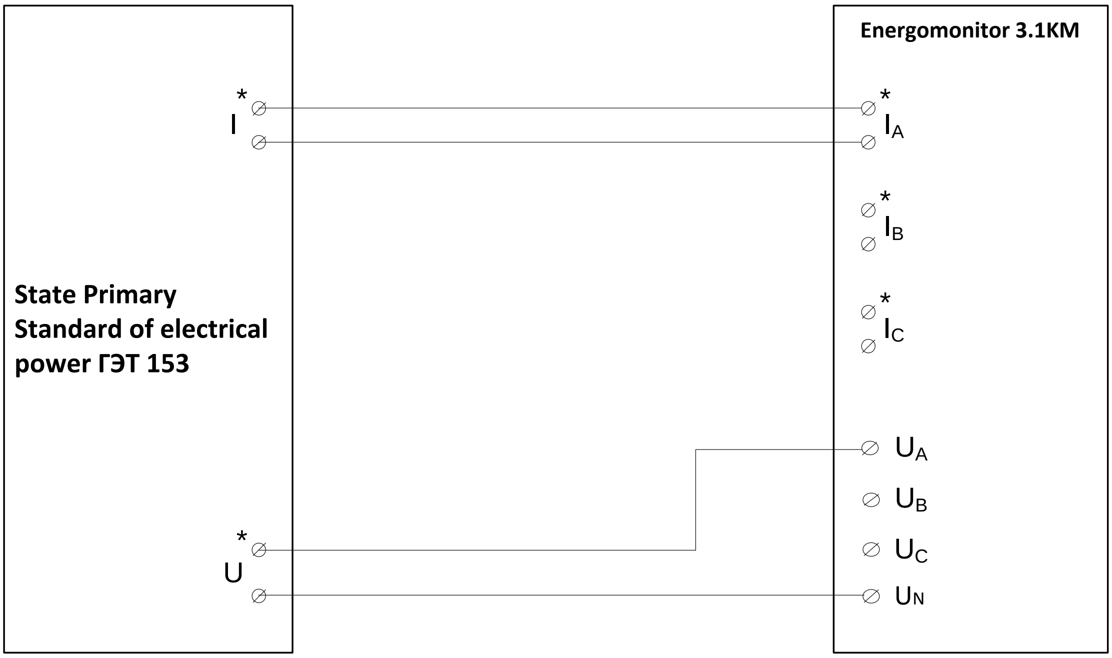

Fig. A3 Connecting the DUT to the State Standard ГЭТ153
(single-phase 2-wire configuration)

The figure shows the State Standard ГЭТ153 connected to phase A of the DUT – terminals “U_A” and “I_A” of the EM 3.1KM are connected to terminals “* **~U**” and “* **~I**” of the Standard respectively.

To connect the State Standard ГЭТ153 to phase B, connect terminals “U_B” and “I_B” of the EM 3.1KM to terminals “* **~U**” and “* **~I**” of the Standard respectively.

To connect the State Standard ГЭТ153 to phase C, connect terminals “U_C” and “I_C” of the EM 3.1KM to terminals “* **~U**” and “* **~I**” of the Standard respectively.

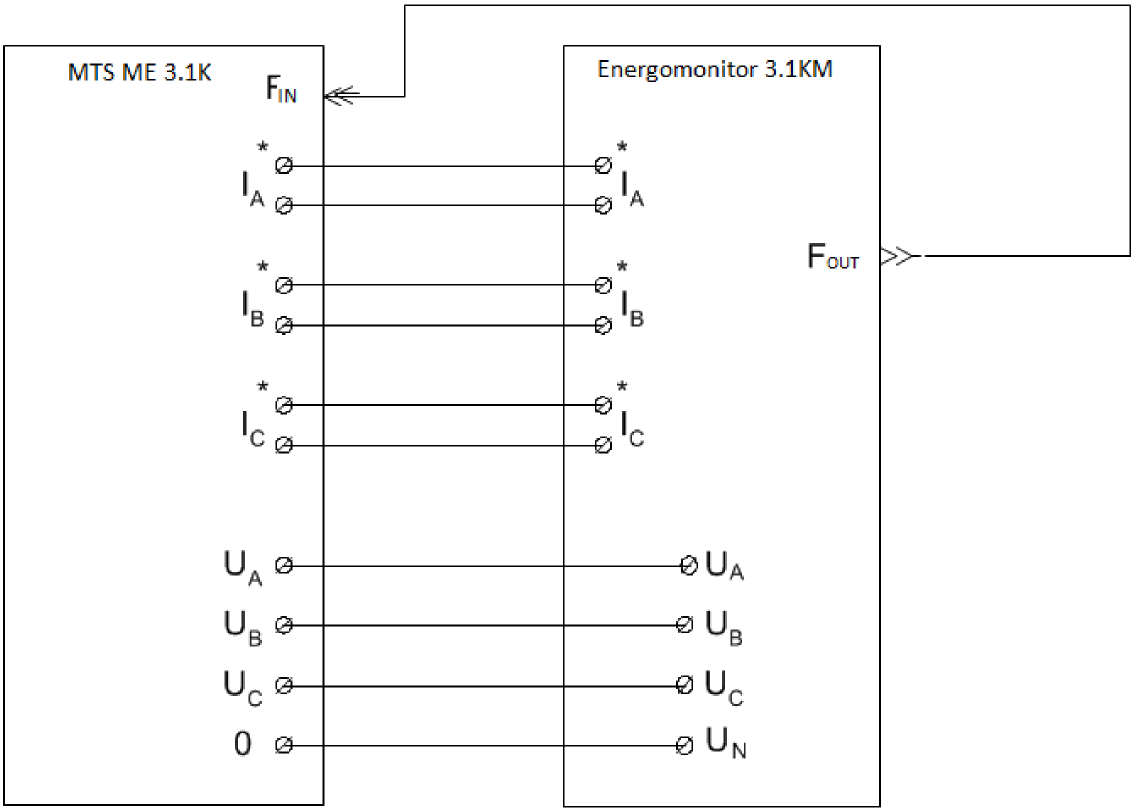

Fig. A4 Connecting the DUT to MTS ME 3.1K test system

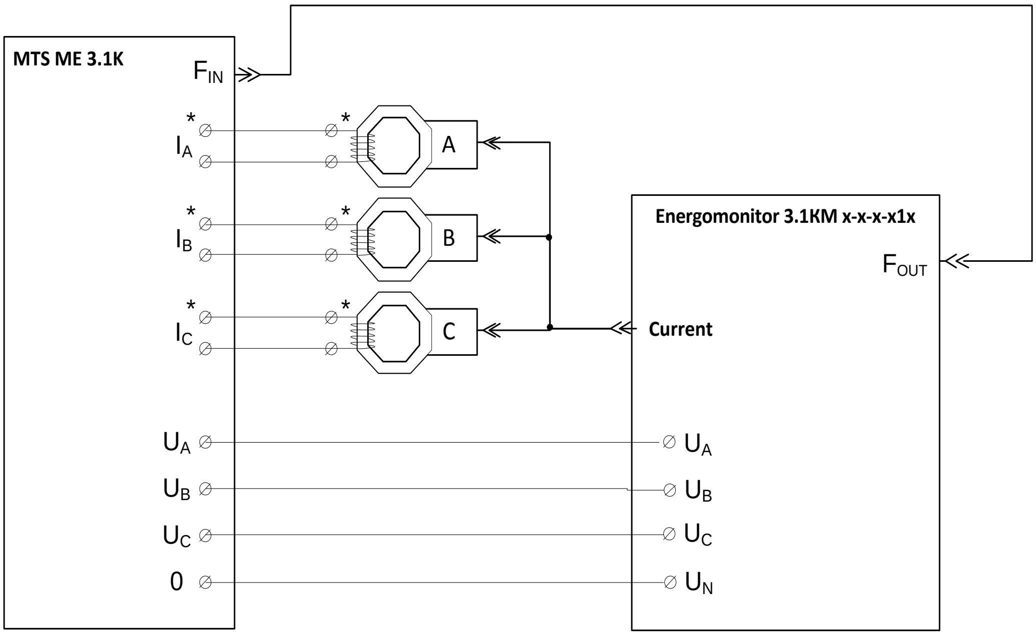

Fig. A5 Connecting the DUT to MTS ME 3.1K test system using AC current probes (three-phase configuration)

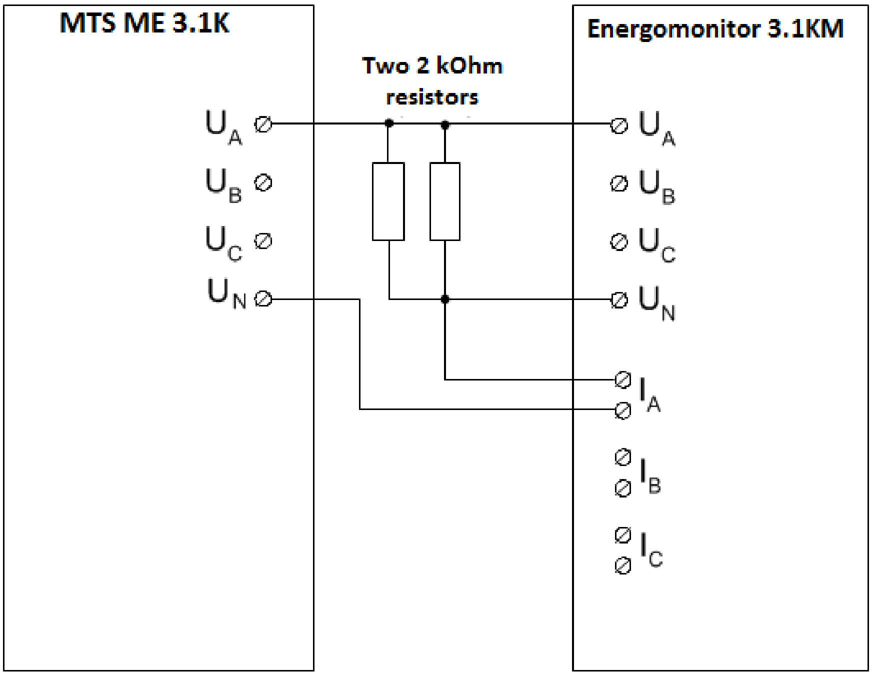

Fig. A6 Connecting the DUT to MTS ME 3.1K test system for determining the absolute error in measuring phase angle between the 1st voltage and 1st current harmonics

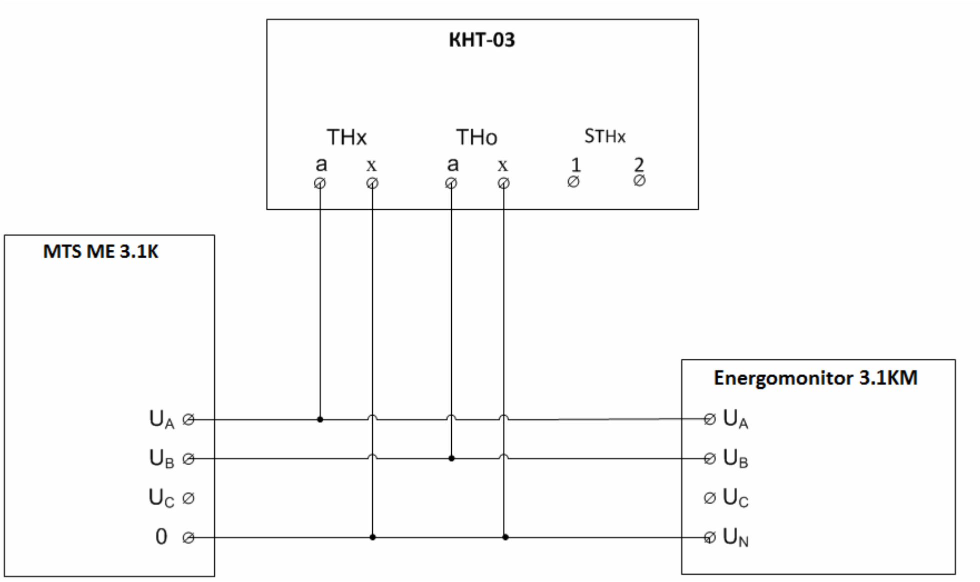

Fig. A7 Connecting the DUT for determining VT modular and angle errors

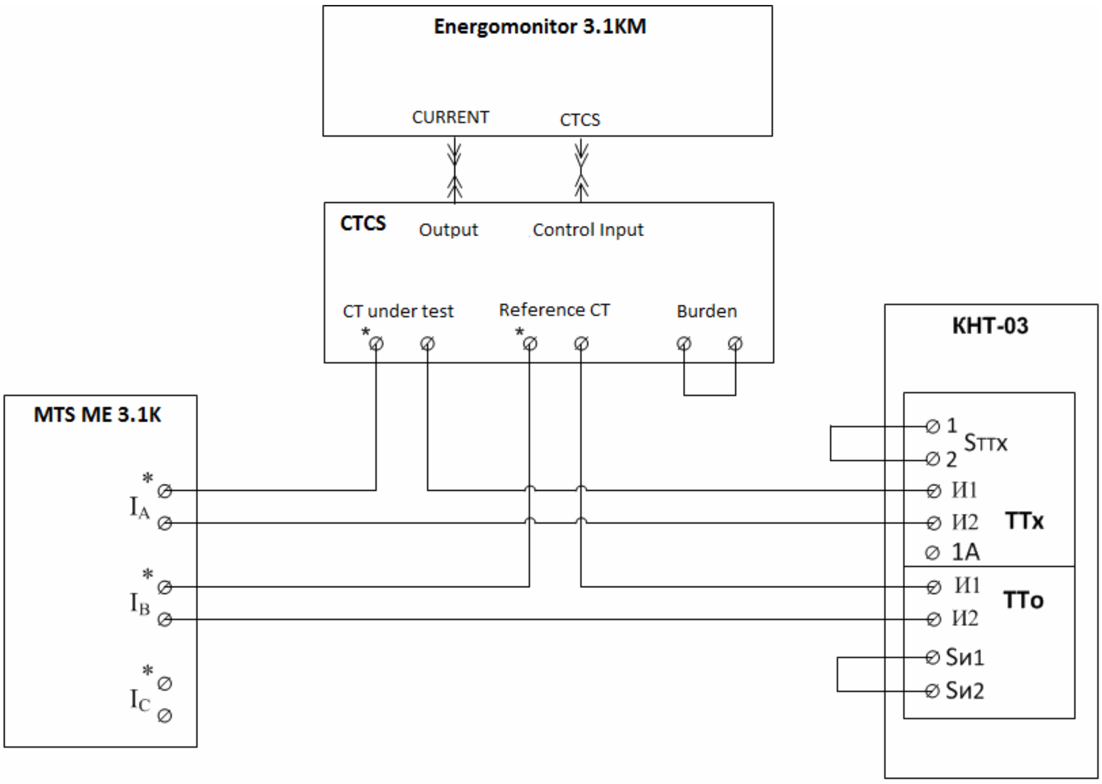

Fig. A8 Connecting the DUT for determining CT modular and angle errors

Appendix B

Table B1

Measurement ranges and limits of permissible measurement errors for EM3.1KM-x-02 (without AC current probes)

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
1 RMS of AC voltage and RMS of fundamental voltage harmonic (U), V	$0.1U_N$ to $1.2U_N$	Relative, %	
		$\pm[0.01+0.002(1.2U_N/U-1)]$	$U_N > 2$ V U_N – nominal voltage
		$\pm[0.015+0.003(1.2U_N/U-1)]$	$U_N \leq 2$ V
2 RMS of AC current and RMS of fundamental current harmonic (I), A	$0.1I_N$ to $1.2I_N$	Relative, % $\pm[0.01+0.002(1.2I_N/I-1)]$	I_N – nominal current
3 Active power and Active power of fundamental harmonic (P), W	$0.1U_N$ to $1.2U_N$; $0.1I_N$ to $1.2I_N$	Relative, %	$P_N = U_N \cdot I_N$
			$0.9 \leq \lvert\cos\varphi\rvert \leq 1.0$
		$\pm[0.01+0.004(1.44P_N/P - 1)]$	$U_N > 2$ V
		$\pm[0.02+0.004(1.44P_N/P - 1)]$	$U_N \leq 2$ V
			$0.2 \leq \lvert\cos\varphi\rvert < 0.9$
		$\pm[0.015+0.004(1.44P_N/P - 1)]$	$U_N > 2$ V
		$\pm[0.025+0.004(1.44P_N/P - 1)]$	$U_N \leq 2$ V
4 Reactive power and Reactive power of fundamental harmonic [1)] (Q), Var		Relative, %	$Q_H = U_N \cdot I_N$
		$\pm[0.03+0.01(1.44Q_N/Q - 1)]$	$0.9 \leq \lvert\sin\varphi\rvert \leq 1.0$
		$\pm[0.05+0.01(1.44Q_N/Q - 1)$	$0.2 \leq \lvert\sin\varphi\rvert < 0.9$
5 Apparent power (S), VA		Relative, %	
		$\pm[0.02+0.005(1.2U_N/U+1.2I_N/I-2)]$	$U_N > 2$ V
		$\pm[0.025+0.01(1.2U_N/U+1.2I_N/I-2)]$	$U_N \leq 2$ V
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute ±0.001	$0.2I_N$ to $1.2I_N$; $0.2U_N$ to $1.2U_N$
7 AC frequency (f_1), Hz	40 to 70	Absolute, Hz ±0.001	$0.2I_N$ to $1.2I_N$; $0.2U_N$ to $1.2U_N$
8 Phase angle between fundamental harmonics of:	0 to 360	Absolute, degree	
- Input voltages, degrees		±0.01	$0.2U_N$ to $1.2U_N$
- Voltage and current in the same phase, degrees		±0.01	$0.2I_N$ to $1.2I_N$; $0.2U_N$ to $1.2U_N$
9 RMS of voltage harmonic of order h [2)], h =2…50 ($U_{H,h}$), V	0 to $0.6U_N$	Absolute, V $\pm0.0005\ U_N$	$U_{H,h} \leq 0.01U_N$
		Relative, %; ±0.05	$U_{H,h} > 0.01U_N$
10 RMS of voltage interharmonic of order m (frequency $m\cdot f_1$), m = 0.5…50.5 in 1.0 increments ($U_{C,m}$), V	0 to $0.15U_N$	Absolute, V $\pm0.001\ U_N$	$U_{C,m} \leq 0.01U_N$
		Relative, % ±0.1	$U_{C,m} > 0.01U_N$
11 RMS of current harmonic of order h, h = 2 to 50 ($I_{H,h}$), A	0 to $0.6I_N$	Absolute, A $\pm0.0005\ I_N$	$I_{H,h} \leq 0.01I_N$
		Relative, % ±0.05	$I_{H,h} > 0.01I_N$

Table B1

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
12 RMS of current interharmonic of order m (frequency $m \cdot f_1$), m=0.5…50 in 1.0 increments ($I_{C,m}$), A	0 to $0.15I_N$	Absolute, A ±0.0005 I_N	$I_{C,m} \le 0.01U_N$
		Relative, % ±0.05	$I_{C,m} > 0.01U_N$
13 Phase angle between h^{th} voltage and h^{th} current harmonics in the same phase, degrees	0 to 360	Absolute, degrees	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h)$ = 2…15% $K_U(h)$ = 2 … 15 %
		±0.3	h = 2 … 10
		±1.0	h = 11 … 50
14 Voltage harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_U(h)$], %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, % ±0.003	$K_U(h) < 1.0$
		Relative, % ±0.3	$K_U(h) \geq 1.0$
15 Current harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_I(h)$], %	0 to 49.9		$0.2I_N$ to $1.2I_N$
		Absolute, % ±0.003	$K_I(h) < 1.0$
		Relative, % ±0.3	$K_I(h) \geq 1.0$
16 Active power of h^{th} harmonic; h = 2 … 50 ($P_{(h)}$), W	0 to $0.05P_N$	Absolute, W ±($0.00003P_N + 0.005P_{(h)}$)	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ |cos φ| = 0.5 … 1.0 $K_I(h)$ = 1 … 40% $K_U(h)$ = 1 … 40 %
17 Total Harmonic Distortion of voltage (THD_U), %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, % ±0.003	$THD_U < 1.0$
		Relative, % ±0.3	$THD_U \geq 1.0$
18 Total Harmonic Distortion of current (THD_I), %	0 to 49.9		$0.2I_N$ to $1.2I_N$
		Absolute, %: ±0.01	$THD_I < 1.0$
		Relative, %: ±1.0	$THD_I \geq 1.0$
19 Negative sequence voltage ratio (K_{2U}) and zero sequence voltage ratio (K_{0U}), %	0 to 15	Absolute, % ±0.05	$0.5U_N$ to $1.2U_N$
20 Positive sequence voltage of fundamental harmonic ($U_{1(1)}$), V	0 to U_N	Absolute, V ±($0.0002\ U_N \times \sqrt{3}$)	
21 Zero sequence voltage of fundamental harmonic ($U_{0(1)}$), V	0 to U_N	Absolute, V ±0.0005 U_N	$0.5U_N$ to $1.2U_N$ K_{2U} < 15 %; K_{0U} < 15 %
22 Negative sequence voltage of fundamental harmonic ($U_{2(1)}$), V	0 to U_N	Absolute, V ±($0.0003\ U_N \cdot \sqrt{3}$)	
23 Positive sequence current of fundamental harmonic ($I_{1(1)}$), A	0 to I_N	Absolute, A ±$0.0002I_N$	
24 Zero sequence current of fundamental harmonic ($I_{0(1)}$), A	0 to I_N	Absolute, A ±$0.0005I_N$	

Table B1

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
25 Negative sequence current of fundamental harmonic ($I_{2(1)}$), A	0 to I_N	Absolute, A $\pm 0.0003 I_N$	
26 Phase angle between voltage and current of positive, or negative, or zero sequence, degrees	0 to 360	Absolute, degrees ±0.3	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$ $I_{1(1)}, I_{2(1)}, I_{0(1)} \geq 0.02\ I_N$ $U_{1(1)}, U_{2(1)}, U_{0(1)} \geq 0.02\ U_N$
27 Flicker short-term severity, relative units	0.2 to 10	Relative, % 5.0	$f = (f_{NOM} \pm 1)$ Hz $\Delta U/U \leq 20$ %, provided that voltage waveforms are meander-like
28 DC voltage (U), V		Relative, %	
	$0.1U_N$ to $1.7U_N$	$\pm[0.01+0.005(1.7U_N/U-1)]$	U_N from 5 to 480 V
		$\pm[0.015+0.005(1.7U_N/U-1)]$	$U_N \leq 2$ V
	$0.1U_N$ to $1.25U_N$	$\pm[0.015+0.005(1.25U_N/U-1)]$	$U_N = 800$ V
29 DC current [3] (I), A	$0.1I_N$ to $1.2I_N$	Relative, % $\pm[0.015+0.005(1.2I_N/I - 1)]$	$I_N = 100$ A
	$0.1I_N$ to $1.5I_N$	Relative, % $\pm[0.015+0.005(1.5I_N/I - 1)]$	$I_N < 100$ A
30 DC power [3] (P), W		Relative, %	
	$0{,}01P_N$ to $2.04P_N$	$\pm[0.03+0.005(2.04P_N/P-1)]$	U_N up to 480 V; I_N=100 A $0.1U_N$ to $1.7U_N$ $0.1I_N$ to $1.2I_N$
	$0.01P_N$ to $2.55P_N$	$\pm[0.03+0.005(2.55P_N/P-1)]$	U_N up to 480 V; $I_N < 100$ A $0.1U_N$ to $1.7U_N$ $0.1I_N$ to $1.5I_N$
	$0.01P_N$ to $1.5P_N$	$\pm[0.03+0.005(1.5P_N/P-1)]$	$U_N = 800$ V; $I_N = 100$ A $0.1U_N$ to $1.25U_N$ $0.1I_N$ to $1.2I_N$
	$0.01P_N$ to $1.875P_N$	$\pm[0.03+0.005(1.875P_N/P-1)]$	$U_N = 800$ V; $I_N < 100$ A $0.1U_N$ to $1.25U_N$ $0.1I_N$ to $1.5I_N$

Notes:

1 Reactive power is calculated by 3 methods: method of cross-connection, geometrical and phase shift (voltage is shifted by ¼ T, where T is the fundamental period) methods.

2 Frequency of the h^{th} harmonic equals $h \cdot f_1$.

3 Parameters marked [3] are only measured by instruments of EM3.1KM x-02-1 modification.

4 Figures specified in the table are valid only if amplitude values of input voltage and current do not exceed 170% of the nominal values of measurement ranges (U_N and I_N respectively).

Table B2

Measurement ranges and limits of permissible measurement errors for EM3.1KM-x-02-x-x1x equipped with AC current probes

Measured parameter	Measure-ment range	Error type and measure-ment unit, limits of permis-sible intrinsic measurement error	Note
1 RMS of AC voltage and RMS of fundamental voltage harmonic (U), V	$0.1U_N$ to $1.2U_N$	Relative, %	
		$\pm[0.01+0.002(1.2U_N/U-1)]$	$U_N > 2$ V
		$\pm[0.015+0.003(1.2U_N/U-1)]$	$U_N \leq 2$ V
2 RMS of AC current and RMS of fundamental current harmonic (I), A	$0.05I_N$ to $1.2I_N$	Relative, % $\pm[0.1+0.01(I_N/I-1)]^{I}$ $\pm[0.2+0.02(I_N/I-1)]^{II}$ $\pm[0.5+0.05(I_N/I-1)]^{III}$ $\pm[1.0+0.05(I_N/I-1)]^{IV}$ $\pm[2.0+0.1(I_N/I-1)]^{V}$	
3 Active power and Active power of fundamental harmonic (P), W	$0.01(U_N \cdot I_N)$ to $1.44(U_N \cdot I_N)$	Relative, %	$0.1U_N$ to $1.2U_N$
			$0.9 < \lvert\cos\varphi\rvert \leq 1.0$
		$\pm0.2^{I}$; $\pm0.4^{II}$; $\pm1.0^{III}$	$0.01I_N$ to $0.05I_N$
		$\pm0.1^{I}$; $\pm0.2^{II}$; $\pm0.5^{III}$; $\pm1.0^{IV}$; $\pm2.0^{V}$	$0.05I_N$ to$1.2I_N$
			$0.5 \leq \lvert\cos\varphi\rvert \leq 0.9$
		$\pm0.25^{I}$; $\pm0.5^{II}$;	$0.02I_N$ to $0.1I_N$
		$\pm0.15^{I}$; $\pm0.3^{II}$; $\pm1.0^{III}$; $\pm2.0^{IV}$; $\pm4.0^{V}$	$0.1I_N$ to $1.2I_N$
		$\pm[0.25+0.02(1.44P_N/P-1)]^{I,}$ $\pm[0.5+0.05(1.44P_N/P-1)]^{II}$ $\pm[1.0+0.1(1.44P_N/P-1)]^{III}$ $\pm[2.0+0.1(1.44P_N/P-1)]^{IV}$	$0.2 \leq \lvert\cos\varphi\rvert < 0.5$; $0.1I_N$ to$1.2I_N$
4 Reactive power and Reactive power of fundamental harmonic [1)](Q), Var		Relative, %	$0.1U_N$ to $1.2U_N$
			$0.9 < \lvert\sin\varphi\rvert \leq 1.0$
		$\pm0.3^{I}$; $\pm0.75^{II}$; $\pm1,5^{III}$;	$0.02I_N$ to $0.05I_N$
		$\pm0.2^{I}$; $\pm0.5^{II}$; $\pm1,0^{III}$; $\pm2.0^{IV}$; $\pm2.0^{V}$	$0.05I_N$ to $1.2I_N$
			$0.5 \leq \lvert\sin\varphi\rvert \leq 0.9$
		$\pm0.3^{I}$; $\pm0.75^{II}$; $\pm1.5^{III}$;	$0.02I_N$ to $0.1I_N$
		$\pm0.2^{I}$; $\pm0.5^{II}$; $\pm1.0^{III}$; $\pm2.0^{IV}$; $\pm2.0^{V}$	$0.1I_N$ to $1.2I_N$
		$\pm0.3^{I}$; $\pm0.75^{II}$; $\pm1.5^{III}$; $\pm2.5^{IV}$; $\pm2.5^{V}$	$0.2 \leq \lvert\sin\varphi\rvert < 0.5$ $0.1I_N$ to$1.2I_N$
5 Apparent power (S), VA		Relative, %	$0.1U_N$ to $1.2U_N$ $0.01I_N$ to $1.2I_N$
		$\pm0.2^{I}$; $\pm0.4^{II}$; $\pm1.0^{II}$	$S < 0.1S_N$
		$\pm0.1^{I}$; $\pm0.2^{II}$; $\pm0.5^{III}$ $\pm1.0^{IV}$; $\pm2.0^{V}$	$0.1S_N$ to $1.44S_N$
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute $\pm0.02^{I}$; $\pm0.02^{II}$; $\pm0.05^{III}$; $\pm0.05^{IV}$; $\pm0.10^{V}$	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
7 AC frequency (f_1), Hz	40 to 70	Absolute, Hz ±0.001	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$

Table B2

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
8 Phase angle between fundamental harmonics of:	0 to 360	Absolute, degrees	
- Input voltages, degrees		±0.01	$0.2U_N$ to $1.2U_N$
- Voltage and current in the same phase, degrees		±0.5	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
9 RMS of voltage harmonic of order h[2)], h = 2 … 50 ($U_{H,h}$), V	0 to $0.6U_N$	Absolute, V: ±0.0005 U_N	$U_{H,h} \leq 0.01U_N$
		Relative, %: ±0.05	$U_{H,h} > 0.01U_N$
10 RMS of voltage interharmonic of order m (frequency $m \cdot f_1$), m = 0.5…50.5 in 1.0 increments ($U_{C,m}$), V	0 to $0.15U_N$	Absolute, V ±0.0005 U_N	$U_{C,m} \leq 0.01U_N$
		Relative, %, ±0.05	$U_{C,m} > 0.01U_N$
11 RMS of current harmonic of order h, h = 2 to 50 ($I_{H,h}$), A	0 to $0.6I_N$	Absolute, A $\pm 0.02\ I_H^{\ I}$; $\pm 0.04\ I_N^{\ II}$	$I_{H,h} \leq 0.01I_N$
		Relative, %, ±5 %^{I}; ±10 %^{II}	$I_{H,h} > 0.01I_N$
12 RMS of current interharmonic of order m (frequency $m \cdot f_1$), m=0.5…50 in 1.0 increments ($I_{C,m}$), A	0 to $0.15I_N$	Absolute, A $\pm 0.02\ I_H^{\ I}$; $\pm 0.04\ I_H^{\ II}$	$I_{C,m} \leq 0.01I_N$
		Relative, % ±5 %^{I}; ±10 %^{II}	$I_{C,m} > 0.01I_N$
13 Phase angle between h^{th} voltage and h^{th} current harmonics in the same phase, degrees	0 to 360	Absolute, degrees	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h) \geq 5\%$; $K_U(h) \geq 1\%$
		±2^{I}; ±2^{II}	h = 2 … 10
		±10^{I}; ±10^{II}	h = 11 … 20
		±20^{I}; ±20^{II}	h = 21 … 50
14 Voltage harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_U(h)$], %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, %: ±0.003 %	$K_U(h) < 1.0$
		Relative, %: ±0.3	$K_U(h) \geq 1.0$
15 Current harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_I(h)$], %	0 to 49.9		$0.2I_N$ to $1.2I_N$
		Absolute, % ±0.05^{I}; ±0.05^{II}	$K_I(h) < 1.0$
		Relative, % ±5.0^{I}; ±5.0^{II}	$K_I(h) \geq 1.0$
16 Total Harmonic Distortion of voltage (THD_U), %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, %: ±0.003	$K_U < 1.0$
		Relative, %: ±0.3	$K_U \geq 1.0$
17 Total Harmonic Distortion of current (THD_I)	0 to 49.9		$0.2I_N$ to $1.2I_N$
		Absolute, %,: ±0.1	$THD_I < 1.0$
		Relative, %: ±10	$THD_I \geq 1.0$

Table B2

Measured parameter	Meas-urement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
18 Active power of hth harmonic; h = 2 … 50 ($P_{(h)}$), W	$0.003P_N$ to $0.1P_N$	Relative, %	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h)$ = 1 … 40% $K_U(h)$ = 1 … 40 %
		±5.0 ^{I}; ±10.0 ^{II}	|cos φ| = 0.9 … 1.0 h = 2 … 50
			|cos φ| = 0.5 … 0.9
		±5.0 ^{I}; ±10.0 ^{II}	h = 2 … 10
		±10.0 ^{I}; ±20.0 ^{II}	h = 11 … 50
19 Positive sequence voltage of fundamental harmonic ($U_{1(1)}$), V	0 to U_N	Absolute, V ±(0.0002 U_H ×√3)	
20 Zero sequence voltage of fun-damental harmonic ($U_{0(1)}$), V	0 to U_N	Absolute, V ±0.0005 U_N	$0.5U_N$ to $1.2U_N$ K_{2U} < 15 %; K_{0U} < 15 %
21 Negative sequence voltage of fundamental harmonic ($U_{2(1)}$), V	0 to U_N	Absolute, V ±(0.0003 U_H ·√3)	$0.5U_N$ to $1.2U_N$ K_{2U} < 15 %; K_{0U} < 15 %
22 Negative sequence voltage ratio (K_{2U}) and zero sequence voltage ratio (K_{0U}), %	0 to 15	Absolute, % ±0.05	$0.5U_N$ to $1.2U_N$
23 Positive, zero and negative sequence currents of fundamental harmonic ($I_{1(1)}$, $I_{0(10}$ and $I_{2(1)}$), A	0 to I_N	Absolute, A	
		±($0.01I_N$) ^{I}; ±($0.01I_N$) ^{II}	$0.01I_N$ to$1.2I_N$
		±($0.02I_N$) ^{III}; ±($0.02I_N$) ^{IV}	$0.05I_N$ to $1.2I_N$
24 Flicker short-term severity, relative units	0.2 to 10	Relative, % 5.0	f = (f_{NOM} ±1) Hz ΔU/U ≤ 20 %; provided that voltage waveforms are meander-like
25 DC voltage (U), V		Relative, %	
	$0.1U_N$ to $1.7U_N$	±[0.01+0.005($1.7U_N$/U-1)]	U_N = 5 … 480 V
		±[0.015+0.005($1.7U_N$/U-1)]	U_N ≤ 2 V
	$0.1U_N$ to $1.25U_N$	±[0.015+0.005($1.25U_N$/U-1)]	U_N = 800 V

Notes:
1 Reactive power is calculated by 3 methods: cross-connection, geometrical and phase shift (voltage is shifted by ¼ T, where T is the fundamental period) methods.
2 Frequency of the hth harmonic equals $h \cdot f_1$.
3 Figures marked with indices "I", "II", "III", "IV" and "V" relate to measurements made by the EM3.1KM equipped with AC current probes of the following accuracy classes: 0.1 ("I"), 0.2 ("II"), 0.5 ("III"), 1.0 ("IV"), and 2.0 ("V"). Nominal values of AC current (I_N) are referred, in this case, to nominal (rated) currents of the AC current probes in use.
4 Figures specified in the table are valid only if amplitude values of input voltage and current do not exceed 170% of the nominal values of measurement ranges (U_N and I_N respectively).

Table B3

Measurement ranges and limits of permissible measurement errors for EM3.1KM-x-05 (without AC current probes)

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
1 RMS of AC voltage and RMS of fundamental voltage harmonic (U), V	$0.1U_N$ to $1.2U_N$	Relative, % $\pm[0.02+0.005(1.2U_N/U–1)]$	
2 RMS of AC current and RMS of fundamental current harmonic (I), A	$0.1I_N$ to $1.2I_N$	Relative, % $\pm[0.02+0.005(1.2I_N/I–1)]$	
3 Active power and Active power of fundamental harmonic (P), W	$0.1U_N$ to $1.2U_N$ $0.1I_N$ to $1.2I_N$	Relative, % $\pm[0.05+0.01(1.44P_N/P–1)]$	$P_N = U_N \cdot I_N$ $\lvert\cos\varphi\rvert = 0.2 \ldots 1.0$
4 Reactive power and Reactive power of fundamental harmonic [1] (Q), Var		Relative, % $\pm[0.1+0.02\ (1.44Q_N/Q–1)]$	$Q_N = U_N \cdot I_N$ $\lvert\sin\varphi\rvert = 0.2 \ldots 1.0$
5 Apparent power (S), VA		Relative, % $\pm[0.04+0.01(1.2U_N/U+1.2I_N/I-2)]$	
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute ±0.005	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
7 AC frequency (f_1), Hz	40 to 70	Absolute, Hz ±0.003	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
8 Phase angle between fundamental harmonics of:	0 to 360	Absolute, degrees	
-phase voltages, degrees		±0.03	$0.2U_N$ to $1.2U_N$
- voltage and current in the same phase, degrees		±0.03	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
9 RMS of voltage harmonic of order h [2], h =2…50 ($U_{H,h}$), V	0 to $0.6U_N$	Absolute, V $\pm0.001\ U_N$	$U_{H,h} \le 0.01U_N$
		Relative, % ±0.1	$U_{H,h} > 0.01U_N$
10 RMS of voltage interharmonic of order m (frequency $m \cdot f_1$), m = 0.5…50.5 in 1.0 increments ($U_{C,m}$), V	0 to $0.15U_N$	Absolute, V $\pm0.001\ U_N$	$U_{C,m} \le 0.01U_N$
		Relative, % ±0.1	$U_{C,m} > 0.01U_N$
11 RMS of current harmonic of order h, h = 2 to 50 ($I_{H,h}$), A	0 to $0.6I_N$	Absolute, A $\pm0.001\ I_N$	$I_{H,h} \le 0.01I_N$
		Relative, % ±0.05 %	$I_{H,h} > 0.01I_N$
12 RMS of current interharmonic of order m (frequency $m \cdot f_1$), m=0.5…50 in 1.0 increments ($I_{C,m}$), A	0 to $0.15I_N$	Absolute, A $\pm0.001\ I_N$	$I_{C,m} \le 0.01I_N$
		Relative, % ±0.05 %	$I_{C,m} > 0{,}01I_H$
13 Phase angle between h^{th} voltage and h^{th} current harmonics in the same phase, degrees	0 to 360	Absolute, degrees	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h) = 2…15\%$ $K_U(h) = 2 \ldots 15\ \%$
		±1.0	h = 2 … 10
		±3.0	h = 11 … 50

Table B3

Measured parameter	Measure-ment range	Error type and measurement unit, limits of permissible in-trinsic measurement error	Note
14 Voltage harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_U(h)$], %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, % ±0.01	$K_U(h) < 1.0$
		Relative, % 1.0	$K_U(h) \geq 1.0$
15 Current harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_I(h)$], %	0 to 49.9		$0.2I_N$ to $1.2I_N$
		Absolute, % ±0.05	$K_I(h) < 1.0$
		Relative, % ±5	$K_I(h) \geq 1.0$
16 Active power of h^{th} har-monic; h = 2 … 50 ($P_{(h)}$), W	0 to $0.05P_N$	Absolute, W $\pm(0.00005P_N+0.005P_{(h)})$	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $\lvert\cos\varphi\rvert = 0.5 \dots 1.0$ $K_I(h) = 1 \dots 40\%$ $K_U(h) = 1 \dots 40$ %
17 Total Harmonic Distortion of voltage (THD_U), %	0 to 49.9		$0.2U_N$ to $1.1U_N$
		Absolute, % ±0.003	$K_U < 1.0$
		Relative, % ±0.3	$K_U \geq 1.0$
18 Total Harmonic Distortion of current (THD_I), %	0 to 49.9		$0.2I_N$ to $1.1I_N$
		Absolute, % ±0.01	$K_I < 1.0$
		Relative, % ±1.0	$K_I \geq 1.0$
19 Negative sequence voltage ratio (K_{2U}) and zero sequence voltage ratio (K_{0U}), %	0 to 15	Absolute, % ±0.20	$0.5U_N$ to $1.2U_N$
20 Positive sequence voltage of fundamental harmonic ($U_{1(1)}$), V	0 to U_N	Absolute, V $\pm(0{,}0004U_N \times\sqrt{3})$	
21 Zero sequence voltage of fundamental harmonic ($U_{0(1)}$), V	0 to U_N	Absolute, V $\pm0.001\ U_N$	$0.5U_N$ to $1.2U_N$ $K_{2U} < 15$ % $K_{0U} < 15$ %
22 Negative sequence voltage of fundamental harmonic ($U_{2(1)}$), V	0 to U_N	Absolute, V $\pm(0.0006U_N \cdot\sqrt{3})$	
23 Positive sequence current of fundamental harmonic ($I_{1(1)}$), A	0 to I_N	Absolute, A $\pm(0.0004I_N)$	
24 Zero sequence current of fundamental harmonic ($I_{0(1)}$), A	0 to I_N	Absolute, A $\pm(0.001I_N)$	
25 Negative sequence current of fundamental harmonic ($I_{2(1)}$), A	0 to I_N	Absolute, A $\pm(0.0006I_N)$	
26 Phase angle between voltage and current of positive, or nega-tive, or zero sequence, degrees	0 to 360	Absolute, degrees ±0.3	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$ $I_{1(1)}, I_{2(1)}, I_{0(1)} \geq 0.02\ I_N$ $U_{1(1)}, U_{2(1)}, U_{0(1)} \geq 0.02\ U_N$

Table B3

Measured parameter	Measure-ment range	Error type and measurement unit, limits of permissible in-trinsic measurement error	Note
27 Flicker short-term severity, relative units	0.2 to 10	Relative, % 5.0	f = (f_{NOM} ± 1) Hz $\Delta U/U \leq 20$ %; provided that voltage waveforms are mean-der-like
28 DC voltage (U), V		Relative, %	
	$0.1U_N$ to $1.7U_N$	$\pm[0.02+0.005(1.7U_N/U–1)]$	$I_N = 100$ A
	$0.1U_N$ to $1.25U_N$	$\pm[0.02+0.005(1.25U_N/U–1)]$	$I_N < 100$ A
29 DC current 3) (I), A	$0.1I_N$ to $1.2I_N$	Relative, % $\pm[0.02+0.01(1.2I_N/I - 1)]$	
	$0.1I_N$ to $1.5I_N$	Relative, % $\pm[0.02+0.01(1.5I_N/I - 1)]$	
30 DC power 3) (P), W		Relative, %	
	$0.01P_N$ to $2.04P_N$	$\pm[0.04+0.01(2.04P_N/P-1)]$	U_N up to 480 V I_N=100 A $0.1U_N$ to $1.7U_N$ $0.1I_N$ to $1.2I_N$
	$0.01P_N$ to $2.55P_N$	$\pm[0.04+0.01(2.55P_N/P-1)]$	U_N up to 480 V $I_N < 100$ A $0.1U_N$ to $1.7U_N$ $0.1I_N$ to $1.5I_N$
	$0.01P_N$ to $1.5P_N$	$\pm[0.04+0.01(1.5P_N/P-1)]$	$U_N = 800$ V $I_N = 100$ A $0.1U_N$ to $1.25U_N$ $0.1I_N$ to $1.2I_N$
	$0.01P_N$ to $1.875P_N$	$\pm[0.04+0.01(1.875P_N/P-1)]$	$U_N = 800$ V $I_N < 100$ A $0.1U_N$ to $1.25U_N$ $0.1I_N$ to $1.5I_N$

Notes:
1 Reactive power is calculated by 3 methods: method of cross-connection, geometrical and phase shift (voltage is shifted by ¼ T, where T is the fundamental period) methods.
2 Frequency of the h^{th} harmonic equals $h \cdot f_1$.
3 Parameters marked 3) are only measured by instruments of EM3.1KM x-05-1 modification.
4 Figures specified in the table are valid only if amplitude values of input voltage and current do not exceed 170% of the nominal values of measurement ranges (U_N and I_N respectively).

Table B4

Measurement ranges and limits of permissible measurement errors for EM 3.1KM-x-05-x-x1x equipped with AC current probes

Measured parameter	Measure-ment range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
1 RMS of AC voltage and RMS of fundamental voltage harmonic (U), V	$0.1U_N$ to $1.2U_N$	Relative, % $\pm[0.02+0.005(1.2U_N/U–1)]$	
2 RMS of AC current and RMS of fundamental current harmonic (I), A	$0.05I_N$ to $1.2I_N$	Relative, % $\pm[0.1+0.01(I_N/I – 1)]^{I}$ $\pm[0.2+0.02(I_N/I – 1)]^{II}$ $\pm[0.5+0.05(I_N/I – 1)]^{III}$ $\pm[1.0+0.05(I_N/I – 1)]^{IV}$ $\pm[2.0+0.1(I_N/I – 1)]^{V}$	
3 Active power and Active power of fundamental harmonic (P), W		Relative, %	$0.1U_N$ to $1.2U_N$
			$0.9 < \lvert\cos\varphi\rvert \le 1.0$
		$\pm0.2^{I}$; $\pm0.4^{II}$; $\pm1.0^{III}$	$0.01I_N$ to $0.05I_N$
		$\pm0.1^{I}$; $\pm0.2^{II}$; $\pm0.5^{III}$; $\pm1.0^{IV}$; $\pm2.0^{V}$	$0.05I_N$ to $1.2I_N$
			$0.5 \le \lvert\cos\varphi\rvert \le 0.9$
		$\pm0.25^{I}$; $\pm0.5^{II}$;	$0.02I_N$ to $0.1I_N$
		$\pm0.15^{I}$; $\pm0.3^{II}$; $\pm1.0^{III}$; $\pm2.0^{IV}$; $\pm4.0^{V}$	$0.1I_N$ to $1.2I_N$
		$\pm[0.25+0.02(1.44P_N/P –1)]^{I,}$ $\pm[0.5+0.05(1.44P_N/P –1)]^{II}$ $\pm[1.0+0.1(1.44P_N/P –1)]^{III}$ $\pm[2.0+0.1(1.44P_N/P–1)]^{IV}$	$0.2 \le \lvert\cos\varphi\rvert < 0.5$; $0.1I_N$ to $1.2I_N$
4 Reactive power and Reactive power of fundamental harmonic [1] (Q), Var	$0.01(U_N \cdot I_N)$ to $1.44(U_N \cdot I_H)$	Relative, %	$0.1U_N$ to $1.2U_N$
			$0.9 < \lvert\cos\varphi\rvert \le 1.0$
		$\pm0.3^{I}$; $\pm0.75^{II}$; $\pm1.5^{III}$;	$0.02I_N$ to $0.05I_N$
		$\pm0.2^{I}$; $\pm0.5^{II}$; $\pm1.0^{III}$; $\pm2.0^{IV}$; $\pm2.0^{V}$	$0.05I_N$ to $1.2I_N$
			$0.5 \le \lvert\sin\varphi\rvert \le 0.9$
		$\pm0.3^{I}$; $\pm0.75^{II}$; $\pm1.5^{III}$;	$0.02I_N$ to $0.1I_N$
		$\pm0.2^{I}$; $\pm0.5^{II}$; $\pm1.0^{III}$; $\pm2.0^{IV}$; $\pm2.0^{V}$	$0.1I_N$ to $1.2I_N$
		$\pm0.3^{I}$; $\pm0.75^{II}$; $\pm1.5^{III}$; $\pm2.5^{IV}$; $\pm2.5^{V}$	$0.2 \le \lvert\sin\varphi\rvert < 0.5$ $0.1I_N$ to $1.2I_N$
5 Apparent power (S), VA		Relative, %	$0.1U_N$ to $1.2U_N$ $0.1I_N$ to $1.2I_N$
		$\pm0.2^{I}$; $\pm0.4^{II}$; $\pm1.0^{II}$	$S < 0.1S_N$
		$\pm0.1^{I}$; $\pm0.2^{II}$; $\pm0.5^{III}$ $\pm1.0^{IV}$; $\pm2.0^{V}$	$0.1S_N$ to $1.44S_N$
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute $\pm0.02^{I}$; $\pm0.02^{,II}$; $\pm0.05^{III}$; $\pm0.05^{IV}$; $\pm0.10^{V}$	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
7 AC frequency (f_1), Hz	40 to 70	Absolute, Hz ±0.003	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$

Table B4

Measured parameter	Measure-ment range	Error type and measure-ment unit, limits of permis-sible intrinsic measurement error	Note
8 Phase angle between funda-mental harmonics of:	0 to 360	Absolute, degrees	
- Input voltages, degrees		±0.03	$0.2U_N$ to $1.2U_N$
- Voltage and current in the same phase, degrees		±0.5	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
9 RMS of voltage harmonic of order h[2)], h =2…50 ($U_{H,h}$), V	0 to $0.6U_N$	Absolute, V $\pm 0.001\ U_N$	$U_{H,h} \leq 0.01U_N$
		Relative, % ±0.1	$U_{H,h} > 0.01U_N$
10 RMS of voltage interhar-monic of order m (frequency $m \cdot f_1$), m = 0.5…50.5 in 1.0 in-crements ($U_{C,m}$), V	0 to $0.15U_N$	Absolute, V $\pm 0.001\ U_N$	$U_{C,m} \leq 0.01U_N$
		Relative, % ±0.1	$U_{C,m} > 0.01U_N$
11 RMS of current harmonic of order h, h = 2 to 50 ($I_{H,h}$), A	0 to $0.6I_N$	Absolute, A $\pm 0.02\ I_N^{\ I}$; $\pm 0.04\ I_N^{\ II}$	$I_{H,h} \leq 0.01I_N$
		Relative, % $\pm 5^{\ I}$; $\pm 10^{\ II}$	$I_{H,h} > 0.01I_N$
12 RMS of current interhar-monic of order m (frequency $m \cdot f_1$), m=0.5…50 in 1.0 incre-ments ($I_{C,m}$), A	0 to $0.15I_N$	Absolute, A $\pm 0.02\ I_N^{\ I}$; $\pm 0.04\ I_N^{\ II}$	$I_{C,m} \leq 0.01I_N$
		Relative, % $\pm 5^{\ I}$; $\pm 10^{\ II}$	$I_{C,m} > 0.01I_N$
13 Phase angle between h^{th} voltage and h^{th} current harmon-ics in the same phase, degrees	0 to 360	Absolute, degrees	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h) \geq 5\%$; $K_U(h) \geq 1\%$
		$\pm 2^{\ I}$; $\pm 2^{\ II}$	h = 2 … 10
		$\pm 10^{\ I}$; $\pm 10^{\ II}$	h = 11 … 20
		$\pm 20^{\ I}$; $\pm 20^{\ II}$	h =21 … 50
14 Voltage harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_U(h)$], %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, % ±0.01	$K_U(h) < 1$ %
		Relative; 1.0	$K_U(h) \geq 1$ %
15 Current harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_I(h)$], %	0 to 49.9		$0.2I_N$ to $1.2I_N$
		Absolute, % $\pm 0.05^{\ I}$; $\pm 0.05^{\ II}$	$K_I(h) < 1.0$
		Relative, % $\pm 5.0^{\ I}$; $\pm 5.0^{\ II}$	$K_I(h) \geq 1.0$
16 Total Harmonic Distortion of voltage (THD_U), %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, %: ±0.05	$THD_U < 1.0$
		Relative, %: ±5	$THD_U \geq 1.0$
17 Total Harmonic Distortion of current (THD_I), %	0 to 49.9		$0.2I_N$ to $1.2I_N$
		Absolute, % ±0.1	$THD_I < 1.0$
		Relative, % ±10	$THD_I \geq 1.0$

Table B4

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
18 Active power of h^{th} harmonic; h = 2 … 50 ($P_{(h)}$), W	$0.003P_N$ to $0.1P_N$	Relative, %	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h)$ = 1 … 40% $K_U(h)$ = 1 … 40 %
		±5.0 $^{\mathrm{I}}$; ±10.0 $^{\mathrm{II}}$	$\lvert\cos\varphi\rvert$ = 0.9 … 1.0 h = 2 … 50
			$\lvert\cos\varphi\rvert$ = 0.5 … 0.9
		±5.0 $^{\mathrm{I}}$; ±10.0 $^{\mathrm{II}}$	h = 2 … 10
		±10.0 $^{\mathrm{I}}$; ±20.0 $^{\mathrm{II}}$	h = 11 … 50
19 Negative sequence voltage ratio (K_{2U}) and zero sequence voltage ratio (K_{0U}), %	0 to 15	Absolute, % ±0.20	$0.5U_N$ to $1.2U_N$
20 Positive sequence voltage of fundamental harmonic ($U_{1(1)}$), V	0 to U_N	Absolute, V $\pm(0.0004U_N \times\sqrt{3})$	
21 Zero sequence voltage of fundamental harmonic ($U_{0(1)}$), V	0 to U_N	Absolute, V ±0.001 U_N	$0.5U_N$ to $1.2U_N$ K_{2U} < 15 % K_{0U} < 15 %
22 Negative sequence voltage of fundamental harmonic ($U_{2(1)}$), V	0 to U_N	Absolute, V $\pm(0.0006U_N \cdot\sqrt{3})$	
23 Positive sequence current, zero sequence current and negative sequence current of fundamental harmonic ($I_{1(1)}$, $I_{0(1)}$ and $I_{2(1)}$), A	0 to I_N	Absolute, A	
		$\pm(0.01I_N)$ $^{\mathrm{I}}$; $\pm(0.01I_N)$ $^{\mathrm{II}}$	$0.01I_N$ to $1.2I_N$
		$\pm(0.02I_N)$ $^{\mathrm{III}}$; $\pm(0.02I_N)$ $^{\mathrm{IV}}$	$0.05I_N$ to $1.2I_N$
24 Flicker short-term severity, relative units	0.2 to 10	Relative, % 5.0	f = (f_{NOM} ± 1) Hz $\Delta U/U \le 20$ %; provided that voltage waveforms are meander-like
25 DC voltage (U), V		Relative, %	
	$0.1U_N$ to $1.7U_N$	$\pm[0.02+0.005(1.7U_N/U–1)]$	U_N up to 480 V
	$0.1U_N$ to $1.25U_N$	$\pm[0.02+0.005(1.25U_N/U–1)]$	U_N = 800 V

Notes

1 Reactive power is calculated by 3 methods: method of cross-connection, geometrical and phase shift (voltage is shifted by ¼ T, where T is the fundamental period) methods.

2 Frequency of the h^{th} harmonic equals $h \cdot f_1$.

3 Figures marked with indices "I", "II", "III", "IV" and "V" relate to measurements made by EM3.1KM equipped with AC current probes of the following accuracy classes: 0.1 ("I"), 0.2 ("II"), 0.5 ("III"), 1.0 ("IV"), and 2.0 ("V"). Nominal values of AC current (I_N) are referred, in this case, to nominal (rated) currents of the AC current probes in use.

4 Figures specified in the table are valid only if amplitude values of input voltage and current do not exceed 170% of the nominal values of measurement ranges (U_N and I_N respectively).

Table B5

Measurement ranges and limits of permissible measurement errors for EM3.1KM-x-10 (without AC current probes)

Measured parameter	Measure-ment range	Error type and measurement unit, limits of permissible in-trinsic measurement error	Note
1 RMS of AC voltage (U), V	$0.1U_N$ to $1.2U_N$	Relative, % ± $[0.04+0.01(1.2U_N/U–1)]$	
2 RMS of AC current and RMS of fundamental current harmonic (I), A	$0.1I_N$ to $1.2I_N$	Relative, % $\pm[0.04+0.01(1.2I_N/I–1)]$	
3 Active power and Active power of fundamental harmonic (P), W	$0.1U_N$ to $1.2U_N$ $0.1I_N$ to $1.2I_N$	Relative, % $\pm[0.1+0.01(1.44P_N/P–1)]$	$P_N = U_N \cdot I_N$ $\lvert\cos \varphi\rvert = 0.2$ to 1.0
4 Reactive power and Reactive power of fundamental harmonic [1] (Q), Var		Relative, %, $\pm[0.2+0.02(1.44Q_N/Q–1)]$	$Q_N = U_N \cdot I_N$ $\lvert\sin \varphi\rvert = 0.2$ to 1.0
5 Apparent power (S), VA		Relative, % $\pm[0.1+0.01(1.2U_N/U+1.2I_N/I–2)]$	
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute ±0.02	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
7 AC frequency (f_1), Hz	40 to 70	Absolute, Hz ±0.01	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
8 Phase angle between funda-mental harmonics of:	0 to 360	Absolute, degrees	
- Input voltages, degrees		±0.05	$0.2U_N$ to $1.2U_N$
- Voltage and current in the same phase, degrees		±0.05	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
9 RMS of voltage harmonic of order h [2], h =2…50 ($U_{H,h}$), V	0 to $0.6U_N$		h = 2 … 50
		Absolute, V $\pm0.002\ U_N$	$U_{H,h} \leq 0.01U_N$
		Relative, % ±0.2	$U_{H,h} > 0.01U_N$
10 RMS of voltage interhar-monic of order m (frequency $m \cdot f_1$), m = 0.5…50.5 in 1.0 in-crements ($U_{C,m}$), V	0 to $0.15U_N$	Absolute, V $\pm0.002\ U_N$	$U_{C,m} \leq 0.01U_N$
		Relative, % ±0.2	$U_{C,m} > 0.01U_N$
11 RMS of current harmonic of order h, h = 2 to 50 ($I_{H,h}$), A	0 to $0.6I_N$	Absolute, A $\pm0.002\ I_N$	$I_{H,h} \leq 0.01I_N$
		Relative, % ±0.1	$I_{H,h} > 0.01I_N$
12 RMS of current interhar-monic of order m (frequency $m \cdot f_1$), m=0.5…50 in 1.0 incre-ments ($I_{C,m}$), A	0 to $0.15I_N$	Absolute, A $\pm0.002I_N$	$I_{C,m} \leq 0.01I_N$
		Relative, % ±0.1	$I_{C,m} > 0.01I_N$
13 Phase angle between h^{th} volt-age and h^{th} current harmonics in the same phase, degrees	0 to 360	Absolute, degrees	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h) = 2…15\%$ $K_U(h) = 2 … 15\ \%$
		±1.0	h = 2 …10
		±3.0	h = 11 … 50

Table B5

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
14 Voltage harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_U(h)$], %	0 to 49.9		$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$
		Absolute, % ±005	$K_U(h) < 1.0$ $K_I(h) < 1.0$
		Relative, % 5	$K_U(h) \geq 1.0$ $K_I(h) \geq 1.0$
15 Active power of h[th] harmonic; h = 2 … 50 ($P_{(h)}$), W	0 to $0.05P_N$	Absolute, W $\pm(0.0001P_N + 0.005P_{(h)})$	h = 2 … 50 $0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $\lvert\cos\varphi\rvert = 0.5$ … 1.0 $K_I(h) = 1$ … 40% $K_U(h) = 1$ … 40 %
16 Total Harmonic Distortion of voltage (THD_U) and Total Harmonic Distortion of current (THD_I), %	0 to 49.9		$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$
		Absolute, % ±0.05	$THD_U < 1.0$ $THD_I < 1.0$
		Relative, %, ±5	$THD_U \geq 1.0$ $THD_I \geq 1.0$
17 Negative sequence voltage ratio (K_{2U}) and zero sequence voltage ratio (K_{0U}), %	0 to 15	Absolute, % ±0.20	$0.5U_N$ to $1.2U_N$
18 Positive sequence voltage of fundamental harmonic ($U_{1(1)}$), V	0 to U_N	Absolute, V $\pm(0.001U_N \times \sqrt{3})$	
19 Zero sequence voltage of fundamental harmonic ($U_{0(1)}$), V	0 to U_N	Absolute, V $\pm 0.002\ U_N$	$0.5U_N$ to $1.2U_N$ $K_{2U} < 15$ %; $K_{0U} < 15$ %
20 Negative sequence voltage of fundamental harmonic ($U_{2(1)}$), V	0 to U_N	Absolute, V $\pm(0.002U_H \cdot \sqrt{3})$	
21 Positive sequence current of fundamental harmonic ($I_{1(1)}$), A	0 to I_N	Absolute, A $\pm(0.001I_N)$	
22 Zero sequence current of fundamental harmonic ($I_{0(1)}$), A	0 to I_N	Absolute, A $\pm(0.002I_N)$	
23 Negative sequence current of fundamental harmonic ($I_{2(1)}$), A	0 to I_N	Absolute, A $\pm(0.002I_N)$	
24 Phase angle between voltage and current of positive, or negative, or zero sequence, degrees	0 to 360	Absolute, degrees ±1.0	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$ $I_{1(1)}, I_{2(1)}, I_{0(1)} \geq 0.02\ I_N$ $U_{1(1)}, U_{2(1)}, U_{0(1)} \geq 0.02\ U_N$
25 Flicker short-term severity, relative units	0.2 to 10	Relative, %, 5.0	$f = (f_{NOM} \pm 1)$ Hz $\Delta U/U \leq 20$ %, provided that voltage waveforms are meander-like

Table B5

Measured parameter	**Measure-ment range**	**Error type and measurement unit, limits of permissible intrinsic measurement error**	**Note**
26 DC voltage (U), V	$0.1U_N$ to $1.7U_N$	Relative, % $\pm[0.04+0.01(1.7U_N/U–1)]$	U_N up to 480 V
	$0.1U_N$ to $1.25U_N$	Relative, % $\pm[0.04+0.01(1.25U_N/U–1)]$	U_N = 800 V
27 DC current [3)] (I), A	$0.1I_N$ to $1.2I_N$	Relative, % $\pm[0.04+0.01(1.2I_N/I - 1)]$	I_N = 100 A
	$0.1I_N$ to $1.5I_N$	Relative, %, $\pm[0.04+0.01(1.5I_N/I - 1)]$	I_N < 100 A
28 DC power [3)] (P), W		Relative, %,	
	$0,01P_N$ to $2.04P_N$	$\pm[0.08+0.01(2.04P_N/P-1)]$	U_N up to 480 V; I_N=100 A $0.1U_N$ to $1.7U_N$ $0.1I_N$ to $1.2I_N$
	$0.01P_N$ to $2.55P_N$	$\pm[0.08+0.01(2.55P_N/P-1)]$	U_N up to 480 V; I_N < 100 A $0.1U_N$ to $1.7U_N$ $0.1I_N$ to $1.5I_N$
	$0.01P_N$ to $1.5P_N$	$\pm[0.08+0.01(1.5P_N/P-1)]$	U_N = 800 V I_N = 100 A $0.1U_N$ to $1.25U_N$ $0.1I_N$ to $1.2I_N$
	$0.01P_N$ to $1.875P_N$	$\pm[0.08+0.01(1.875P_N/P-1)]$	U_N = 800 V I_N < 100 A $0.1U_N$ to $1.25U_N$ $0.1I_N$ to $1.5I_N$

Notes
1 Reactive power is calculated by 3 methods: method of cross-connection, geometrical and phase shift (voltage is shifted by ¼ T, where T is the fundamental period) methods.
2 Frequency of the h^{th} harmonic equals $h \cdot f_1$.
3 Parameters marked [3)] are only measured by instruments of EM3.1KM x-10-1 modification.
4 Figures specified in the table are valid only if amplitude values of input voltage and current do not exceed 170% of the nominal values of measurement ranges (U_N and I_N respectively).

Table B6

Measurement ranges and limits of permissible measurement errors for Energomonitor-3.1KM-x-10 equipped with AC current probes

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
1 RMS of AC voltage and RMS of fundamental voltage harmonic (U), V	$0.1U_N$ to $1.2U_N$	Relative, % $\pm[0.04+0.01(1.2U_N/U-1)]$	
2 RMS of AC current and RMS of fundamental current harmonic (I), A	$0.05I_N$ to $1.2I_N$	Relative, % $\pm[0.1+0.01(I_N/I-1)]^{\mathrm{I}}$ $\pm[0.2+0.02(I_N/I-1)]^{\mathrm{II}}$ $\pm[0.5+0.05(I_N/I-1)]^{\mathrm{III}}$ $\pm[1.0+0.05(I_N/I-1)]^{\mathrm{IV}}$ $\pm[2.0+0.1(I_N/I-1)]^{\mathrm{V}}$	
3 Active power and Active power of fundamental harmonic (P), W	$0.01(U_N \cdot I_N)$ to $1.44(U_N \cdot I_N)$	Relative, %	$0.1U_N$ to $1.2U_N$
			$0.9 < \lvert\cos\varphi\rvert \le 1.0$
		$\pm0.2^{\mathrm{I}}$; $\pm0.4^{\mathrm{II}}$; $\pm1.0^{\mathrm{III}}$	$0.01I_N$ to $0.05I_N$
		$\pm0.1^{\mathrm{I}}$; $\pm0.2^{\mathrm{II}}$; $\pm0.5^{\mathrm{III}}$; $\pm1.0^{\mathrm{IV}}$; $\pm2.0^{\mathrm{V}}$	$0.05I_N$ to $1.2I_N$
			$0.5 \le \lvert\cos\varphi\rvert \le 0.9$
		$\pm0.25^{\mathrm{I}}$; $\pm0.5^{\mathrm{II}}$	$0.02I_N$ to $0.1I_N$
		$\pm0.15^{\mathrm{I}}$; $\pm0.3^{\mathrm{II}}$; $\pm1.0^{\mathrm{III}}$; $\pm2.0^{\mathrm{IV}}$; $\pm4.0^{\mathrm{V}}$	$0.1I_N$ to $1.2I_N$
			$0.2 \le \lvert\cos\varphi\rvert < 0.5$
		$\pm[0.25+0.02(1.44P_N/P-1)]^{\mathrm{I},}$ $\pm[0.5+0.05(1.44P_N/P-1)]^{\mathrm{II}}$ $\pm[1.0+0.1(1.44P_N/P-1)]^{\mathrm{III}}$ $\pm[2.0+0.1(1.44P_N/P-1)]^{\mathrm{IV}}$	$0.1I_N$ to $1.2I_N$
4 Reactive power and Reactive power of fundamental harmonic [1)] (Q), Var		Relative, %	$0.1U_N$ to $1.1U_N$
			$0.9 < \lvert\cos\varphi\rvert \le 1.0$
		$\pm0.3^{\mathrm{I}}$; $\pm0.75^{\mathrm{II}}$; $\pm1.5^{\mathrm{III}}$;	$0.02I_N$ to $0.05I_N$
		$\pm0.2^{\mathrm{I}}$; $\pm0.5^{\mathrm{II}}$; $\pm1.0^{\mathrm{III}}$; $\pm2.0^{\mathrm{IV}}$; $\pm2.0^{\mathrm{V}}$	$0.05I_N$ to $1.2I_N$
			$0.5 \le \lvert\cos\varphi\rvert \le 0.9$
		±0.3 % $^{\mathrm{I}}$; ±0.75 % $^{\mathrm{II}}$; $\pm1.5^{\mathrm{III}}$;	$0.02I_N$ to $0.1I_N$
		$\pm0.2^{\mathrm{I}}$; $\pm0.5^{\mathrm{II}}$; $\pm1.0^{\mathrm{III}}$; $\pm2.0^{\mathrm{IV}}$; $\pm2.0^{\mathrm{V}}$	$0.1I_N$ to $1.2I_N$
		$\pm0.3^{\mathrm{I}}$; $\pm0.75^{\mathrm{II}}$; $\pm1.5^{\mathrm{III}}$; $\pm2.5^{\mathrm{IV}}$; $\pm2.5^{\mathrm{V}}$	$0.2 \le \lvert\cos\varphi\rvert < 0.5$ $0.1I_N$ to $1.2I_N$
5 Apparent power (S), VA		Relative, %	$0.1U_N$ to $1.2U_N$ $0.1I_N$ to $1.2I_N$
		$\pm0.2^{\mathrm{I}}$; $\pm0.4^{\mathrm{II}}$; $\pm1.0^{\mathrm{II}}$	$S < 0{,}1S_H$
		$\pm0.1^{\mathrm{I}}$; $\pm0.2^{\mathrm{II}}$; $\pm0.5^{\mathrm{III}}$ $\pm1.0^{\mathrm{IV}}$; $\pm2.0^{\mathrm{V}}$	$0.1S_N$ to $1.44S_N$
6 Power factor (PF=P/S)	0.1 to 1.0	Absolute $\pm0.02^{\mathrm{I}}$; $\pm0.02^{,\mathrm{II}}$; $\pm0.05^{\mathrm{III}}$; $\pm0.05^{\mathrm{IV}}$; $\pm0.10^{\mathrm{V}}$	$0.2I_N$ to $1.2I_N$ $0.2U_N$ to $1.2U_N$
7 AC frequency (f_1), Hz	40 to 70	Absolute, Hz ±0.01	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$

Table B6

Measured parameter	**Measurement range**	**Error type and measurement unit, limits of permissible intrinsic measurement error**	**Note**
8 Phase angle between fundamental harmonics of:	0 to 360°	Absolute, degrees	
- Phase voltages, degrees		±0.2	$0.2U_N$ to $1.2U_N$
- Voltage and current in the same phase, degrees		±0.5	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$
9 RMS of voltage harmonic of order h [2)], h =2…50 ($U_{H,h}$), V	0 to $0.6U_N$	Absolute, V ±0.002 U_N	$U_{H,h} \leq 0.01U_N$
		Relative, % ±0.2	$U_{H,h} > 0.01U_N$
10 RMS of voltage interharmonic of order m (frequency $m \cdot f_1$), m = 0.5…50.5 in 1.0 increments ($U_{C,m}$), V	0 to $0.15U_N$	Absolute, V ±0.002 U_N	$U_{C,m} \leq 0.01U_N$
		Relative, % ±0.2	$U_{C,m} > 0.01U_N$
11 RMS of current harmonic of order h, h = 2 to 50 ($I_{H,h}$), A	0 to $0.6I_N$	Absolute, A ±0.02 I_N [I]; ±0.04 I_N [II]	$I_{H,h} \leq 0.01I_N$
		Relative, % ±5 % [I]; ±10 % [II]	$I_{H,h} > 0.01I_N$
12 RMS of current interharmonic of order m (frequency $m \cdot f_1$), m=0.5…50 in 1.0 increments ($I_{C,m}$), A	0 to $0.15I_N$	Absolute, A ±0.02 I_H [I]; ±0.04 I_H [II]	$I_{C,m} \leq 0.01I_N$
		Relative, % ±5 [I]; ±10 [II]	$I_{C,m} > 0.01I_N$
13 Phase angle between h^{th} voltage and h^{th} current harmonics in the same phase, degrees	0 to 360	Absolute, degrees	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h) \geq 5\%$; $K_U(h) \geq 1\%$
		±2 [I]; ±2 [II]	h = 2 … 10
		±10 [I]; ±10 [II]	h = 11 … 20
		±20 [I]; ±20 [II]	h = 21 … 50
14 Voltage harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_U(h)$], %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute, % ±0,05	$K_U(h) < 1.0$
		Relative, % 5	$K_U(h) \geq 1.0$
15 Current harmonic of order h (in reference to fundamental harmonic); h = 2 … 50 [$K_I(h)$], %	0 to 49.9		I от $0,2I_Н$ до $1.2I_Н$;
		Absolute, % ±0.05 [I]; ±0.05 [II]	$K_I(h) < 1.0$
		Relative, % ±5.0 [I]; ±5.0 [II]	$K_I(h) \geq 1.0$
16 Total Harmonic Distortion of voltage (THD_U), %	0 to 49.9		$0.2U_N$ to $1.2U_N$
		Absolute ±0.05 %	$THD_U < 1.0$
		Relative ±5 %	$THD_U \geq 1.0$
17 Total Harmonic Distortion of current (THD_I), %	0 to 49.9		$0.2I_N$ to $1.2I_N$
		Absolute ±0.1 %	$THD_I < 1.0$
		Relative ±10 %	$THD_I \geq 1.0$

Table B6

Measured parameter	Measurement range	Error type and measurement unit, limits of permissible intrinsic measurement error	Note
18 Active power of hth harmonic; h = 2 … 50 ($P_{(h)}$), W	$0.003P_N$ to $0.1P_N$	Relative, %	$0.2U_N$ to $1.2U_N$ $0.2I_N$ to $1.2I_N$ $K_I(h)$ = 1 … 40% $K_U(h)$ = 1 … 40 %
		$\pm 5.0^{\mathrm{I}}$; $\pm 10.0^{\mathrm{II}}$	$\lvert\cos\varphi\rvert = 0.9 \ldots 1.0$
			$\lvert\cos\varphi\rvert = 0.5 \ldots 0.9$
		$\pm 5.0^{\mathrm{I}}$; $\pm 10.0^{\mathrm{II}}$	h = 2 … 10
		$\pm 10.0^{\mathrm{I}}$; $\pm 20.0^{\mathrm{II}}$	h = 11 … 50
19 Negative sequence voltage ratio (K_{2U}) and zero sequence voltage ratio (K_{0U}), %	0 to 15	Absolute, % ±0.20	$0.5U_N$ to $1.2U_N$
20 Positive sequence voltage of fundamental harmonic ($U_{1(1)}$), V	0 to U_N	Absolute, V $\pm(0.001U_H \times\sqrt{3})$	
21 Zero sequence voltage of fundamental harmonic ($U_{0(1)}$), V	0 to U_N	Absolute, V $\pm(0.002\,U_N)$	$0.5U_N$ to $1.1U_N$ K_{2U} < 15 %; K_{0U} < 15 %
22 Negative sequence voltage of fundamental harmonic ($U_{2(1)}$), V	0 to U_N	Absolute, V $\pm(0.002U_N \cdot\sqrt{3})$	
23 Positive sequence current, zero sequence current and negative sequence current of fundamental harmonic ($I_{1(1)}$, $I_{0(1)}$ and $I_{2(1)}$), A	0 to I_N	Absolute, A	
		$\pm(0.01I_N)^{\mathrm{I}}$; $\pm(0.01I_N)^{\mathrm{II}}$	$0.01I_N$ to $1.2I_N$
		$\pm(0.02I_N)^{\mathrm{III}}$; $\pm(0.02I_N)^{\mathrm{IV}}$	$0.05I_N$ to $1.2I_N$
24 Flicker short-term severity, relative units	0.2 to 10	Relative, %, 5.0	f = (f_{NOM} ±1) Hz $\Delta U/U \le 20$ %, provided that voltage waveforms are meander-like
25 DC voltage (U), V		Relative, %	
	$0.1U_N$ to $1.7U_N$	$\pm[0.04+0.01(1.7U_N/U-1)]$	U_N up to 480 V
	$0.1U_N$ to $1.25U_N$	$\pm[0.04+0.01(1.25U_N/U-1)]$	U_N = 800 V

Notes

1 Reactive power is calculated by 3 methods: method of cross-connection, geometrical and phase shift (voltage is shifted by ¼ T, where T is the fundamental period) methods.

2 Frequency of the hth harmonic equals $h \cdot f_1$.

3 Figures marked with indices "I", "II", "III", "IV" and "V" relate to measurements made by EM3.1KM equipped with AC current probes of the following accuracy classes: 0.1 ("I"), 0.2 ("II"), 0.5 ("III"), 1.0 ("IV"), and 2.0 ("V"). Nominal values of AC current (I_N) are referred, in this case, to nominal (rated) currents of the AC current probes in use.

4 Figures specified in the table are valid only if amplitude values of input voltage and current do not exceed 170% of the nominal values of measurement ranges (U_N and I_N respectively).

Table B7

Measurement ranges and limits of permissible measurement errors of Energomonitor 3.1KM-x-02-xx1 as applied to calibration of VTs and CTs

Measured parameter	Measurement range and measurement units	Error type and limits of permissible intrinsic measurement error	Note
1 Voltage instrument transformer (VT) ratio error		Absolute, %	$0.2U_{NOM}$ to $1.2U_{NOM}$ $f = (f_{NOM} \pm 1)$ Hz
	±0.1999 %	± 0.002	
	±1.999 %	± 0.02	
	±19.99 %	± 0.2	
2 Voltage instrument transformer (VT) angle error		Absolute, min	
	±600 min	± 0.1	
	±180 degrees	± 1.0	
3 Current instrument transformer (CT) ratio error		Absolute, %	$0.01I_{NOM}$ to $1.2I_{NOM}$ $f = (f_{NOM} \pm 1)$ Hz
	±0.1999 %	± 0.002	
	±1.999 %	± 0.02	
	±19.99 %	± 0.2	
4 Current instrument transformer (CT) angle error		Absolute, min	
	±600 min	± 0.1	
	±180 degrees	± 1.0	
U_{NOM} – Nominal (rated) secondary voltage of the VT under test (from 100/√3 to 800 V); I_{NOM} – Nominal (rated) secondary current of the CT under test (1 A or 5 A); F_{NOM} – Nominal (rated) frequency of the CT or VT under test (50 Hz or 60 Hz).			

Table B8

Measurement ranges and limits of permissible measurement errors of Energomonitor-3.1KM-x-05-xx1 and Energomonitor -3.1KM-x-10-xx1 as applied to calibration of VTs and CTs

Measured parameter	Measurement range and measurement units	Error type and limits of permissible intrinsic measurement error	Note
1 Voltage instrument transformer (VT) ratio error		Absolute, %	$0.2U_{NOM}$ to $1.2U_{NOM}$ $f = (f_{NOM} \pm 1)$ Hz
	±0.1999 %	±0.005	
	±1.999 %	±0.05	
	±19.99 %	±0.5	
2 Voltage instrument transformer (VT) angle error		Absolute, min	
	±600 min	± 0.2	
	±180 degrees	± 2.0	
3 Current instrument transformer (CT) ratio error		Absolute, %	$0.01I_{NOM}$ to $1.2I_{NOM}$ $f = (f_{NOM} \pm 1)$ Hz
	±0.1999 %	±0.005	
	±1.999 %	±0.05	
	±19.99 %	±0.5	
4 Current instrument transformer (CT) angle error		Absolute, min	
	±600 min	± 0.2	
	±180 degrees	± 2.0	
U_{NOM} – Nominal (rated) secondary voltage of the VT under test (from 100/√3 to 800 V); I_{NOM} – Nominal (rated) secondary current of the CT under test (1 A or 5 A); F_{NOM} – Nominal (rated) frequency of the CT or VT under test (50 Hz or 60 Hz).			

APPENDIX C
Calibration report (sample)

CALIBRATION REPORT
issued for
Multifunctional reference standard meter Energomonitor 3.1KM,
_______________________, serial N____ TS 4381-026-49976497-2012
modification
Date of manufacture _________________
Month, year

1 Environmental conditions during calibration
- Ambient temperature, °C
- Relative humidity, %
- Atmospheric pressure, kPa (mm Hg)

2 Visual inspection
Conclusion: the DUT conforms (does not conform) to the requirements of Calibration Procedure MC3.055.500 МП.

3 Measuring resistance of insulation
Resistance of insulation ≥ MOhm

Conclusion: the DUT conforms (does not conform) to the requirements of Calibration Procedure MC3.055.500 МП.

4 Clock / Memory function testing
The Date / Time setting function works correctly (incorrectly).
The date/time and other configuration settings are retained (not retained) in the memory after removing power from the DUT.
The “Data Exchange with PC” mode works (does not work) correctly.

Conclusion: the DUT conforms (does not conform) to the requirements of Calibration Procedure MC3.055.500 МП.

5 Accuracy testing
5.1 The results of determining the relative intrinsic error in the measurements of RMS values of voltage δ_U and fundamental (1st) harmonic of voltage δ_{U1} are listed in Table C1.

Table C1

U_{NOM}, V	U_{ref}, V	Measurement error of the DUT, %					
		Phase A		Phase B		Phase C	
		δ_U	δ_{U1}	δ_U	δ_{U1}	δ_U	δ_{U1}
800	600						
480	480						
240	288						
240	120						
240	24						
120	120						
60	60						
30	30						
10	10						
5	5						
2	2						
1	1						
1	0.1						

5.2 The results of determining the relative intrinsic error in the direct (without AC current probes) measurements of RMS values of current δ_I and fundamental (1st) harmonic of current δ_{I1} are listed in Table C2.

Table C2

I_{NOM}, A	I_{ref}, A	Measurement error of the DUT, %					
		Phase A		Phase B		Phase C	
		δ_I	δ_{I1}	δ_I	δ_{I1}	δ_I	δ_{I1}
100	100						
50	50						
25	25						
10	10						
5	5						
2.5	2.5						
1	1						
1	0.5						
1	0.1						
0.5	0.5						
0.25	0.25						
0.1	0.1						
0.05	0.05						

5.3 The results of determining the relative intrinsic error in the contactless (with AC current probes) measurements of RMS values of current δ_I and fundamental (1st) harmonic of current δ_{I1} are listed in Table C3.

AC current probes:

Clip-on CTs; rated current I_{NOM} = ___ A; rated frequency f_{NOM} = ____ Hz; accuracy class _______.

The current measurement channels of the DUT were connected to MTS ME 3.1K via the Blocks of Calibrated coils (number of turns in a coil n = ____).

Table C3

I_{ref}, A	Measurement error of the DUT, %					
	Phase A		Phase B		Phase C	
	δ_I	δ_{I1}	δ_I	δ_{I1}	δ_I	δ_{I1}
$1.2I_{NOM}/n$						
$0.5I_{NOM}/n$						
$0.05I_{NOM}/n$						
$0.01I_{NOM}/n$						

5.4 The relative intrinsic error in measuring apparent power δ_S conforms (does not conform) to the requirements of Calibration Procedure MC3.055.500 МП.

5.5 The results of determining the relative intrinsic error in measuring DC voltage δ_{UD} are listed in Table C4.

5.6 The relative intrinsic error in measuring DC power δ_{PD} conforms (does not conform) to the requirements of Calibration procedure MC3.055.500 МП.

5.7 The results of determining the relative intrinsic error in the direct (without AC current probes) measurements of single-phase active power δ_P are listed in Table C5.

5.8 The results of determining the relative intrinsic error in the direct (without AC current probes) measurements of three-phase active power δ_{P3} are listed in Table C6.

Table C4

U_{NOM}, V	U_{ref}, V	Measurement error of the DUT (δ_{UD}), %		
		Phase A	Phase B	Phase C
800	1000			
480	800			
240	400			
240	200			
240	100			
240	24			
120	200			
60	100			
30	50			
10	17			
5	8.5			
2	3.4			
1	1.7			
1	0.1			

Table C5

Measurement range		Parameters of test signal			Measurement error of the DUT (δ_P), %		
U_{NOM}, V	I_{NOM}, A	U, V	I, A	Cos φ	Phase A	Phase B	Phase C
800	5	600	5	1.0			
480	5	480	5	1.0			
480	5	480	5	0.5L			
480	5	480	2.5	0.5C			
240	1	220	1	1.0			
240	1	220	1	0.5L			
240	1	220	0.5	0.5C			
240	1	220	0.1	0.5L			
120	1	100	1	1.0			
120	1	100	0.5	0.5L			
120	1	100	0.5	0.5C			
120	1	100	0.5	0.2C			
120	1	100	0.5	0.2 L			
60	5	66	6	1.0			
60	5	60	2.5	0.5L			
60	5	60	0.5	0.5C			
30	1	30	1	0.5L			
10	1	10	1	0.5C			
5	1	5	1	1.0			
1	1	1	1	1.0			

5.9 The results of determining the relative intrinsic error in the direct (without AC current probes) measurements of three-phase active power δ_{P3} are listed in Table C7.

5.10 The additional relative intrinsic error in measuring active power caused by crosstalk of measurement channels δ_{P3Cr} conforms (does not conform) to the requirements of Calibration procedure МС3.055.500 МП.

Table C6

Measurement range		Parameters of test signal			Measurement error of the DUT (δ_{P3}), %
U_{NOM}, V	I_{NOM}, A	U, V	I, A	Cos φ	
800	5	600	5	1.0	
480	5	480	5	1.0	
480	5	480	5	0.5L	
480	5	480	2.5	0.5C	
240	1	220	1	1.0	
240	1	220	1	0.5L	
240	1	220	0.5	0.5C	
240	1	220	0.1	0.5L	
120	1	100	1	1.0	
120	1	100	0.5	0.5L	
120	1	100	0.5	0.5C	
120	1	100	0.5	0.2C	
120	1	100	0.5	0.2 L	
60	5	66	6	1.0	
60	5	60	2.5	0.5L	
60	5	60	0.5	0.5C	
30	1	30	1	0.5L	
10	1	10	1	0.5C	
5	1	5	1	1.0	
1	1	1	1	1.0	

5.11 The results of determining the intrinsic error in the contactless (with AC current probes) measurements of active power δ_P are listed in Table B7.

AC current probes:

Clip-on CTs; rated current I_{NOM} = ___ A; rated frequency f_{NOM} = ____ Hz; accuracy class _______.

The current measurement channels of the DUT were connected to MTS ME 3.1K via the Blocks of Calibrated coils (number of turns in a coil n = ____).

Table C7

Measurement range	Parameters of test signal			Measurement error of the DUT (δ_P), %		
U_{NOM}, V	U, V	I, A	Cos φ	Phase A	Phase B	Phase C
800	480	$1.2I_{NOM}/n$	1.0			
480	480	$1.2I_{NOM}/n$	1.0			
480	480	$0.2I_{NOM}/n$	0.5L			
480	480	$0.2I_{NOM}/n$	0.5C			
240	220	$0.1I_{NOM}/n$	1.0			
240	220	$0.05I_{NOM}/n$	0.5L			
240	220	$0.05I_{NOM}/n$	0.5C			
240	220	$0.01I_{NOM}/n$	1.0			
240	220	$0.1I_{NOM}/n$	0.2C			
240	100	$0.1I_{NOM}/n$	0.2L			
120	100	I_{NOM}/n	0.5C			
60	60	I_{NOM}/n	0.2C			
30	30	I_{NOM}/n	0.2L			
10	10	I_{NOM}/n	1.0			
5	5	I_{NOM}/n	0.5L			
2	2	I_{NOM}/n	0.5C			
1	1	I_{NOM}/n	0.5L			

5.12 The absolute intrinsic error in measuring power factor Δ_{PF} conforms (does not conform) to the requirements of Calibration procedure MC3.055.500 МП.

5.13 The results of determining the absolute intrinsic error in measuring AC frequency Δ_F are listed in Table C8.

Table C8

Test values of frequency, Hz	Measurement error of the DUT (Δ_F), Hz
42.5	
53	
60	
70	

5.14 The absolute intrinsic error in the direct (without AC current probes) measurements of phase angle between the fundamental harmonics of voltage and current in the same phase (on condition that the phase angle equals zero) $\Delta\varphi_{UI}$ conforms (does not conform) to the requirements of Calibration procedure MC3.055.500 МП.

5.15 The results of determining the absolute intrinsic error in the contactless (with AC current probes) measurements of phase angle between the fundamental harmonics of voltage and current in the same phase ($\Delta\varphi_{UI}$) are listed in Table C9.

Table C9

Measurement range	Parameters of test signal			Measurement error of the DUT ($\Delta\varphi_{UI}$), °		
U_{NOM}, V	U, V	I, A	φ, °	Phase A	Phase B	Phase C
240	220	I_{NOM}/n	0			
240	220	$0.5I_{NOM}/n$	45			
240	220	$0.1I_{NOM}/n$	60			
240	220	$0.05I_{NOM}/n$	-45			
240	220	$0.1I_{NOM}/n$	-60			

5.16 The results of determining the absolute intrinsic modular δ_{CU} and angular θ_{CU} errors of the DUT as applied to testing of voltage instrument transformers are listed in Table C10.

Table C10

Nominal voltage of the DUT (U_{NOM}), V	Parameters of test signals generated by MTS ME 3.1K			Expected values of modular and angle errors		Modular and angular errors of the DUT	
	U_A, V	U_B, V	φ_{UAB}, degrees	δ, %	θ, min	δ_{CU}, %	θ_{CU}, min
120	120	120	0.00	0.00	0.0		
	120.24	120	0.17	0.20	10.0		
	119.76	120	-0.17	-0.20	-10.0		
120	100	100	0.00	0.00	0.0		
	100.2	100	-0.17	0.20	-10.0		
	99.8	100	0.17	-0.20	10.0		
120	80	80	-0.17	0.00	-10.0		
	80.16	80	0.17	0.20	10.0		
	79.84	80	0.00	-0.20	0.0		
60	60	60	0	0.00	0.0		
	60.12	60	0.17	0.20	10.0		
	59.88	60	-0.17	-0.20	-10.0		

5.17 The results of determining the absolute intrinsic modular δ_{CI} and angular θ_{CI} errors of the DUT as applied to testing of current instrument transformers are listed in Table C11.

Table C11

Nominal Current of CTCS, A	Parameters of test signals generated by MTS ME 3.1K			Expected values of modular and angle errors		Modular and angle errors of the DUT	
	I_A, A	I_B, A	φ_{UAB}, град	δi, %	θi,min	δ_{CI}, %	θ_{CI}, min
10	6.01200	6.00000	0.17	0.2	10		
5	4.99000	5.00000	-0.17	-0.2	-10		
5	1.00200	1.00000	-0.17	0.2	-10		
2.5	2.50500	2.50000	-0.17	0.2	-10		
1	1.00200	1.00000	-0.17	0.2	-10		
0.25	0.25050	0.25000	-0.25	0.2	-15		
0.05	0.04990	0.05000	0.50	-0.2	30		

Conclusion: the DUT conforms (does not conform) to the requirements of Calibration Procedure MC3.055.500 МП as applied to the accuracy characteristics.

6 Performance of frequency outputs and pulse input

6.1 Performance testing of the frequency outputs

6.1.1 The pulse signal characteristics on F_{OUT} (TTL) conform (do not conform) to the requirements of Calibration procedure MC3.055.500 МП.

6.1.2 The pulse signal characteristics on F_{OUT} (TM) conform (do not conform) to the requirements of Calibration Procedure MC3.055.500 МП.

6.2 Performance testing of the pulse input

6.2.1 The pulse input of the DUT works correctly (incorrectly) and provides (does not provide) for determining measurement errors of electrical energy meters.

Conclusion: The DUT conforms (does not conform) to the requirements of Calibration Procedure MC3.055.500 МП as applied to the frequency outputs and pulse input performance.

7 Testing of firmware

7.1 The FW name, version and checksum of the metrologically significant component of the firmware conform (do not conform) to the requirements of Calibration Procedure MC3.055.500 МП.

Summary: The Energomonitor 3.1KM conforms (does not conform) to the requirements of Calibration Procedure MC3.055.500 МП.

Date   Calibrator’s signature

Seal